PLANT KINGDOM

ARTIFICIAL SYSTEM

A system of classification based on one or a few superficial characters chosen arbitrarily is called an *artificial system of classification.*

- **Theophrastus (C70-B85 B.C.)-** A Greek botanist, classified plants into four groups herbs, undershrubs, shrubs and trees on the basis of their habit.
- **Pliny the Elder (BC-79 A.D.)** distinguished animals into flight and nonflight ones. Flight animals included bats, birds and insects. He divided plants into herbs, shrubs, undershrubs, trees, vines, succulents, aquatic and terrestrial.
- **Carolus Linnaeus (A707 - A778),** classified plants into BD classes on the basis of sexual characters. He took only the number, length and union of stamens and carpels into consideration for BC classes.
- artificial system is simpler and easier to practise in the field, however it has several drawbacks in this system of classification that are follows:

  1. It lacks the natural relationship amongst the organism.
  2. Organisms do not show a clear-cut evolutionary line.
  3. It leads to heterogeneous assemblage of unrelated organisms.
  4. The traits used for artificial system are liable to change.

NATURAL SYSTEM

- This system is based on natural affinities of plants.
- Natural classification is mainly based on morphological relationships realizing all information available at the time of collection of plants.
- The natural systems remained dominant before the idea of evolution was accepted. However, evolutionary characters are not considered.
- Some of the natural systems are briefly discussed below:
- A.L. de Jussieu (A686-A758) attempted a natural classification in his Genera Plantarum (A789).
- He adopted the views of John Ray as to the primary divisions and applies them to the system of Tournefort which was in common use in France.
- He particularly took into consideration the position of stamens with respect to the ovary and number of cotyledons.
- He considered A5 classes of plants. These classes were further divided into A00 natural orders (equivalent to our present day families).
- A.P. de Candolle in A8A9 published a system of classification in his book Theorie Elementaire de la Botanique.
- **George Bentham (a800-a88D) and Joseph Dalton Hooker (A8A7-AAA9)** worked together at Royal Botanical Gardens, Kew, England and proposed the most important and the last of the natural system for classification of seed plants.
- The system presented by them was published in Latin language in their treaties Genera Plantarulm (A88C) which appeared in three volumes.
- Natural system of classification not only brings out natural relationships but also studies the evolutionary tendencies and phylogeny with the help of all the available data including fossils.
- This system of classification is certainly better than any artificial system of classification.

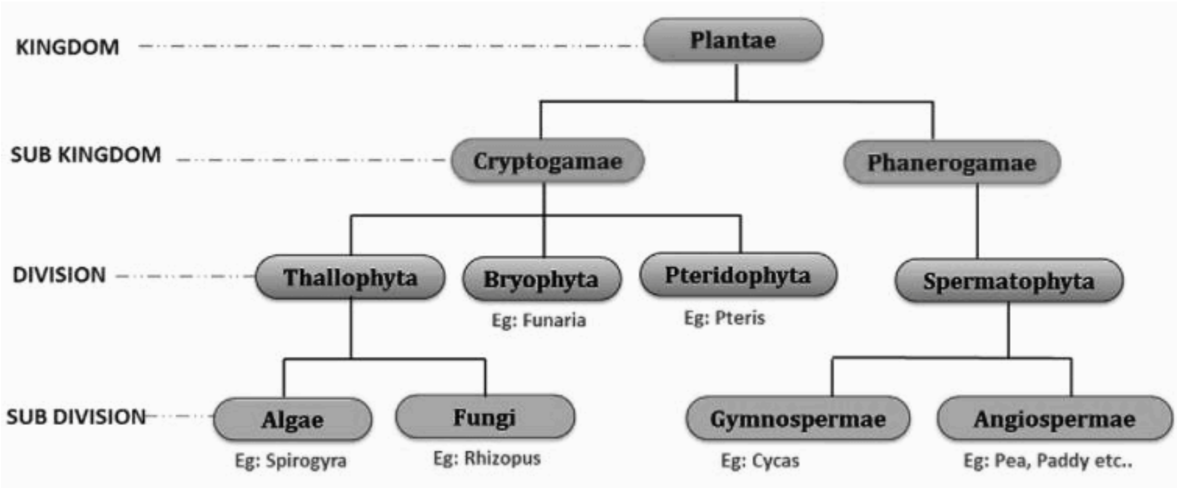
PHYLOGENETIC SYSTEM

- The evolutionary history of a group of organisms is called phylogeny.
- The system of classification reflecting the evolutionary sequence as well as the genetic interrelationships of organisms is called phylogenetic system.
- **adolf Engler (A88D-A9C0) and his associate Karl Prantl (A8D9-A89C)** published a phylogenetic system in the monograph Die Naturlichen Pflanzenfamilien.
- They placed families and orders of the flowering plants in ascending series based on the complexity of floral morphology.
- The characters like one whorl of perianth or no perianth, unisexual flowers and pollination by wind were considered primitive as compared to perianth with two whorls, bisexual flowers and pollination by insects.
- The plant Kingdom according to their classification is further divided into divisions, sub-divisions, classes, orders and families. asteraceae (Compositae) among dicots and Orchidaceae (Orchid family) among monocots are considered highly advanced.

- Moder attempts at developing a phylogenetic classification of flowering plants are those of Cronquist, Hutchinson (A959), Takhtajan (A967), etc.

PLANT CLASSIFICATION

- **For the classification of plants several systems were proposed from time to time by various botanists.**
- C. Linnaeus **(A7C5) using the number and position of stamens, divided flowering plants into BC classes starting with the class** Monandria **with a single stamen**
- **(e.g., *Canna*) and plants with twenty or more stamens were assigned to class** Icosandria.
- The system proposed by Eichler, who was famous for his work entitled Bluthendiagramme (A875-78) was actually the first phylogenetic system of plant classification.
- He divided the plant kingdom into two sub-kingdoms, named as Cryptogamae and Phanerogamae, on the basis of the absence or presence of flowers and seeds.
- Cryptogams are further classified into three divisions namely Thallophyta, Bryophyta and Pteridophyta on the basis of simplicity and complexity of the plant body.



THALLOPHYTA-ALGAE

- Algae and fungi (in Five Kingdom System, Fungi have their own Kingdom) are considered together In thallophyta (having undifferentiated plant body), though there is basic difference in the mode of nutrition (i.e., Autotrophic in algae and heterotrophic in fungi).
- The term algae (L. Alga - sea weed) was first introduced by Linnaeus (A755) but the present day algae were delimited by de Jussieu (a789).
- Fritsch (A9C5) included algae under all holophytic organisms (as well as their numerous colourless derivatives) that fail to reach the level of differentiation characteristic of archegoniate plants The study of algae is called phycology or algology.

CHARACTERISTICS OF ALGAE

- Algae usually occur in a variety of habitats such as water, land as well as on the other plants and even animals. Some grow in marine water called seaweeds.
- Plant body is unicellular, colonial, filamentous, parenchymatous or pseudoparenchymatous.
- Vascular tissues are absent.
- A mechanical tissue is absent.
- Nutrition is autotrophic.
- A variety of pigments in algae provides different colours.
- Vegetative and asexual modes of reproduction are abundant.
- Sexual reproduction involves isogamy, anisogamy and oogamy. Sex organs are unicellular and non-jacketed. an embryo stage is absent.
- Life cycle is various-haplontic, diplontic or diplohaplontic.

CLASSIFICATION OF ALGAE

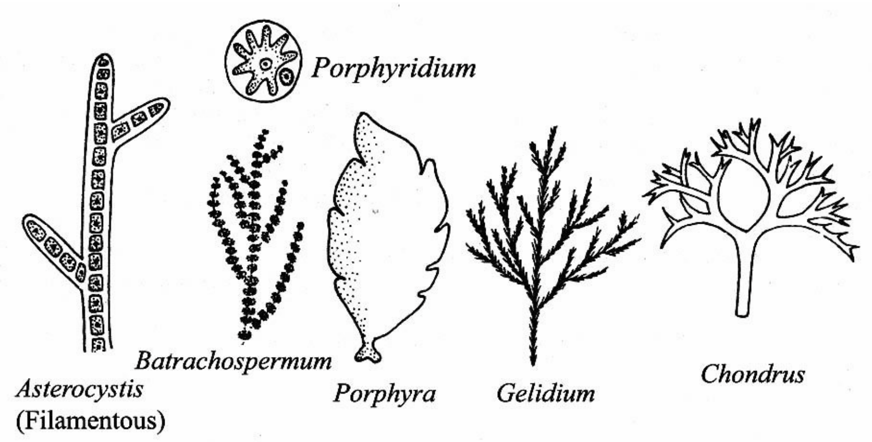
- Algae are usually differentiated on the basis of their pigments and storage products.
- Algae included under kingdom Plantae by **Whittaker** (A969) are of three types: red algae, brown algae and green algae.

Table: Characteristics of algae

		PHOTOSYNTHETIC PIGMENTS			
Kingdom	**Name of algae**	**Chlorophyll**	**Other**	**Food reserve**	**Structure**
	Red algae (Rhodophyceae)	a + d	Phycobilins- phycoerythrin, phycocyanin	Floridian starch	Unicellular to multicellular
Plantae	Brown algae (Phaeophyceae)	a + c	Special carotenoids and fucoxanthin	Lipid, Mannitol, Laminarin starch	Multicellular
	Green algae (Chlorophyceae)	a + b	β carotene and other carotenoids	Starch	Unicellular to multicellular

RHODOPHYCEAE: RED ALGAE

- They are marine except for a few fresh water species (e.g. *Batrachospermum, Compsopogon. Lemnea).*
- Red algae are autotrophic with the exception of a few like *Harveyella* and *Riccardia* that are colourless and parasitic on other red algae *Harveyella* is parasitic over *Polysiphonia.*
- A motile or flagellate stage is completely absent.
- The plant body varies from unicellular to multicellular forms.
- Cell wall possesses cellulose, pectic compounds and certain mucopolysaccharides called phycocolloids.
- The latter are usually sulphated. The important phycocolloids of red algae are agar, carrageenin and funori.
- The photosynthetic organelles are called chromatophores.
- They have single thylakoid. Photosynthetic pigments include chlorophyll a, carotenoids and phycobilins.
- Chlorophyll d has been reported in some cases.
- Phycobilins are water soluble pigments of two types, red coloured phycoerythrin and blue coloured phycocyanin.
- The **red colour** of red algae is due to abundant formation of **phycoerythrin**.
- Reserve food is floridiean starch. In constitution, it is very much similar to glycogen.
- Vegetative reproduction takes place by fragmentation, gemmae, and regeneration of holdfast.
- Sexual reproduction takes place through a variety of spores.

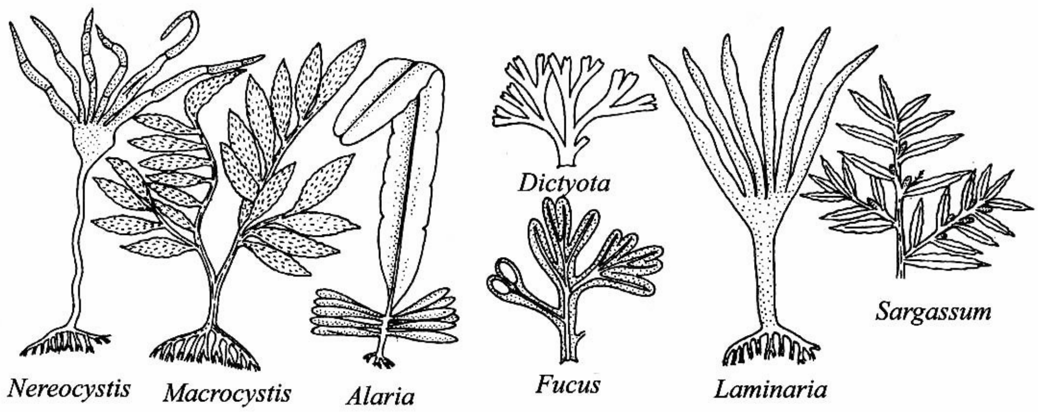


Some Red Algae

- Sexual reproduction is an advanced type of oogamy.
- The male sex organ is called **spermatangium** or **antheridium**. It produces non flagellate male gamete known as spermatium.
- The female sex organ is flask shaped and is termed **carpogonium.**
- Each carpogonium has a long neck like structure called trichogyne and a bulbous base laving female nucleus.
- Red algae have two or more phases in their life cycle so that they can be haplontic, haplobiontic, diplohaplontic, etc.

PHAEOPHYCEAE: BROWN ALGAE

- Most of the brown algae are marine, except *Pleurocladia, Heribaudiella* and *Bodanellia,* which are found in fresh water.
- e.g., *Ectocarpus, Dictyota, Sargassum,* etc.
- Unicellular forms are absent.
- Brown algae include the largest algae.
- The giant brown algae are called **kelps.**
- The plant body is often differentiated into holdfast, stipe and lamina.
- The algae are commonly found attached by means of their holdfasts.
- Cell wall contains cellulose non glycan polysaccharides and phycocolloids.
- Phycocolloids of brown algae are non sulphated mucopolysaccharides.
- The common ones are **alginic acid, fucoidin** and **fuein.**
- The photosynthetic pigments are chlorophyll a, chlorophyll c, β, and c– carotenes and xanthophylls (e.g., lutein, flavoxanthin, violaxanthin).
- Food reserve is **laminarin** (starch) and **D-mannitol** (a sugar alcohol).
- Conducting tubes or **trumpet hyphae** are present in large brown algae or kelps. It is analogous structure of phloem cells.
- Vegetative reproduction occurs through fragmentation *(*e.g., *Sargassum),* adventitious branches, stolons*(*e.g., *Dictyota)* and propagules or specialized nests of cells.
- asexual reproduction occurs with the help of both motile (e.g., zoospores) and non motile spores (e.g., neutral spores, tetraspores, and monospores).
- Sexual reproduction varies from isogamy, anisogamy to oogamy
- There is no zygotic meiosis in brown algae.
- The diploid zygote produces a diploid thallus.
- Isomorphic alternation of generation is found in some brown algae, e.g., *Ectocarpus. Dictyota.*

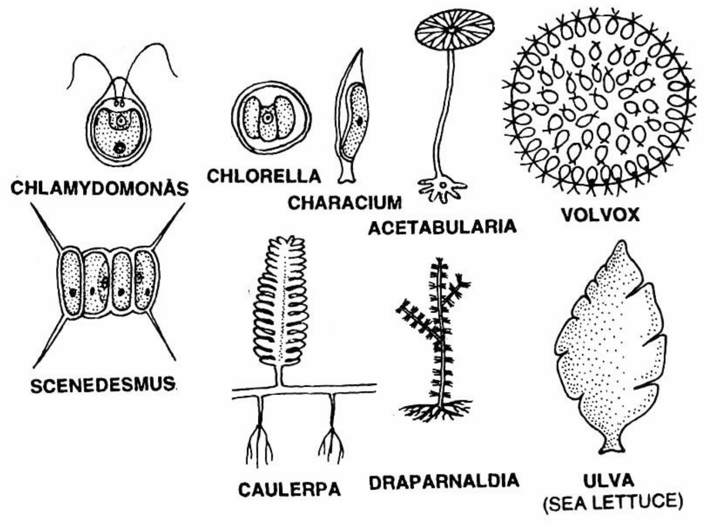


Some Brown Algae

CHLOROPHYCEAE: GREEN ALGAE

- Unicellular flagellate *(e.g. Chlamydomonas),*
- Unicellular non flagellate (e.g., *Chlorella, Characium, acetabularia)* or flagellate colonies, (e.g., *Volvox), non-flagellate colonies* (e.g., *Hydrodictyon),*
- Coenocytic and siphonaceous (e.g., *Vaucheria, Caulerpa),* unbranched filament (e.g., *Ulothrix),* simple branched (e.g., *Cladophora),*
- Heterotrichous with prostrate and vertical branches, (e.g., *Draparnaldia),* and parenchymatous (e.g., *Ulva).*
- Cell wall contains cellulose with a few exceptions.
- Photosynthetic pigments are similar to those of higher plants: chlorophyll a, chlorophyll b, carotenes and xanthopylls.
- Food reserve is Starch.
- Chloroplasts generally contain **pyrenoids** for storage of starch.
- Vegetative reproduction occurs by fragmentation, stolons and tubers.
- Asexual reproduction takes place by **mitospores.** The common asexual spores are **zoospores, aplanospores, hypnospores, akinetes,** etc.

- Sexual reproduction is effected by isogamy, anisogamy and oogamy.
- Three types of life cycle occur in green algae: **haplontic, diplontic** and **diplohaplontic.**
- In haplontic life cycle the dominant phase is haploid.
- The diploid stage is present only in the form of zygote or zygospore.
- Meiosis occurs at the time of its germination of zygote (zygotic meiosis, e.g., *Ulothrix, Spirogyra* and *Chlamydomonas).*
- In diplontic life cycle, the dominant phase of the alga is diploid.
- It gives rise to haploid gametes through meiosis (gametic meiosis, e.g., Caulerpa).
- The gametes fuse and the fusion product or zygote regenerates the diploid phase.
- The haplodiplontic life cycle possesses well developed multicellular haploid and diploid structures.
- The haploid gametophyte gives rise to haploid gametes. The fusion product of gametes or diploid zygote grows directly into diploid sporophyte.
- The sporophyte produces haploid spores through meiosis (sporic meiosis, e.g., *Ulva. Cladophora).* Meiospores germinate into new gametophytes.



Some Green Algae.

CHLAMYDOMONAS: LIFE CYCLE

- *Chlamydomonas* is widely distributed fresh water unicellular alga, commonly occurring in standing or stagnant rainwater, ponds, pools, ditches and on moist soils. It grows, in abundance in water rich in ammonium compounds. There are about CB5 species.

PLANT BODY

- It is a simple, unicellular motile, green algae.
- The individuals are spherical or ellipsoidal. In many species a papilla like out growth is visible in the anterior region.
- The protoplast is surrounded by a definite layer of glucoprotein wall and motile cells of some species have a gelatinous pectic sheath outside the cellulose layer.
- Most of the species have a single large cup shaped chloroplast and occupies most of protoplast.
- Chloroplasts of most of species have a single pyrenoid, which is a protein body and is the site of starch storage. Some species like C. *reticulata* do not have pyrenoids.

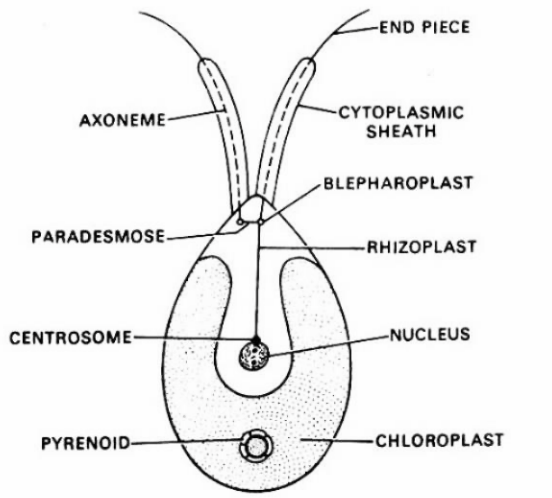


Fig. Neuromotor apparatus of *Chlamydomonas*

REPRODUCTION

- *Chlamydomonas* reproduces both asexually and sexually.

ASEXUAL REPRODUCTION

- **Zoospores:** The protoplasm of each vegetative cell undergoes repeated longitudinal divisions, either into B, D, 8 or A6 daughter protoplasts.
- The parent cell normally loses its flagella before the onset of division.
- after the last series of divisions, each daughter protoplast secretes a cell wall and neuromotor apparatus that develops two flagella, eyespot and contractile vacuoles.

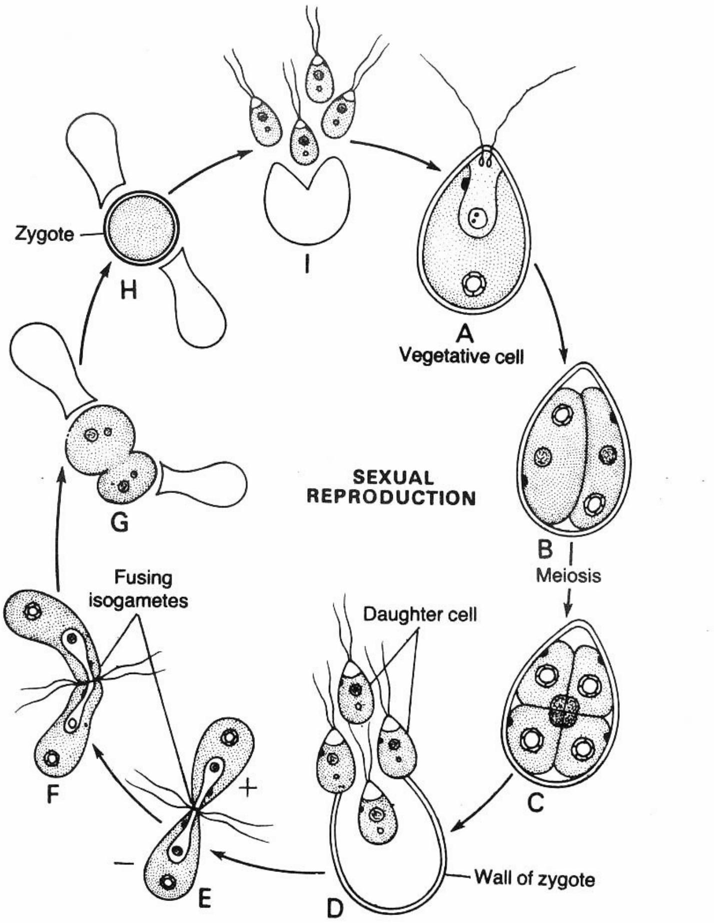
- The daughter cells (zoospores) are liberated by gelatinization or by the rupture of the cell wall. Thus, each daughter cell resembles the parent cell in all respects, except that it is smaller in size.
- **aplanospores:** During unfavourable conditions, sometimes undischarged zoospores develop into aplanospores. The aplanospores are thin walled, uninucleate, unicellular structure.
- Often, they develop singly in the cell and may germinate *in situ (i.e.,* before liberation). On germination, each develops into a new filament.
- **Hypnospores:** In some species (e.g., *C. nivalis*)*,* the protoplast withdraws from the cell wall, rounds up and develops a thick wall under unfavourable conditions.
- These resting spores are called *hypnospores.* Hypnospores usually develop red colour due to the formation of **haematochrome.**
- **akinetes:** akinetes are formed during extreme conditions. They are formed in certain cells that accumulate food and secrete a thick and resistant wall. During favourable condition each germinates to produce a new cell.

SEXUAL REPRODUCTION

- Some species of *Chlamydomonas* are homothallic, while others are heterothallic. Gametic union may be isogamous, anisogamous, or oogamous.

ISOGAMY

- Each *Chlamydomonas* cell may produce 8, A6, CB or 6D biflagellate gametes that are (+)ve or (-)ve in character. In C. *longistigma,* the gametes are naked (gymnogametes) whereas in C. *media,* the gametes become covered with a wall, just before their emergence from the cell (calyptogamete).



Sexual reproduction-Isogamous in *Chlamydomonas Longistigma*

HOLOGAMY

- In most of the isogamous species any vegetative cell may function as gamete and their walls fuse prior to the gametic union *e.g.,* C. *debaryana.*

PHYSIOLOGICAL ANISOGAMY

- In species where the two uniting gametes, though they are morphologically similar, behave differently such as the cell contents of one gamete may pass into another gamete, the process is called as **physiological anisogamy.**

ANISOGAMY

- In anisogamous species like C. *braunii,* B-D large female gametes are formed in one cell and 8-a6 small male gametes are formed in another cell.
- Both the gametes are provided with a wall.
- The male and female gametes join by their anterior ends.
- at the point of contact, their membranes dissolve and contents of the male gamete pass into the female gamete with the result of formation of zygote. The gametes do not shed their walls at the time of gametic union.

OOGAMY

- In oogamous species, like C. *coccifera* the male cell divides to form 8, A6 or CB small biflagellate **antherozoids.**
- The large female cell loses its flagella and becomes an egg cell or oogonium. Fusion takes place between a male gamete and an egg. Both the gametes are covered with a cell wall and form a zygote.

ZYGOTE AND ITS GERMINATION

- Disappearance of flagella from quadriflagellate zygote of isogamous or anisogamous species is followed by the formation of a wall around it.
- The resting zygote enlarges to B-5 times of its original size, owing to the accumulation of reserve food material during photosynthesis.
- However, there are few species, in which there is no increase in size of the resting zygote that develops a red pigment, called **hematochrome.**
- When the resting period is over and the conditions are favourable, the zygote germinates.
- The diploid nucleus undergoes reduction division and forms four nuclei and the cytoplasm gets accumulated around each nucleus.
- The daughter protoplasts are liberated to the outside by the breaking up of the zygote wall. Thus, the new cells formed are usually four in number, from a single zygote.
- But in some species, there may be eight (c. *reinhardi)* or A6 to CB (c. *intermedia)* biflagellate zoospores.

ULOTHRIX: LIFE CYCLE

THE PLANT BODY

STRUCTURE OF THE THALLUS

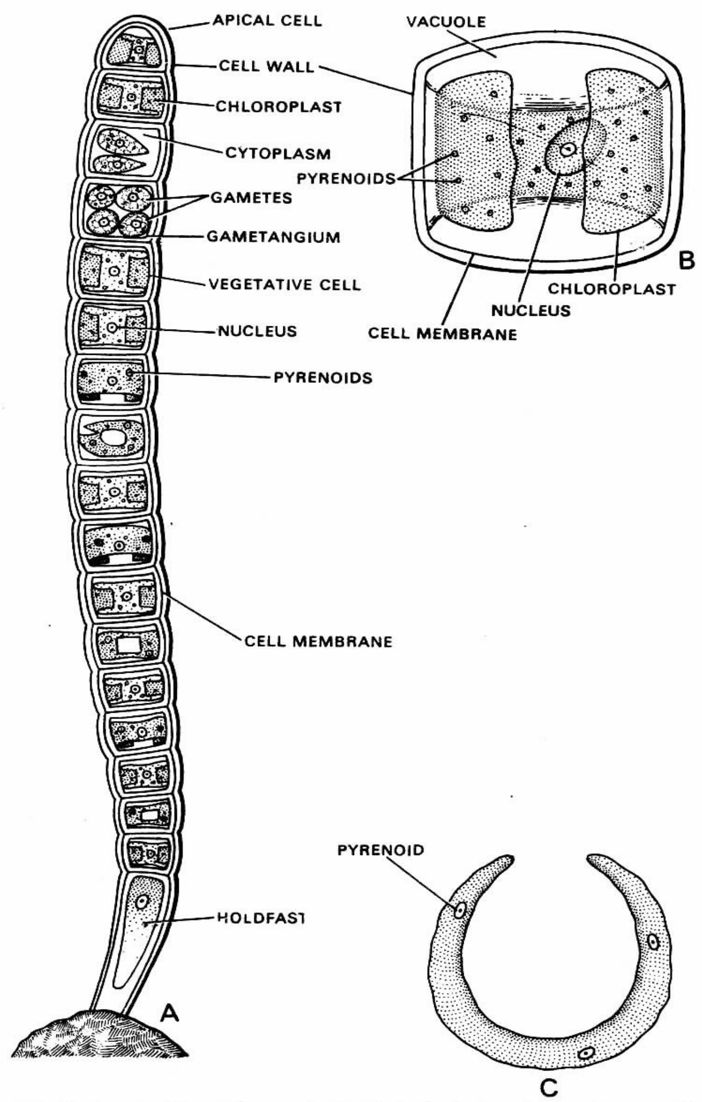
- The plant body is a thallus consisting of an extremely fine unbranched filament.
- The filament comprises of single row of cells placed end to end, and firmly united. The filaments appear slender, thread like and may be upto 0.0D mm in diameter.
- Except for basal one, all the cells of the filament are similar in structure and behaviour.
- The basal cell (holdfast) is slightly elongated, hyaline or achlorophyllous and through it, the filament remains attached to the substratum.
- The remaining cells of a filament are barrel shaped and are often wider than long. However, the apical cell is down-shaped.
- The growth is apical.

STRUCTURE OF A CELL

- The cells are usually cylindrical, sometimes slightly swollen in middle, and often broader than long as in *U. zonata* and most other species.
- Each cell consists of a cell wall enclosing the protoplast. The cell wall consists of two layers:
- the inner layer consisting of cellulose, and
- the outer layer consisting of propectin which is insoluble in water.
- The protoplast is differentiated into a cell membrane, cytoplasm, a single nucleus, chloroplast with one or more pyrenoids and a central vacuole.
- Cytoplasm forms the lining layer or primordial utricle and is closely invested by the cell membrane.
- The central portion of the cell is occupied by a large vacuole containg a cell sap.
- The cells are always uninucleate and possess a single girdle, collar or ring shaped chloroplast with one

(e.g., *U. variabilis)* or more *(*e.g., *U. zonata)* pyrenoids.

- The number of pyrenoids may increase during cell division.
- The chloroplast may be closed *(*e.g., *U zonata)* or open at one end.



Ulothrix: A. One filament, B. Detailed structure of one cell
C. A girdle shaped chloroplast

- The cell is uninucleate.
- The nucleus in resting condition possesses a prominent nucleolus

REPRODUCTION

- ❑ Ulothrix reproduces by the following means:

VEGETATIVE REPRODUCTIONS

- ❑ accidental breaking or the death of intermediate cell causes breaking of the filament into fragments, the process being known as fragmentation.

ASEXUAL REPRODUCTION

- ❑ **Zoospores:** The zoospores are formed during favourable conditions. all cells are capable to form zoospores except the holdfast.
- ❑ During the formation of zoospores, the protoplast divides mitotically into number of daughter protoplasts by repeated longitudnal divisions.
- ❑ Each develops into a zoospore.

Following are the two types of zoospores:

1. **Macrozoospores:** They are quadriflagellate, uninucleate and pyriform (pear shaped) with a pointed anterior end and are often fewer in number. Each macrozoospore consists of a pair of contractile vacuoles, a single chloroplast with a pyrenoid and almost anteriorly placed stigma.
2. **Microzoospores:** Filaments of *U. zonata* produce microzoospores that are formed in large number (D to CB) similar to that of macro zoospores. They are smaller in size, uninucleate, narrowly ovoid with a round posterior end and they may be quadri - or biflagellate. They swim for a longer period for about B to 6 days.

   Aplanospores: During unfavourable conditions, sometimes undischarged zoospores develop into aplanospores.

   The aplanospores are thin walled, uninucleate, unicellular structure.

   Hypnospores: During drought, the entire content of the cell rounds off and secretes a thick wall and is called **hypnospore.**

   Akinetes: akinetes are formed during extreme conditions in *U. idiospora.* They are formed in certain cells that accumulate food and secrete a thick and resistant wall. During favourable conditions each germinates to produce a new filament.

SEXUAL REPRODUCTION

- Isogamous type of sexual reproduction is found in *Ulothrix* and in majority, the plants are heterothallic, the gametes are formed in large number *i.e.,* CB to 6D in number in each gametangium.
- Each gamete looks quite similar to biflagellate microzoospore.
- However, gametes are smaller in size.
- These are formed and liberated in a way similar to zoospores.
- Each gamete is biflagellate, pyriform and has prominent stigma and a chloroplast.
- They look like *Chlamydomonas.* but are naked. Since, male and female gametes are indistinguishable, they are denoted as (+) or (–) strain gametes.
- During fusion the two gametes fuse from anterior to lateral side.
- as a result, a quadriflagellate zygospore is fomed, which possesses a pair of nuclei, chloroplasts and eyespots.
- Plasmogamy (fusion of protoplasm) takes place at this stage that is followed by karyogamy (nuclear fusion).
- After swimming for a short while, it secrets a thick lamellated wall and undergoes or resting period.

GERMINATION OF ZYGOSPORES

- The diploid nucleus of zygospore divides meiotically and generally produces four motile (zoospores) or non motile spores (aplanospores) of which' two develop into male filament (+ type) and other two into female ones (- type).
- Each spore develops into a new plant. Sometimes, after meiosis, a few mitotic divisions may also occur in zygote each followed by protoplast cleavage.

SPIROGYRA: LIFE CYCLE
OCCURRENCE

- *Spirogyra* is a large genus consisting of about C00 species widely distributed throughout the world. It grows as free-floating extensive masses and hence commonly called **pond scum**.
- It grows frequently in fresh water, stagnant reservoirs and in slow running streams and rivers.
- In natural conditions, *Spirogyra* looks like a mass of shining silky long filaments and hence it is popularly known as **pond silk.**

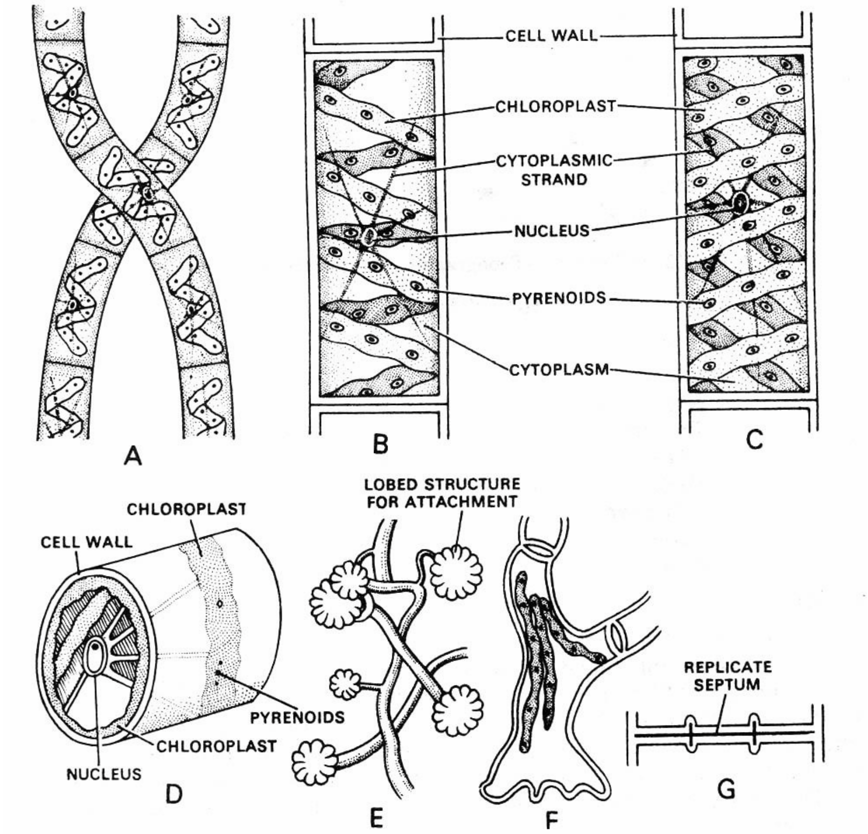
THE PLANT BODY (THE GAMETOPHYTE)

STRUCTURE OF THE THALLUS

- The plant body consists of slender, unbranched filament.
- The young filament of *Spirogyra* is found attached to some substratum by a modified basal cell, while adult plant is always free floating.
- The basal cell that helps in the attachment is called as hapteron. Each filament consists of a single row of cylindrical cells.

STRUCTURE OF A CELL

- Each cell consists of a firm cell wall enclosing a mass of protoplast.
- Cell wall is commonly two layered, the inner composed of cellulose while outer of pectic substances. The pectic substances gelatinize in the presence of water and render the plants slimy touch.



Spirogyra- a. Two filaments B-C. Detailed structure of cell, D. T.S. of a cell, E. Hold fast of *Spirogyra,* F. Holdfast of *Spirogyra,* G. Replicate septum

- The protoplast consists of a single nucleus, mass of cytoplasmflat, ribbon shaped chloroplasts and a large central vacuole.
- The nucleus is found centrally suspended by strands of cytoplasm or it may be parietal in position.
- The Cytoplasm is peripheral due to presence of large central vacuole but central vacuole is traversed by several cytoplasmic strands.
- The number of chloroplasts is the characteristic feature of the alga.
- Their arrangement is also specific and spiral *i.e.,* twisted to the right in the ascending order.
- The name of the alga is after the spiral arrangement of chloroplast.

REPRODUCTION

- *Spirogyra* reproduces by vegetative and sexual methods.
- However, aplanospores formation has been reported in S. *aplanosporum* and akinetes in S. *farlowii.*

VEGETATIVE REPRODUCTION

- Fragmentation is the common method of vegetative reproduction in *Spirogyra.*
- accidental breaking or injury breaks the filaments into B-C celled pieces, each germinates to produce a new plant. However, in certain cases, cross walls also play a role in separating the two cells apart by the process of invagination.

SEXUAL REPRODUCTION

- The sexual reproduction in *Spirogyra* is called *conjugation,* which involves fusion of two morphologically identical but physiologically dissimilar gametes.
- It is called as physiological anisogamy.
- The gametes are aflagellate **(aplanogametes).**
- For development of gametes some of the cells start to act like male and female gametangia.
- The cell contents taking part in development of gametangia become separated from the cell wall and shrink and are ultimately converted into gametes.
- The process of conjugation involves following methods:

SCALARIFORM CONJUGATION

- The process begins with two filaments getting intimately associated due to mucilage.
- Lateral outgrowths arise from the cells of these two filaments, placed opposite one another and are called **papillae.**
- The outgrowths enlarge because of the repulsion between the two conjugating filaments and result in the formation of conjugation tubes.
- Later the common walls of the conjugation tubes dissolve and a free passage is formed. Simultaneously, the protoplasts accumulate abundant starch.
- The male gamete moves in amoeboid manner through the conjugation tube into the female cell of another filament.
- Ultimately the nucleus of male gamete fuses with the nucleus of the female gamete involving plasmogamy followed by karyogamy and forms a diploid zygospore.
- at the completion of scalariform conjugation, the cells of the male filaments become empty while the cells of the female filament are filled with the zygospores.

LATERAL CONJUGATION

In *Spirogyra* lateral conjugation takes place by one of the following three methods:

- **Indirect lateral conjugation:** In this process two adjacent cells of the filament take part.
- These cells develop tube like outgrowths close to the common cross walls.
- These outgrowths extend laterally and ultimately form conjugation tube like structure that connects the adjacent cells.
- The protoplast of conjugating cells contract and form gametes.
- The outgrowths of the adjacent cells fuse to form a passage between them.
- The contracted protoplast of one cell (so called male gametangium) moves through the conjugation passage into the adjacent cell (so called female gametangium).
- The fusion of both the gametic protoplasts results in the formation of a diploid zygote.
- The male cells or male gametangium becomes empty due to migration of the its contents while zygospores occupies the female gametangium.
- This type of conjugation has been reported in S. *gratiana.*
- **Terminal conjugation:** a different process of conjugation has been described in S. *colligata.* called terminal conjugation.
- In this method, conjugation tubes are produced on either side of the septum of the two conjugating cells. The male gamete enters the female gametangia by perforating the septum of the conjugation tube.
- **Direct lateral conjugation:** This type of lateral conjugation was reported in S. *jogensis.* The filament is attached to the substratum by its basal cell.
- Lateral conjugation takes place between the two cells placed immediately next to the basal cell.

- The protoplast of male cells pushes and pierces the septum between the two cells and the whole protoplast of the male cells moves into the female cell through the perforation.
- after fusion zygote is formed. It is believed that the secretion of an enzyme effects perforation.

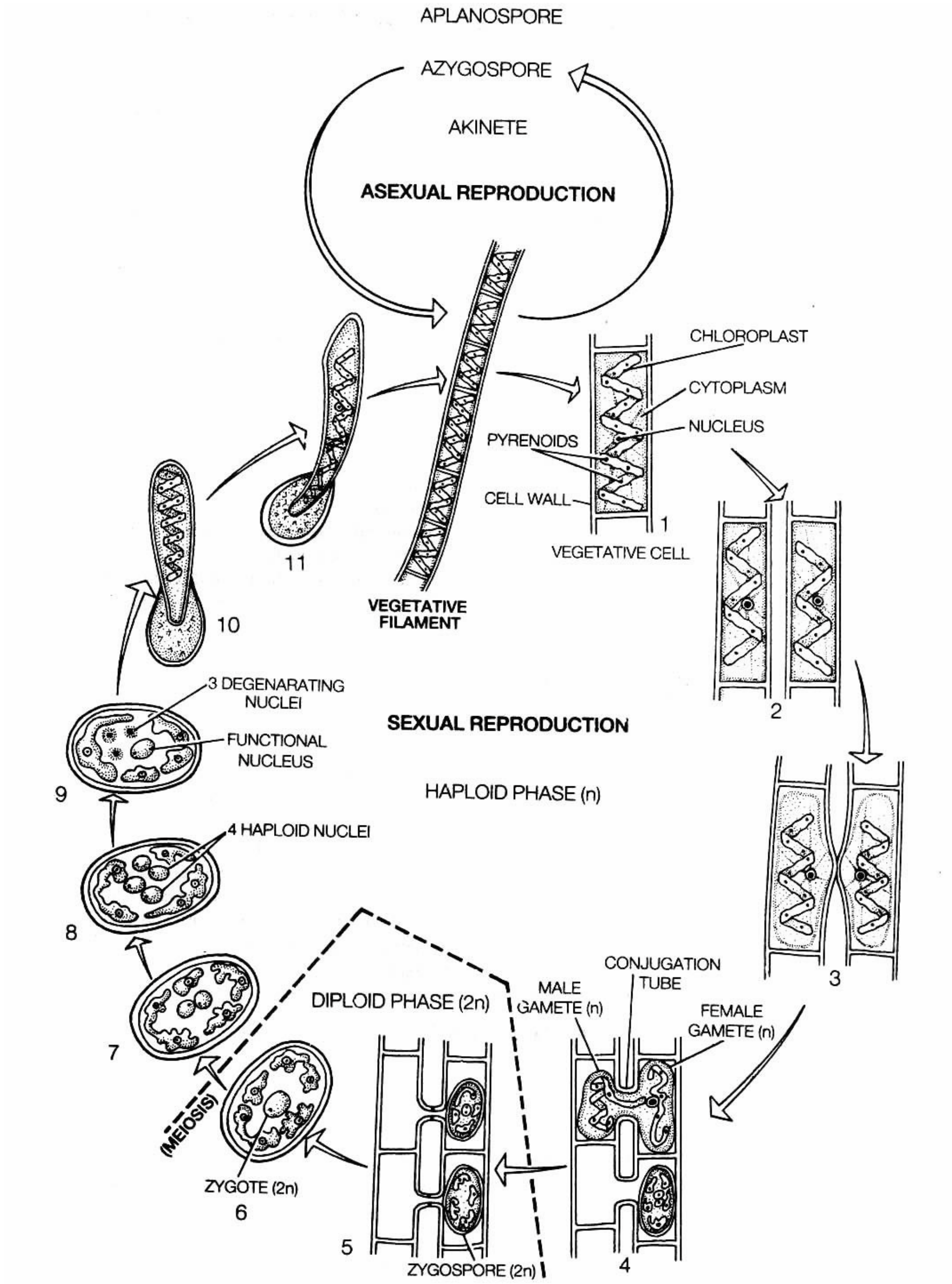


Fig. *Spirogyra*: Diagrammatic representation of life cycle

BRYOPHYTA.

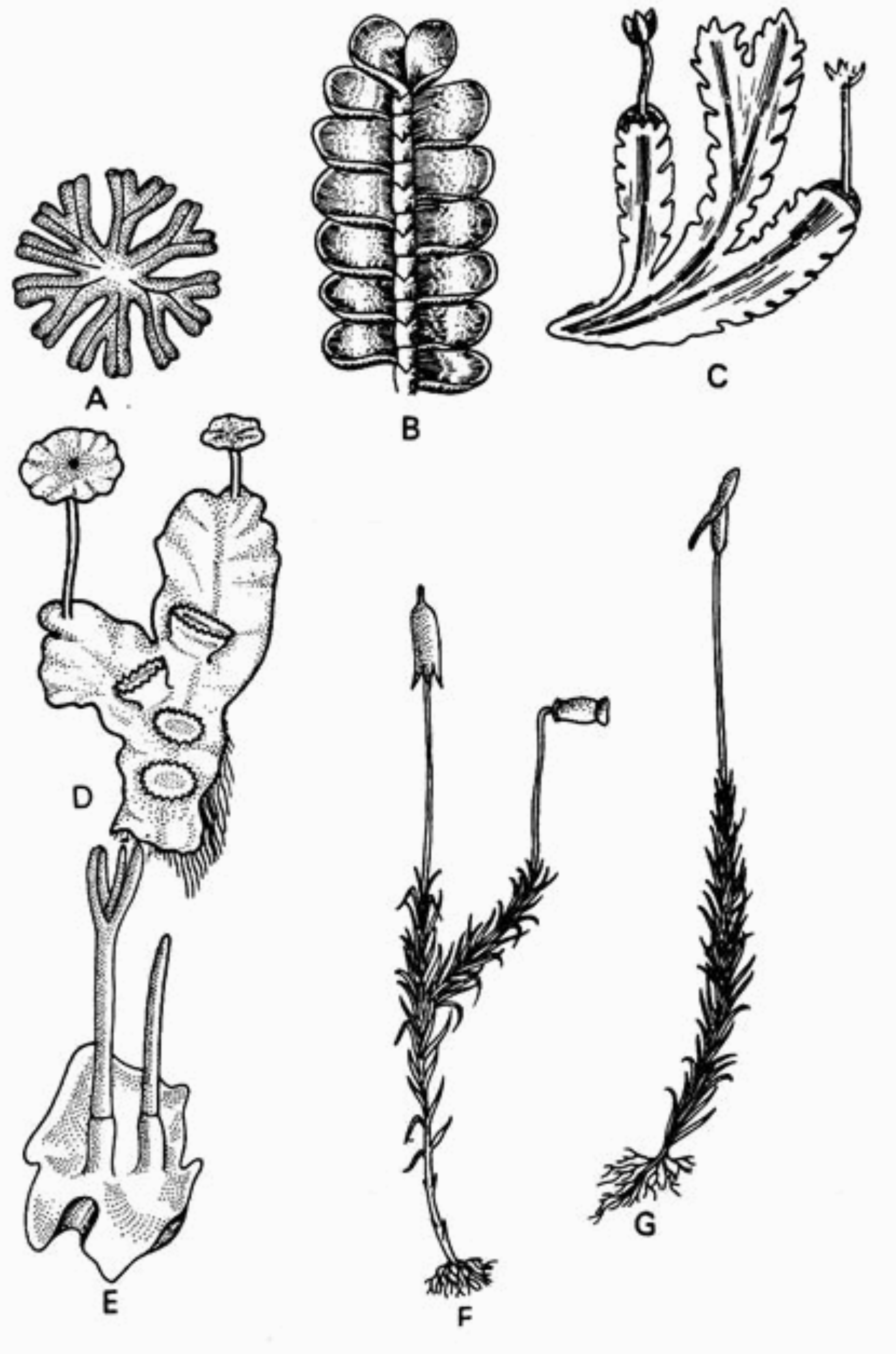
GENERAL CHARACTERS OF BRYOPHYTES

HABITAT

- The plants grow predominantly in amphibious habitat though some forms like *Ricciafluitans, Ricciocarpus natans* and *Riella sp.* are aquatic; *Sphagnum* grows in bogs (wet and softground); *Polytrichum juniperianum* and some other mosses grow in xeric conditions;
- *Frullania sp. Radulla protensa* etc. are epiphyllous and *Bauxbaumia minakatae, B. aphylla* and *Cryptothallus mirabilis* are saprophytes.
- *Porella platyphylloidea* grows on rocks and barks and can withstand without water for several months.

Size and Form

- Bryophytes though minute in size represent wide diversity in form.
- These range from microscopic *(Zoopsis argentea* and male plant of *Bauxbaumia aphylla:* C-D mm) to macroscopic *(Fontinalis antipyritica, D0-50* cm and *Dawsonia superba,* 50-70 cm long).
- However, the plant body of *Monocarpus spherocmpus* measures only 0.5-B.0 mm in diameter.



Different forms of Bryophytes:
A. *Riccia.* **B.** *Lejeunea.* **C.** *Pellia.* **D.** *Marchantia.* **E.** *Anthoceros*
F. *Polytrichum.* **G.** *Barbula*

Structure: Gametophyte (The plant Body)

- The plants show two morphologically distinct heteromorphic generations, i.e., gametophytic and sporophytic generations.
- Gametophytic generation is the dominant phase of life cycle and in general the *term plant body* is used to represent this phase

- The gametophytes are well developed, green and autotrophic to which the sporophytes are not only attached but are also physically and physiologically (nutritionally) dependent.
- The plant body of primitive forms, e.g., *Riccia* and *Marchantia* is thalloid but in mosses. It is foliose and is differentiated into root like (rhizoids), stem like (axis) or cauloid and leaf like (phylloid) structures.
- The thalli of primitive forms are found attached to the substratum by unicellular unbranched rhizoids but in higher forms as in mosses these are attached by means of branched multicellular rhizoids.
- Bryophytes lack vascular tissues.
- The plant body consists of simple parenchymatous cells.
- Xylem, phloem and lignified cells are completely absent.
- The parenchymatous cells may be differentiated into several types.

REPRODUCTION

- Bryophytes reproduce by vegetative and sexual methods.

Vegetative Reproduction

- Bryophytes largely multiply by means of vegetative reproduction which is accomplished by fragmentation, adventitious branches, tubers, persistent apices, buds, gemmae, rhizoids, primary protonema, secondary protonema, etc.

Sexual Reproduction

- The sexual reproduction is invariably advanced oogamous type.
- Sex organs are multicellular and jacketed with sterile jacket. They may be embedded type, e.g., *Riccia, anthoceros* or projected type, e.g., *Marchantia,* mosses, etc.
- The male reproductive organ is called **antheridium.** It consists of a central mass of androcytes enclosed by a single layer of sterile jacket. Each androcyte produces a single biflagellate **spermatozoid** or **antherozoid.**
- The female reproductive organ is called **archegonium**.
- Each archegonium is a multicellular and flask shaped structure.
- The basal swollen portion is called *venter* whereas slender and elongated upper portion is called neck.
- Wall of the neck is single layered made up of 6 rows of 6-8 cells each.
- Venter has a-B layered wall. The neck of archeogonium is filled with 6-a0 neck canal cells (D-6 in *Riccia)* and the venter has a large egg cell and small venter canal cell.
- The egg is large and non-motile.

Fertilization

- Water is indispensable for fertilization (**zooidiogamy**).
- Many antherozoids swim to the neck to archegonium.
- all the neck canal cells and venter canal cell disorganise to form mucilage, carbohydrate, proteins, K+, etc.
- These chemicals not only provide the medium for swimming of antherozoids but also chemotract them.
- Many antherozoids enter into the venter but only one, the most active one, fuses with egg to form diploid zygote (oospore).
- With the formation of diploid zygote, the gametophytic generation ends and the sporophytic generation starts.

The Sporophyte

- The zygote, immediately after fertilization, divides repeatedly without undergoing any resting period. The first division of zygote is transverse and the embryo proper develops from the outer cell. This type of embryogeny is commonly known as **exoscopic embryogeny.**
- The embryo is not liberated but is retained within the archegonium where it develops into a sporophyte.
- The sporophyte in bryophytes is called **sporogonium** because it is dependent and mainly meant for producing spores.
- The sporophyte consists of **foot, seta** and **capsule**.
- Wall of the venter proliferates to form a covering around the growing embryo. It is called **calyptra.**
- In a capsule, the spores are formed after meiosis.
- These spores *(***meiospores***),* that are all of one kind make the plants **homosporous.**

The Young Gametophyte

- The spore is the mother (first) cell of the gametophytic generation. .
- The spores are cutinized and non motile.
- The spores germinate directly into the new gametophytic plants (e.g., *Riccia* and *Marchantia),*
- Thus, bryophytes have heteromorphic or heterologous alternation of generation.

CLASSIFICATION

- Bryophytes are divided into three classes: Hepaticae (Liverworts), Anthocerotae (Hornworts), Musci (Mosses). However, ICBN recommended names of these classes as Hepaticopsida, anthocerotopsida and Bryopsida.
- The recent classification of Bryophyta is a as follows:

BRYOPHYTA

Hepaticopsida | Anthocerotopsida | Bryopsida

FUNARIA: LIFE CYCLE

- The plant reproduces vegetatively and sexually.

VEGETATIVE REPRODUCTION

- The-protonema-developed from the part of the plant other than spores are called the seeondary **protonema.**
- In their function and behaviour they are similar to the primary protonema. Secondary protonema may be formed from any of the detached living part of the leafy gametophore such as from the axis, leaves, paraphysis and sex organs or from the rhizoids.
- When developed from the wounded parts of the sporophyte such as from these sterile cells of the capsule and seta, they exhibit a phenomenon of **apospory.**
- These detached secondary protonema form the new plant.
- In some cases terminal cells of the protonemal branches divide by longitudinal oblique or transverse walls to produce a small multicellular structure, the **gemmae**.
- The cells of gemmae are thin walled and contain abundant chloroplasts.

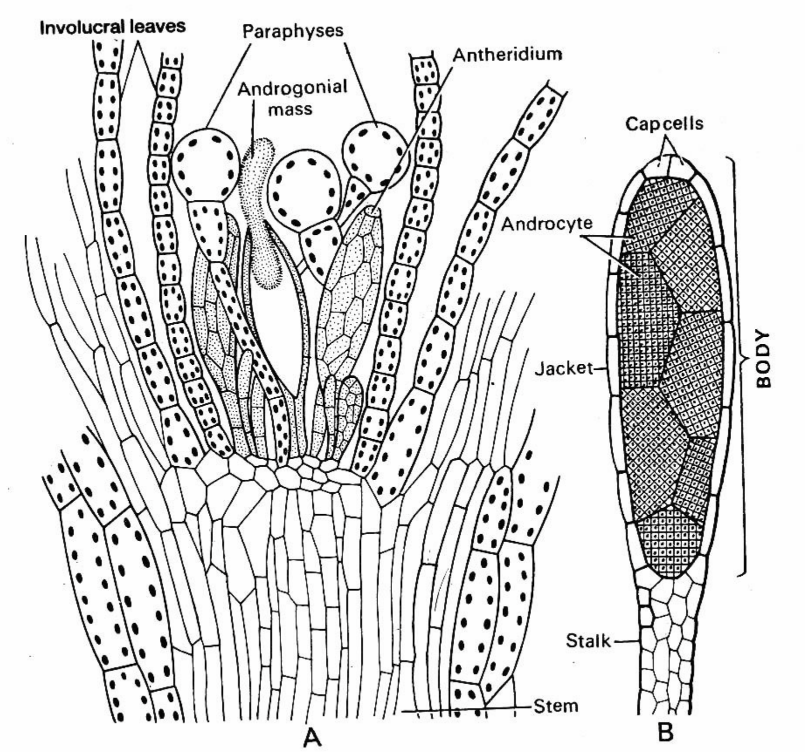
SEXUAL REPRODUCTION

- The plants are monoecious autoecious and protandrous, i.e., antheridia and archegonia occur on the different branches of the same plant, and the antheridia develop first.
- The sex organs are borne in terminal groups on the apices of fertile branches, the **gametophores.**

THE ANTHERIDIUM

Male shoot

- The main axis of the gametophytic plant bears male sex organs, the *antheridia,* at its apex and behaves as a male shoot.
- The antheridia are erect and occur in groups.
- They are surrounded by a large number of closely set **perigonial leaves** spreading out like a rosette of petals and forming a **perigonial cup** that provides protection to the developing antheridia.



Moss: A. L.S of antheridial hend, B. L.S. of one antheridium

Paraphyses

- A large number of sterile structures, the paraphyses occur intermixed with the antheridia.
- They occur in clusters and are green. Each paraphysis is multicellular, D-6 cells high, filamentous structure *i.e.*, the cells being arranged in a single row.
- The terminal cell of the paraphyses is large, nearly sub spherical and capitate, but the cells below it are narrow, elongated and rich in chloroplasts.
- The paraphyses in addition to their photosynthetic function provides protection to the developing antheridia.
- They hold water in between them and secrete mucilage that assists in the liberation of antherozoids and protects the young antheridia from drying.

Structure of mature antheridium

- A mature antheridium consists of a short massive multicellular stalk on which lies a club shaped antheridial body.
- The jacket of the body consists of a single layer of polyhedral and flattened cells. Within the jacket of the antheridium lies a mass of androcytes of which each later changes into a single biflagellate spermatozoid.
- The free distal end of the antheridium bears one or two large thick walled colourless cells, the **opercular cells.**
- The dehiscence of mature antheridium takes place when it comes in contact with the water.
- The opercular cell becomes mucilaginous, absorbs water and swells.
- It causes a pressure that ruptures its inner wall.
- The cell contents become free, move towards the inner side and reach the antheridial cavity.

THE ARCHEGONIUM

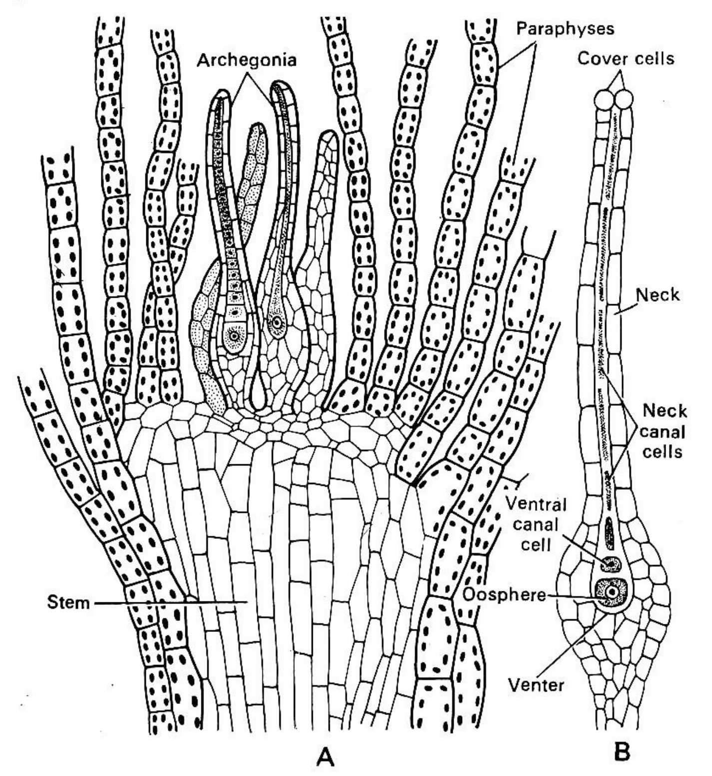
Female shoot

- The archegonia intermingled with paraphyses occur at the apex of the female shoot.
- The leaves that enclose the group of archegonia and sterile paraphyses are similar to the ordinary foliage leaves.
- The female shoot emerges laterally from the base of the male shoot and goes higher up.
- It is usually larger than the male shoot.

Structure of archegonium

- The massive multicellular stalk of the archegonium is comparatively larger than that of the antheridium.
- Situated on the long stalk each archegonium appears as a flask shaped structure differentiated into a basal swollen venter and an elongated neck.

- The jacket or wall of the archegonium in the region of the venter is two layered thick but in the region of the neck it is single layered thick.
- The neck is comparatively large, twisted and tubular; enclose 6-a0 or more neck canal cells.
- In a fully mature archegonium venter canal cell and neck canal cells disintegrate forming a mucilaginous substance.
- The terminal cells (cover cells) separate apart and later are thrown off, thus a passage is left for the cavity within the archegonium.



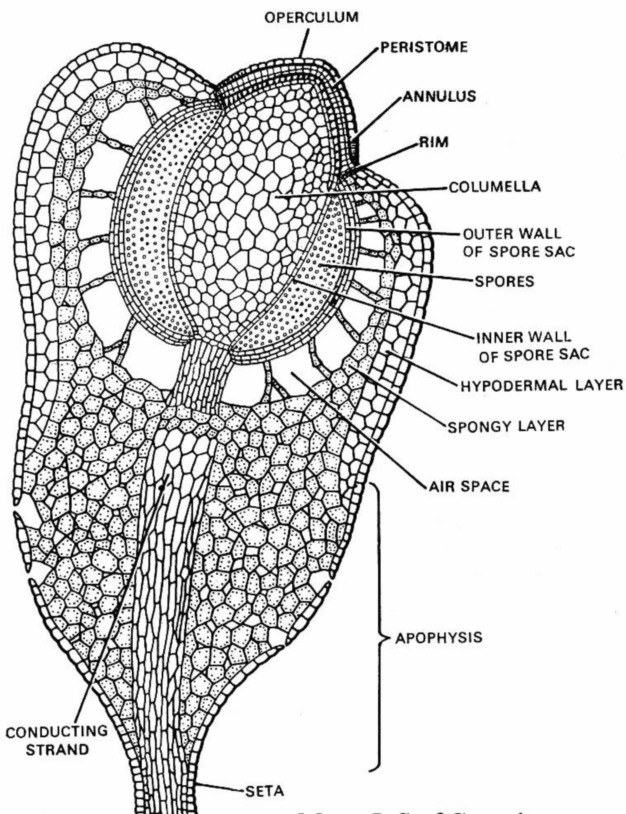
Moss: **A. L.S. of archegonial head, B. One archegonium.**

Fertilization

- The antherozoids are attracted chemotactically.
- The antherozoids reach the archegonium by the agency of water perhaps by splashing and trickling of rain drops from male shoot to underlying female shoot.
- The antherozoids passing through the mucilage filled neck canal reach the egg containing venter cavity where finally one of them fuses with the egg nucleus and form the zygote.

THE SPOROPHYTE
STRUCTURE OF MATURE SPOROGONIUM

- The mature sporophyte is a complex and highly elaborated structure differentiated into the foot, seta and capsule.
- **Foot:** It is a poorly developed, small, dagger like conical basal part of the capsule embedded in the apical tissue of the female shoot. It functions both as an absorbing and anchorage organ.
- **Seta:** It is a long, slender, tough and twisted reddish-brown stalk like structure. It bears capsule at the top.
- **Capsule:** The capsule is highly organized, erect or pendent, pear shaped structure situated at the tip of long seta. It is chiefly concerned with the formation and dispersal of the spores.
- Externally it is differentiated into three well marked regions
  (i) sterile basal region the **apophysis**
  (ii) central fertile region, the *theca* and
  (iii) upper region the **operculum** enclosing peristome.



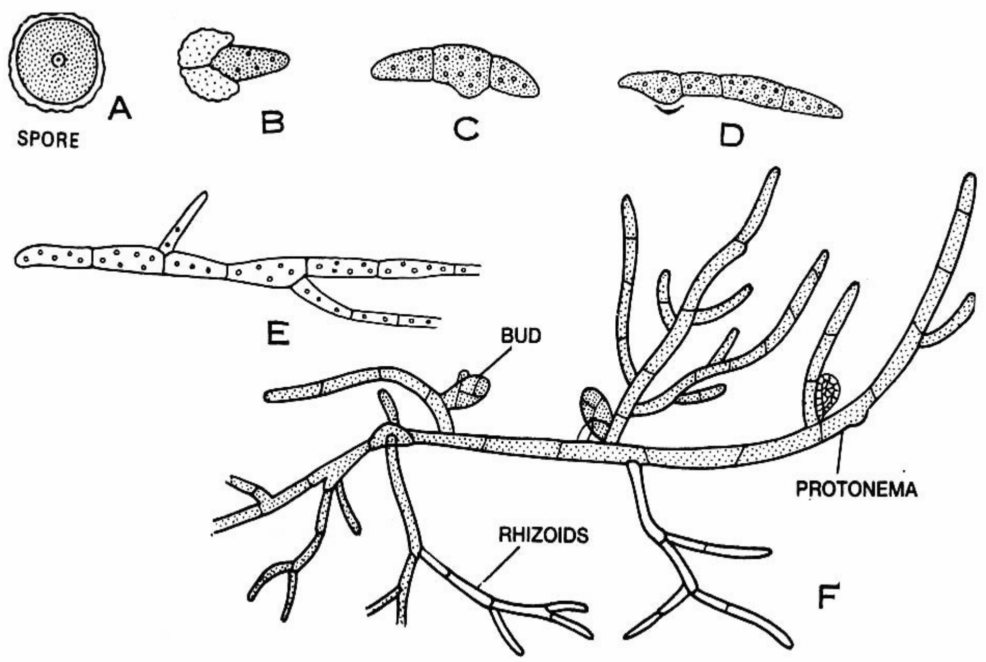
Moss: L.S of Capsule

DEHISCENCE OF CAPSULE

- In dry atmosphere, capsule begins to dry up loosing water from the thin walled cells.
- Thus, a tension is developed which ruptures the spore sac.
- Thin-walled delicate cells of the annulus break away, the operculum is thrown off and the peristome teeth are exposed.
- The outer peristome teeth, which by this time remain bent so as to cover the open spore sac, jerk and bend back dispersing the spores.
- The peristome teeth form a fringe around the mouth of the capsule.
- These by their hygroscopic movements assist in liberating the spores from the spore sac.

THE YOUNG GAMETOPHYTE

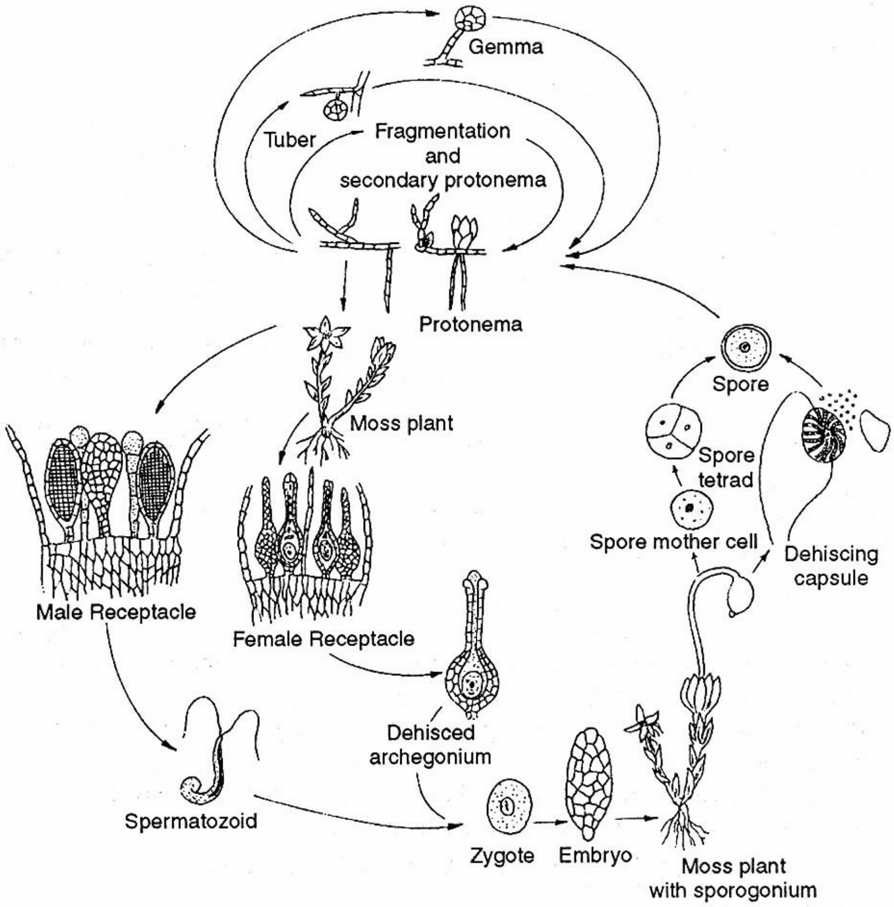
- **The spore:** The spores are small 0.AB–0.B0 mm in diameter.
- Each spore is spherical with a smooth surface.
- The spore wall is differentiated into an outer smooth, coloured exosporium and an inner colour less hyaline, smooth endosporium.
- Enclosed within the wall lies a single nucleus, chloroplasts and numerous oil globules.
- **Germination of the spore:** On reaching suitable moist substratum the spore germinates immediately. It absorbs water, swells, and increases in size.
- The exosporium may rupture at one or both ends of the spores producing germ tube at one or both the ends, which are opposite to each other.
- Each of the germ tube develops a cross wall near the point of emergence and turns green. The germ tubes elongate, become septate and produce a filamentous protonema.



Moss : A. spore, B-C. Germinating spore, D-E. Developing protonema, F. Mature protonema with gemma and bud.

- These are known as **rhizoidal filaments** and are primarily meant for fixing the protonema to the substratum.
- The rhizoidal branches when exposed to light behave as **chloronemal filaments**.
- The formation of these two types of filaments depends on the environmental conditions in response to which the protonema is extremely plastic.

- Soon after the formation of the buds near a cross wall towards the base of the chloronemal branches or even on the rhizoidal branches the growth of protonema stops.
- The buds after becoming B-D celled develop the tetrahedral apical cell with three cutting faces and cut segment to form the stem and three rows of leaves.
- The development of the rhizoids takes place from the base of the stem.



Diagrammatic life cycle of *Funaria*.

Fig**. Diagrammatic representation of life cycle of *Funaria***

- The erect gametophores of the moss plants develop by the activity of the apical cell.
- The gametophores are usually very large in number even in the protonema formed by the germination of a single spore, become independent as soon as the protonema dies off.
- The germination of a large number of spores develop several protonema intermingled due to which a large number of gametophores are developed.
- Several gametophores are formed from each protonema of a spore and become independent shortly after its death.
- a dense growth of plants is seen because of this property.

PTERIDOPHYTA

- They are commonly called **vascular cryptogams.**

THE SALIENT FEATURES OF PTERIDOPHYTES

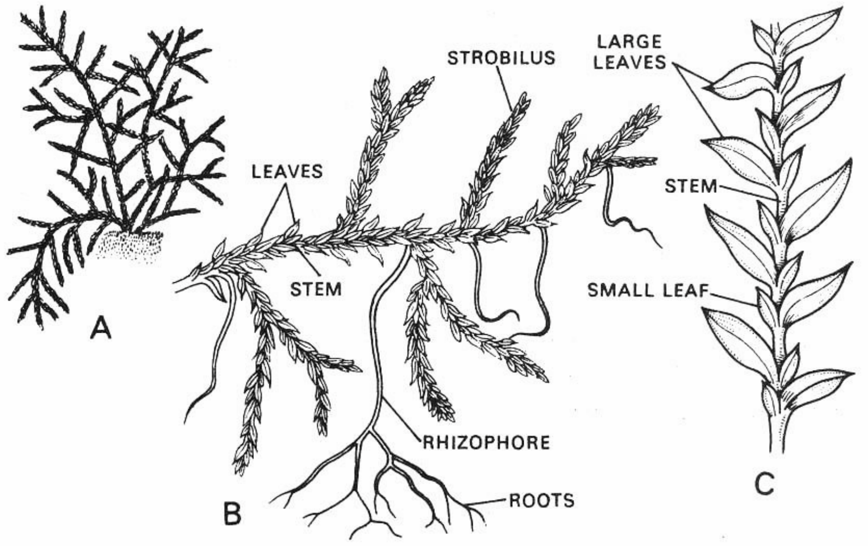
Occurrence

- The pteridophytes grow under varied habitats, most of them are terrestrial plants and thrive well under damp and shady conditions while some flourish well in open grasslands or even under xeric conditions.

The Plant Body (The adult Sporophyte)

- The main independent plant body of pteridophytes is sporophyte (Bn).
- The sporophytic plant body is **cormophyte** differentiated into true root, stem and leaves.

- Some primitive members of the group may lack true root and well developed leaves *e.g.,* order Psilophytales and Psilotales.
- In these, roots are replaced by rhizoids and stem axis becomes photosynthetic.



Selaginella kraussiana—**A. general habit, B. A part of the plant, C. Small portion of B showing arrangement of leaves.**

- Plants generally exhibit dorsi ventral or radial symmetry.
- The branching of stem may be dichotomous or monopodial.
- The stem bears leave which may be small **microphyllous**

REPRODUCTION

- The sporophytic plant reproduces by means of spores that are produced in small capsules called **sporangia.**
- Leaves bearing-the sporangia arc called **sporophylls**.
- In aquatic pteridophytes, the sporangia are produced within the specialized structures called the **sporocarps** (e.g., *Marsiliea, Salvinia* and ***azolla***).
- according to the mode of development, the sporangia are of two fundamental types, the **eusporangium** and **leptosporangium**.
- The eusporangium is found in most cases and develops from several sporangial initials (e.g., *Psilotum, Lycopodium, Selaginella, Equisetum,* etc).
- The leptosporangium is found only in some of the advanced ferns and develops from a single superficial cell (e.g., *Marsilea, Pteridium, Pteris,* etc.).
- Within the sporangia are developed the diploid spore mother cells or sporocytes.
- These spore mother cells undergo meiosis or reduction division to form spores.
- If all the spores are of the same size, the plant is said to be **homosporous** and if they are of two different sizes, the plant is called **heterosporous**.

THE GAMETOPHYTE

- The spores, on germination give rise to the haploid gametophytes or prothalli that are usually small and insignificant structures.
- The gametophytes are inconspicuous as compared to the sporophytes.
- One of the most characteristic features of the pteridophytes is that the sporophyte has become the dominant morphological part of the life cycle while the gametophyte has been much reduced.
- The gametophytes are of two general types.
- Gametophytes that develop from homospores and grow upon the soil (outside the spore wall) to form independent plants, are known as **exosporic gametophytes.**

SEX ORGANS

- The gametophyte or prothallus bears the **sex organs**, the **antheridia** and **archegonia**.
- The gametophytes formed from the heterospores are **dioecious**, the antheridia and archegonia developing on separate male and female gametophytes.
    - **Antheridia:** The antheridia may be embedded either wholly or partially in the tissue of gametophyte or they may project from it. at maturity, each antheridium is a globular structure.

- It consists of an outer single cell layered sterile wall inside which are found a large number of androcytes.
- **Archegonia:** The archegonia in pteridophytes resemble closely with those of the bryophytes.
- Each archegonia is a flask shaped structure,
- consisting of a basal swollen, embedded portion the venter and a short neck.
- The neck consists of D vertical rows of cells, each with B to D cells.
- The neck has a single binucleate neck canal cell (aD neck canal cells in *Lycopodium).*
- The venter encloses the egg and ventral canal cell.
- **Fertilization:** Fertilization in all cases is accomplished by the agency of water.
- The mucilage and malic acid, formed by the disintegration of neck canal cell and venter canal cell, not only provide a medium for swimming of antherozoids but also chemotract them.
- Many antherozoids enter into the venter but only one, the most active one, fuses with female gamete.
- The fusion of a male gamete and an egg restores the diploid chromosome *(Bn)* number and results in the formation of the zygote.

LIFE CYCLE OF PTERIDOPHYTES

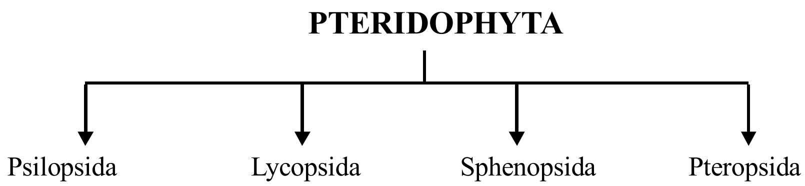
- The life cycle of a pteridophyte comprises of two distinct phases or generations, each of which produces the other.
- One phase or generation, the sporophyte, is diploid (Bn) and the dominant part of the life cycle.
- It is the part of the life cycle in which vascular tissue is developed.
- The sporophyte develops sporangia within which are diploid cells called spore mother cells or sporocyte. Each spore mother cell divides by meiotic division.
- The gametophytic generation is always small, inconspicuous and bears male and female gametes.
- The male gamete i.e. antherozoids are produced in large number within the antheridium.
- The female gamete i.e. egg is generally borne single within the archegonium.
- Fertilization takes place in the presence of water when an antherozoid fuses with an egg to produce a diploid zygoyte. The zygote germinates to form the new sporphyte. This generation is called sporophytic generation.
- Thus, the life cycle of a pteridophyte consists of an alternate succession of sporophytic and gametophytic generations (heteromorphic or heterologous alternation of generation).

Heterospory and Seed Habit in Pteridophytes

- The occurrence of two kinds of spores in the same plant is called **heterospory.** Of the two kinds of spores, the smaller ones are called **microspores** and the larger ones are termed as **megaspores** and are produced within the **microsporangi***a* and **megasporangia***,* respectively.

Classification of Peteridophyta

- The Pteridophyta is divided into four classes, viz. Psilopsida, Lycopsida, Sphenopsida and Pteropsida, on the basis of organization of plant body including the nature of leaf, vascular system, and location of sporangia.



DRYOPTERIS: LIFE CYCLE

- The most common species is *Dryopteris fluxmas,* which is commonly known as Beech fern or male shield fern or Hay scented fern. It is found in moist and shady places in tropical, sub-tropical and temperate regions.
- The plant body is a sporophyte, which is differentiated into root, stem and leaves.
- The roots are adventitious.
- The stem is dark brown underground rhizome growing obliquely.
- From upper surface of rhizome many leaves arise acropetally.
- The leaves are large, called fronds, and are bipinnately compound.
- The young leaves show circinate vernation.

- Persistent leaf bases of the dead leaves are present in the old part of rhizome.
- The younger part of rhizome and rachis are covered with multicellular brownish scales called ramenta.
- Reproduction takes place by vegetative methods and by spores.

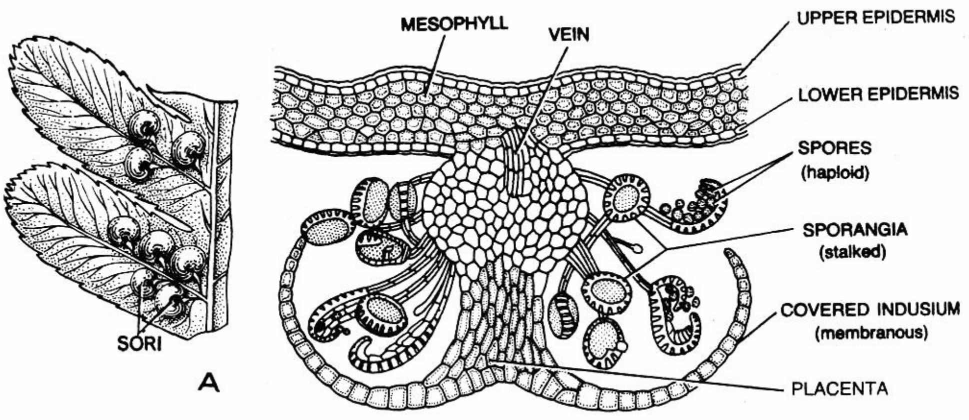
VEGETATIVE REPRODUCTION

- Vegetative reproduction takes place by adventitious buds that develop on the rhizome. These buds give rise to new plants. Besides this, fragmentation of rhizome also helps in vegetative propagation.

SEXUAL REPRODUCTION

SPORE PRODUCING ORGANS

- Spores are formed within sporangia.
- They develop on the ventral (lower) surface of ordinary foliage leaves.
- The leaves bearing sporangia are known as *sporophylls.*
- Many sporangia arise irregularly from **placental tissue** developed at the tip of an ultimate vein.
- The sporangia of all developmental stages are aggregated in cluster called sori.
- These are arranged in two rows, one on each side of the main vein.
- Thus, sori are sub marginal and discontinuous.
- Sorus is covered by a thin membranous shield like or kidney shaped outgrowth of the leaf, called **indusium.**



Dryopteris. **A. Part of a sporophyll with sori, B. T.S. of sorus .**

- The development is of leptosporangiate type.
- Mature sporangium consists of a stalk and a body or capsule.
- The stalk is long, slender and multicellular.
- The capsule is lens shaped.
- The capsule wall is only one cell in thickness.
- a row of thin cells on one side of the capsule marks the line of dehiscence. It is called stomium.

Dispersal of spores: Dispersal of spores takes place when the atmosphere is dry.

- In such conditions the indusium dries and shrivels and the sporangia are exposed to the dry atmosphere.
- The annulus and stomium help in the dehiscence of sporangium by a purely mechanical action
- This causes the capsule to break open transversely at the stomium.
- In this process the upper half of the sporangial wall swings backward along with annulus in the form of a cup.

GAMETOPHYTE

THE PROTHALLUS

- The spore is the mother cell of gametophytic generation It germinates when temperature and moisture are suitable.

- It develops chloroplasts and divides transversely to form a green filamentous structure resembling moss protonema.
- The germ tube attaches itself to the soil by rhizoids.
- at a very early stage in development, the uppemost cell of the filament divides and establishes an apical cell.
- It cuts off cells alternately on two sides till a heart shaped gametophyte is formed.
- Mature gametophyte is thin flat and green structure, approximately a/D inch in diameter.
- It is known as prothallus.
- The apical part of prothallus has an apical notch where the growing point is situated.
- The lobes of prothallus are only one cell in thickness whereas the central part lying immediately below the apical notch is several cell layers thick.
- Many one-celled rhizoids develop on the ventral surface of the thallus and serve as organs of attachment.

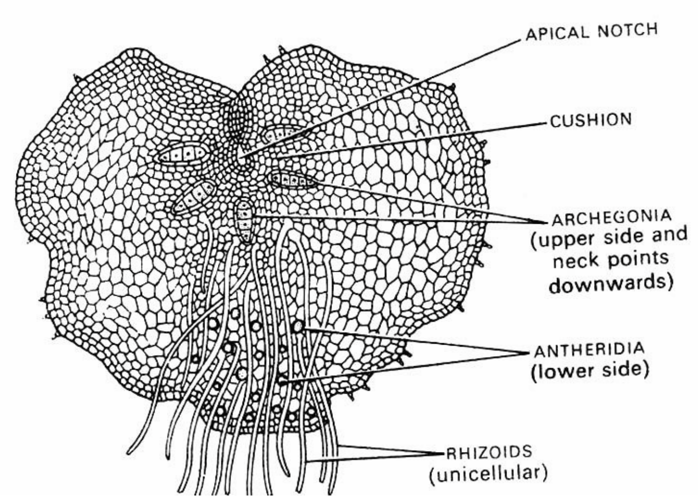


Fig. Detailed structure of a prothallus showing position of archegonia, antheridia and rhizoids

SEX ORGANS

- The male and female reproductive structures are antheridia and archegonia.
- The prothalli are strictly monoecious or homothallic and protandrous (antheridia maturing earlier than archegonia).
- Both the sex organs are produced on the ventral surface of the thallus.

ANTHERIDIA

- The antheridia develop in the basal region of the prothallus, among the rhizoidal cushion.
- Mature antheridium is a dome shaped structure that projects beyond the surface of the prothallus.
- The wall of the antheridium is composed of only three cells.
- Two cells form a ring around antheridium and are known as first ring cell and second ring cell.
- The third cell, which forms a cap of the antheridium, is known as cap cell. In each antheridium, there are usually CB spirally coiled multiflagellate antherozoids.
- The antherozoids of ferns thus resemble with those of *Cycas* in their multiflagellate nature.

ARCHEGONIA

- The archegonia are produced in the thickened portion of the prothallus, just behind the apical notch.
- Mature archegonium is a flask shaped structure.
- It has a basal enlarged venter that is deeply sunken in the tissue of the prothallus and a neck that project beyond the surface of the prothallus.
- The wall of the neck consists of four rows of neck cells.

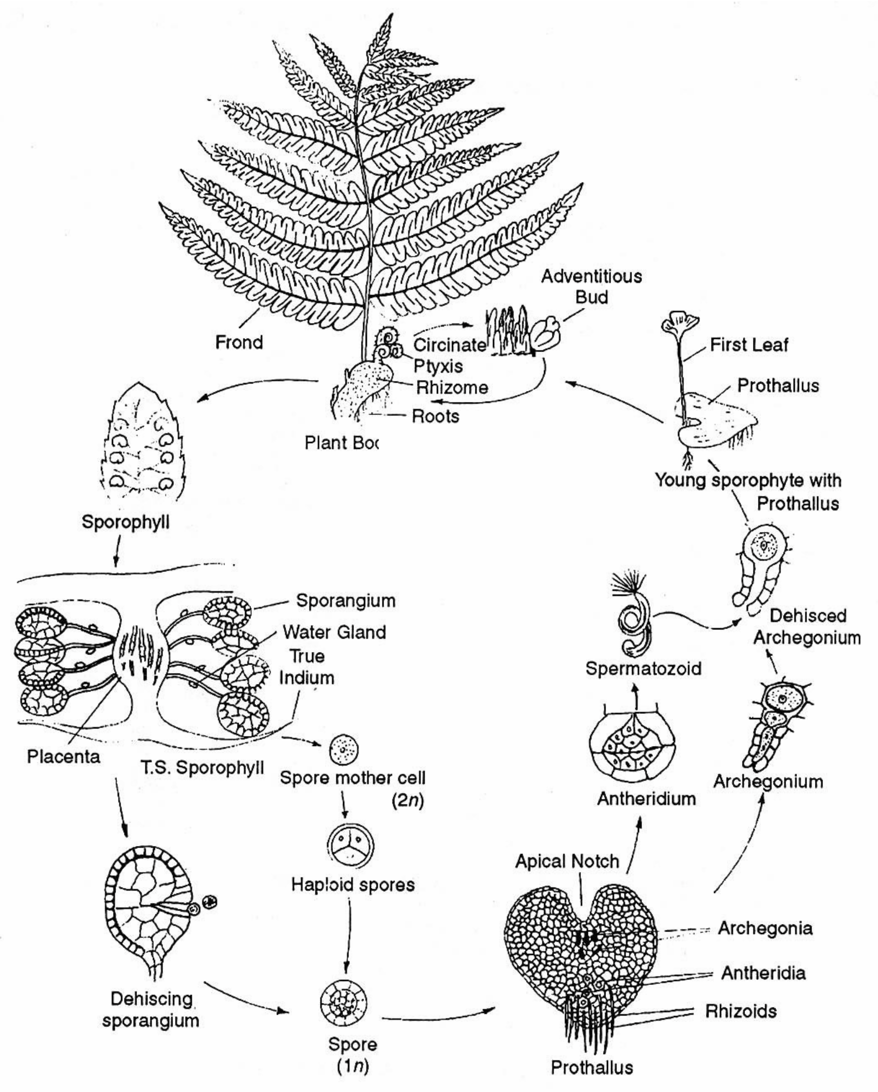
- The venter has a large egg and a small venter canal cell.
- The neck canal of the young archegonium is occupied by an axial formation between the two neck canal cells and, therefore, almost invariably there is a single binucleate neck canal cell.

FERTILIZATION

- Fertilization takes place when the antheridium absorbs water.
- This creates turgor force that pushes the cover cell of the antheridium and the antherozoids are set free.
- It contains malic acid that attracts antherozoids towards the neck of the archegonium.
- This is a chemotactic movement.
- Many antherozoids swim into the neck of the archegonium, but only one of them fuses with the egg.
- The fusion results in the formation of a diploid zygote or oospore.
- The new sporophytic phase begins with the zygote.

EMBRYO AND THE YOUNG SPOROPHYTE

- Archegonia are fertilized but only one of them develops into embryo. So, only a single sporophyte is found attached to each prothallus.
- After fertilization, the zygote secretes a thick wall and begins to grow.
- The first division of zygote is vertical, *i.e.,* along the long axis of the archegonium.
- The resulting two hemispherical cells divide till eight cells are formed.
- These are arranged in two tiers of four cells each. It is called octant stage. The upper tier, known as **epibasal tier**, forms primary leaf (or first leaf) and primary root.
- The lower of the hypobasal tier forms foot and the embryonal stem.
- After the establishment of foot, the primary leaf and primary root, the embryo emerges from the archegonial wall.



Diagrammatic life cycle of *Dryopteris*.

- The embryonal stem forms rhizome that gives out a number of adventitious roots.
- The primary leaf is replaced by a bipinnately compound leaf.
- Thus, a new independent sporophyte is established and the prothallus dries up and disintegrates.
- The young sporophyte now manufactures its own carbohydrate food and absorbs water and minerals from the soil.

ALTERNATION OF GENERATION

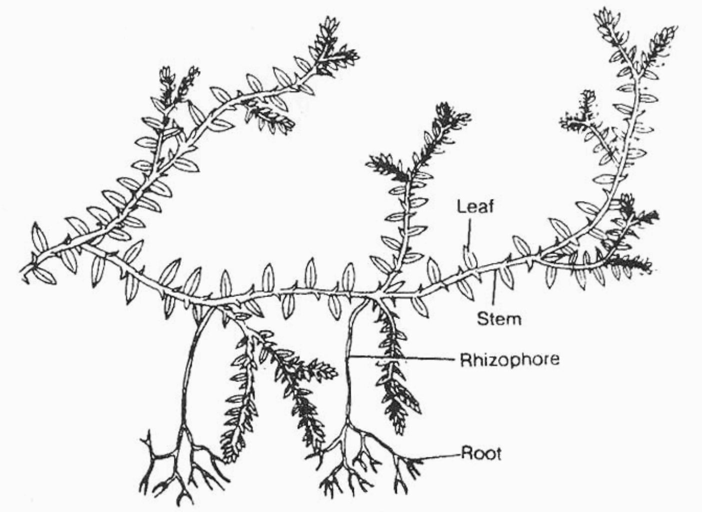
- *Dryopteris* has a heteromorphic alternation of generation.
- There are two morphologically distinct phases in its life cycle:
- The sporophytic phase and the gametophytic phase, which alternate with each other.
- The sporophytic phase that forms spores is long lived and is differentiated into roots, stem and leaves.
- The gametophyte, on the other hand is relatively short lived and thalloid.
- The sporophyte is dependent upon gametophyte when young but becomes independent as it attains maturity.
- The sporophyte is diploid.
- The diploid spore mother cells undergo meiosis and form haploid spores.
- The spore is the mother cell of the haploid gametophytic generation and forms gametophyte which produces haploid gametes.
- Haploid male and female gametes fuse to form diploid zygote, which is the mother cell of the sporophytic generation.
- The zygote grows into embryo and develops into sporophyte.

SELAGINELLA : LIFE CYCLE

- *Selaginella,* commonly known as spike moss or little club moss prefers moist, cool and shady places, though a few species.
- (e.g., S. *lepidophylla* and S. *rupestris)* are xerophytes.
- The xerophytic species roll up to form ball-like structures (cespitose habit) during dry season but spread out and revive when sufficient moisture is available *(*e.g., S. *lepidophylla).*
- Such plants are called resurrection plants. S. *bryopteris* is sold in the market under the name "Sanjivani".

EXTERNAL FEATURES

- The main plant body represents the sporophyte (Bn), and is an evergreen herb differentiated into root, stem and leaves.
- The stem is erect prostrate and dichotomously branched.
- Positively geotropic structures called **rhizophores** arise from the stem at the point of branching.
- Rhizophore bears adventitious roots at its tip.
- Rhizophores are non-green, leafless thread like structures.
- They lack root hair and root cap.
- The leaves are small, simple, sessile called microphylls (being single-veined).
- The bulbous basal region of the ligule is made up of larger cells called **glossopodium**.



Sporophyte of *S. kraussiana*

INTERNAL ORGANISATION

- **Stem:** anatomically stem has an outer parenchymatous epidermis, a few layers of sclerenchymatous hypodermis, parenchymatous cortex and one or more steles.
- Thus, the stem is polystelic with a to a6 steles depending upon the species.
- Each stele is a protostele and is surrounded by air space.
- The stele is connected to the cortex across the air space by radially elongated filament-like **trabeculae.**
- The trabeculae show casparian strips; hence, are believed to be endodermal cells.
- The xylem is **diarch, exarch** and made up of tracheids, though a few vessels are present in S. *rupestris.*
  - **Root:** Root has a layer of epiblema with occasional root hair. It is followed by cortex, endodermis, pericycle and a single **monarch** exarch xylem surrounded by C-shaped phloem.
  - **Rhizophore:** Rhizophore has an outer thick walled epidermis without root hair, sclerenchymatous hypodennis, thin walled cortex, endodennis, pericycle and phloem surrounding mesarch xylem on all sides.
  - **Leaf:** Leaf has an upper and lower epidennis with stomata.
  - Mesophyll is not differentiated.
  - Its cells contain one or more cup-shaped chloroplasts having **granoids** One vascular strand with

protostelic condition occurs in the mid-rib region.

- It is covered by **bundle sheath.**

REPRODUCTION

- *Selaginella* reproduces vegetatively and sexually.

VEGETATIVE REPRODUCTION

- Vegetative reproduction occurs by fragmentation, bulbils (e.g. S. *subdiaphana)* and stem tubers *(S. chrysocaulos).*

SEXUAL REPRODUCTION

- It takes place by spores.
- Being heterosporous, *Selaginella* produce two types of spores microspores and megaspores produced-in microsporangia .
- The microsporangia and megasporangia are borne on microsporophylls and megasporophylls.
- The sporangia are eusporangiate (developing from a group of initial cells).
- Each sporophyll is ligulate and bears only one sporangium at its base on the adaxial surface.
- Microsporangium consists of a multicellular stalk and a round/oval body covered by two-layered jacket.
- A single-layered tapetum present beneath the jacket, provides nourishment for developing spores.
- Many diploid microspore mother cells are formed in each sporangium which undergo meiosis to form numerous microspores.
- Megasporangium is large four-lobed structure (one megaspore per lobe) having two-layered jacket and a multicellular stalk.
- Megaspores are formed by meiosis in megaspore mother cell.

GAMETOPHYTIC GENERATION

- Microspore develops into male gametophyte which is highly reduced.
- at one stage it is aC-celled consisting of one prothallial cell plus aB cells of the antheridium.
- The microspores are liberated at **aC-celled stage**.
- The primary androgonial cells divide each metamorphoses into an oval biflagellate **antherozoid.**
- The megaspore germinates to form an autotrophic multicellular female gametophyte .
- after the release of megaspores at this multicellular stage, a few superilcial cells act as archegonial initials each of which develops into an archogonium.
- Each archegonium has a short, projecting neck with venter embeded.
- The jacket of neck is one-cell thick and is made up of two tiers of four cells each.
- Cover cells/lid cells are absent.
- antherozoids swim through rainwater or dew towards archegonium to fuse with egg forming a diploid zygote that develops into embryo.
- The embryo is gradually pushed into the interior of female gametophyte

GYMNOSPERMS

- Gymnosperms (Gk gymnos: naked, sperma, seed) are naked seeded plants with their ovules freely exposed on open megasporophylls.
- Gymnosperms are the most ancient seed plants that originated during the late Paleozoic era (B65 million years ago) but flourished well during the Mesozoic era.
- The Jurassic period perhaps was the best time for gymnosperms.

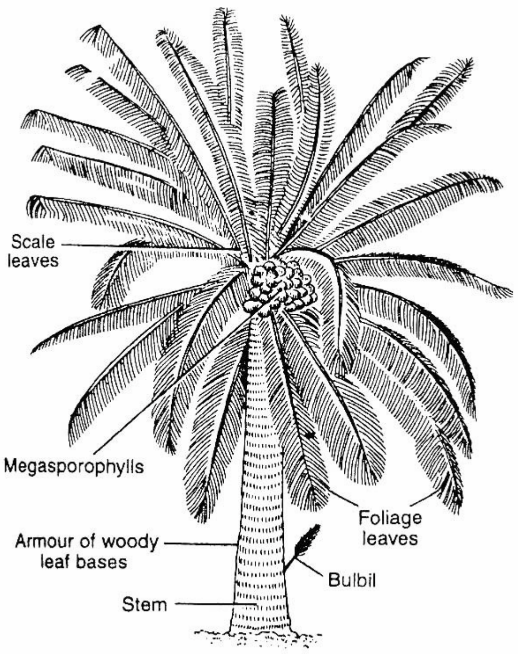
Salient features

- The living gymnosperms are widely distributed in the cold climates.
- Cycads occurs in tropical and subtropical areas.
- In India, mostly the conifers thrive well in hilly areas.
- Very few gymnospenns grow in plains.
- Several gymnosperms are now grown as ornamentals, e.g., *Thuja, araucaria* (native of South america), *Ginkgo.*

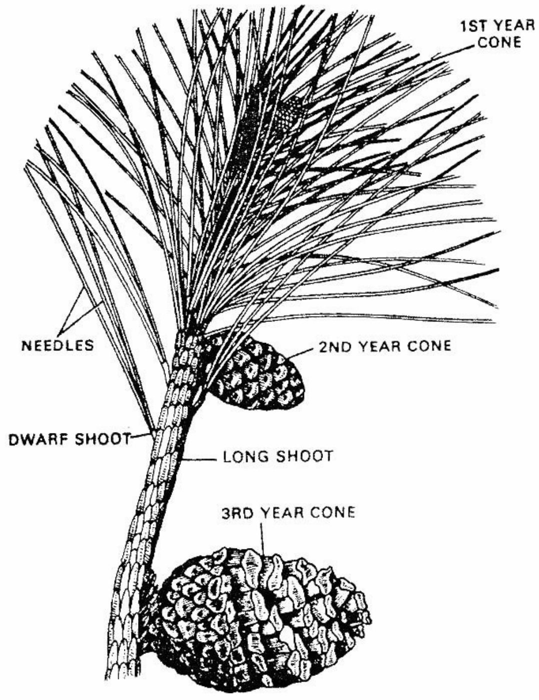
External Features

- Gymnosperms are predominatly woody plants represented by trees, shrubs (e.g., *Ephedra)* or rarely climbers.
- The main plant body is sporophyte (Bn) and is well differentiated into root, stem and leaves.
- Plants possess taproot. In some cases, roots show symbiosis with certain blue green algal cells.

- Stems are erect, branched (unbranched in most species of *Cycas)* and woody.
- Leaf scars show their characteristic presence on the stem.
- Leaves may be of one kind.
- Foligae leaves that are all invariably evergreen may be simple or compound, and Scale leaves that are minute and deciduous.
- The leaves may be few, large and pinnately compound as in *Cycas,* numerous small, simple and needle shaped as in *Pinus* or reduced and scaly as in *Ephedra.*



External morphology of *Cycus*



External morphology of *Pinus*

INTERNAL FEATURES

- Roots possess diarch to polyarch and radial vascular cylinder with exarch xylem.
- Stems are characterized by the presence of collateral and open vascular bundles arranged in a ring, with endarch xylem.
- The vessels are absent in the xylem (except in Gnetales) and the companion cells are absent in phloem..
- Secondary growth is well marked with distinct annual rings.
- Parenchymatous rays are also present.
- Hence the wood is not compact and is called *manoxylic* and *polyxylic.* e.g., *Pinus* and *Taxus* pith and cortex both are much reduced and parenchymatous rays are free.
- The foliage leaves are protected by thick layers of cuticle and sometimes by an additional waxy layer.
- Stomata are protected as they develop in the sunken cavities.
- The leaves of gymnosperms may be hypostomatic (e.g., *Cycas)* or amphistomatic (e.g., *Pinus).* Mesarch xylem and transfusion tissue (hydrostereom) occur in the leaves of most of the gymnosperms.

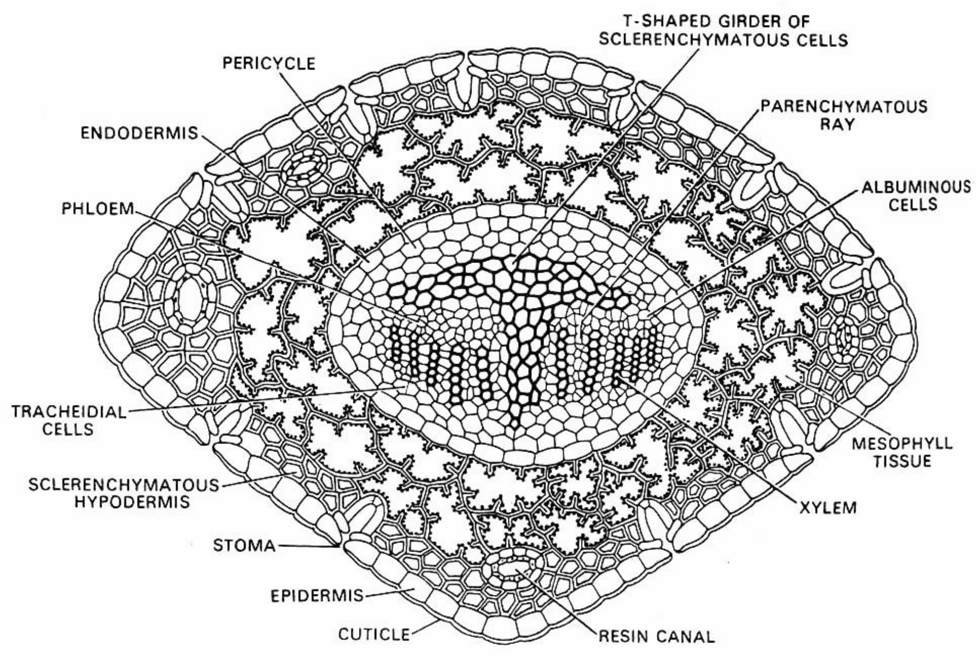


Fig. *Pinus:* Detailed cellular structure of the T.S. of needle

REPRODUCTION

- In most of the living gynmosperms (except ovulate structures of *Cycas)* reproductive organs are aggregated in the form of compact cones.
- Cones may either be male (microsporangiate) or female (megasporangiate). rarely they are bisporangiate.
- Male cones are usually short lived and smaller than female cones.
- Microsporophylls may be flat as in *Cycas* or peltate as in *Pinus.*
- Female cones are usually long lived.
- Megasporophylls may be foliar and are loosely arranged to form female strobilus (e.g. *Cycas)* or cauline and compactly aggregated to form female cones (e.g. *Pinus).*
- Microsporangia (pollen sacs) are borne on the abaxial surface of microsporophylls.
- They may be numerous and grouped in sori as in ferns, (e.g., *Cycas)* or reduced to two (e.g., *Pinus).*
- Megasporangia (ovules) are borne naked on the sporophyllous scales.
- They are generally **orthotropous** and covered by a single integument.
- Integument that surrounds nucellus may be differentiated into an outer fleshy (outer sarcotesta), inner fleshy (inner sarcotesta) and middle stony (sclerotesta) layers.

THE GAMETOPHYTE

- The plants are heterosporous.
- The male gameteophyte bears only one (e.g. *Cycas, Gnetum) or* two (e.g., *Pinus, Ginkgo, Ephedra*) prothallial cells.
- Pollen tube may-act-as haustorium (e.g., *Cycas*) or as sperm carrier, *e.g. Pinus.*
- The female gametophyte possesses one (e.g. *Gnetum*), two *(e.g. Pinus)* or more *(e.g. Cycas)* archegonia.
- Each archegonium possesses single egg and a ventral canal cell.
- Neck canal cells are lacking. In *Gnetum* and *Welwitschia,* no archegonia are formed.
- Pollination takes place by-direct contact of pollen grains with the ovules (anemophilous).
- Pollen grains are deposited, in the pollen chamber where they germinate.
- a pollen tube is formed due to elongation of tube cell.
- In *Cycas* and *Ginkgo,* the pollen tube is haustorial in nature.
- Fertilization (siphonogamy) takes place by the fusion of male and female nuclei resulting in the formation of zygote.
- In *Cycas* zooidiogamy as well as siphonogamy is found.

THE YOUNG SPOROPHYTE

- The development of the zygote is meroblastic part develops into an embryo while the upper (haustorial) and middle (suspensorial) parts do not participate in the formation of embryo.

- Polyembryony development of several embryos in one seed, out of which through ony one survives, is of common occurrence. e.g., *Pinus.*
- It is resulted by the formation of several zygotes or cleavage of a single embryonal mass.
- Embryo is differentiated into radicle, plumule and cotyledons.
- It is endoscopic, *i.e.,* with the shoot end (plumule) directed away from the micropyle and the root end (radicle) towards the micropyle.
- Embryo is developed at the end of long suspensor that is pushed down into the food-laden endosperm that develops before fertilization.
- Female gametophyte, soon after it has absorbed the food from nucellus, becomes the endosperms.
- as double fertilization or triple fusison does not take place, the endosperm is a haploid tissue.
- Since there is no ovary, true fruits like that of angiosperms are not found in the gymnosperm.
- Cotyledons may be one or two, e.g., *Cycas* or a whorl of many e.g., *Pinus.*
- Seeds may germinate immediately without undergoing a period of rest.
- Seed coat ruptures, radicle grows downward and develops primary taproot while the plumule grows upright and develops stem whose growth in most cases is unlimited but rarely limited e.g., *Welwitschia.*
- Sporophytic generation (diploid) is dominant and independent.
- It greatly exceeds the reduced and dependent gametophytic generation (halploid).

CLASSIFICATION

- Gymnosperms are divided into seven major taxa (divisions) by **Gifford** and F**oster** (a989).
- Three of them are extinct or occur in fossil state.
- They are Progymnospermatophyta, Pteridospermatophyta and Cycadofilicodophyta.
- Four divisions have living gymnosperms and their fossil relatives.
- They are Cycadophyta, Ginkgoaphyta, Coniferophyta and Gnetophyta.

CYCAS: LIFE CYCLE

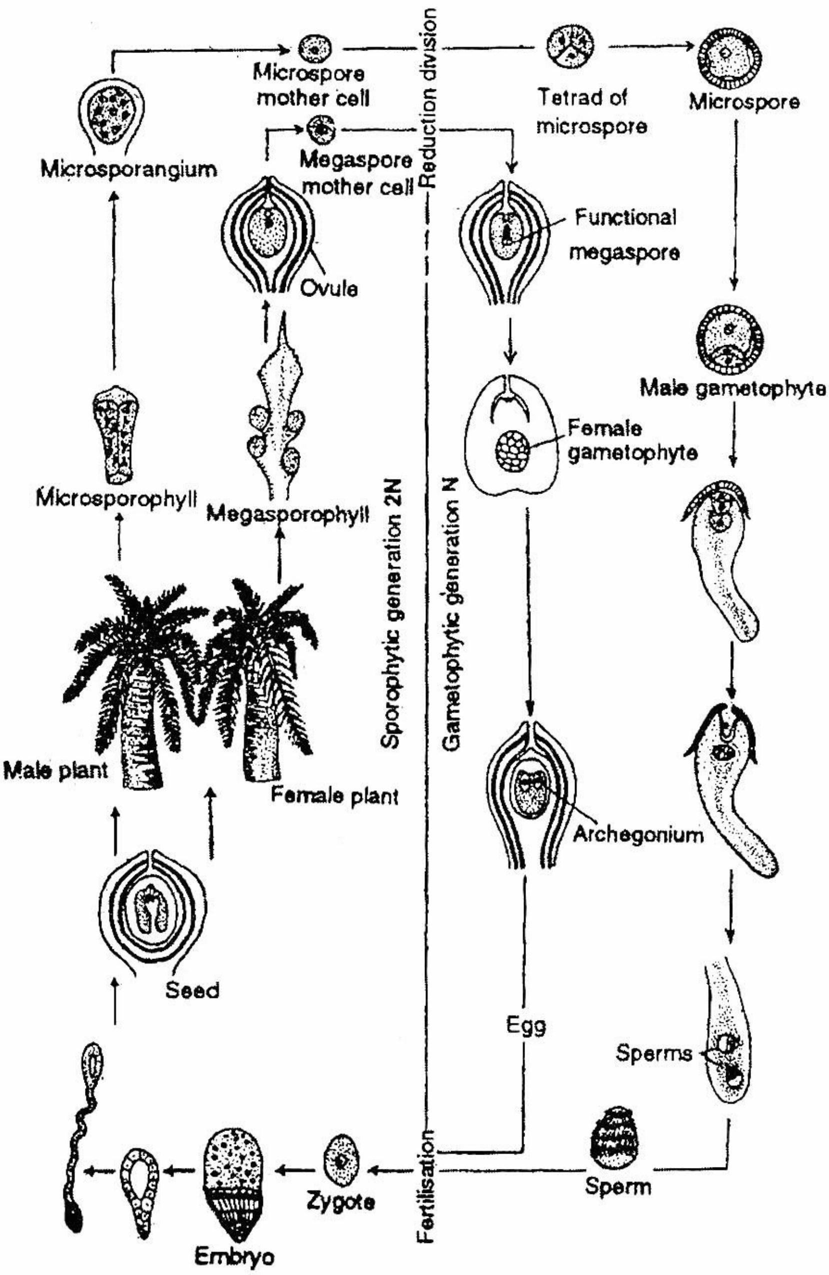
- *Cycas* is small or medium sized palm-like evergreen tree of tropical and subtropical areas of both plains and slopes of hills.
- The main plant body is sporophyte differentiated into root, stem and leaves.
- The roots are dimorphic, normal, and coralloid.
- The coralloid roots are coral like, profusely branched, spongy and dichotomously branched.
- They are apogeotropic lacking a root cap and root hair.
- The stems are aerial, erect, wood, and unbranched (caudex), except C. *rumphii.*
- They are covered by an armour of dried leaf bases.
- The leaves are also dimorphic, scaly and foliage.
- The two are borne in alternate spirals.
- Scale leaves are covered by brown ramental hairs.
- Foliage leaves are A-C m long, petiolate and unipinnate paripinnate, young leaves show circinate ptyxis.
- The reproduction in *Cycas* is of two types:

VEGETATIVE REPRODUCTION

- It takes place by bulbils formed on the stem in the axil of scale leaves.
- These break up from the parent plant and genninate to develop into new plant.

SEXUAL REPRODUCTION

- The *Cycas* is dioecious.
- Only one male cone is present at the apex of the male plant.
- Each cone has a thick central axis around which microsporophylls are spirally arranged.
- Each microsporophyll is flat, wedgeshaped, triangular structure with a pointed sterile tip called apophysis.
- On the lower or abaxial side of the sporophyll, groups of sporangia called sori are arranged.
- Each sorus consists of B-6 sporangia that are filled up with pollen grains or micros pores.



Diagrammatic representation of the life cycle of *Cycas*

- ❑ There is no female cone in *Cycas.*
- ❑ The megasporophylls arise at the apex of the female plant and are loosely arranged in a rosette manner.
- ❑ Each megasporophyll has a pinnate leaf-like structure.
- ❑ On either side of the broader part of sporophyll D–6 red coloured ovules or megasporangia are arranged.
- ❑ Each ovule is open, having a thick integument and nucellus.
- ❑ The integument is differentiated into outer sarcotesta (fleshy layer), middle sclerotesta (stony layer) and inner sarcotesta (fleshy layer).
- ❑ Deep in the nucellus of the mature ovule lies the megaspore mother cell that divides to form four megaspores.
- ❑ Out of these only one megaspore remains functional and remaining three degenerates.
- ❑ **Development of male gametophyte before pollination:**
- ❑ The microspores start germination while they are still inside the microsporangium *(in situ* germination). The microspore nucleus divides into lower smaller prothallial cell and the upper larger antheridial cell. The antheridial cell divides further to form a generative cell and tube cell. at this three-celled stage the microspores are shed from the microsporangia for pollination.

- ❑ **Pollination:** In *Cycas* pollination is anemophilous Pollination drop is secreted by the micropyle of fhe ovule. The microspores get depostted on the micropyle of the ovule being held in the pollination drop.

Due to drying of pollination drop, microspores are sucked inside the pollen chamber.

- **Development of male gametophyte after pollination:**
- Now exine breaks and intine comes out in the form of pollen tube.
- The pollen tube penetrates the nucellus and acts as a haustorium.
- The generative cell divides into stalk cell and body cell.
- The body cell divides to form two top-shaped, multiciliate spermatozoids (largest among plant kingdom).
- **Development of female gametophyte:**
- The functional megaspore is the first cell of female gametophyte.
- The megaspore nucleus divides repeatedly to form a multicellular female gametophyte or endosperm.
- Each archegonium develops from a single archegonial initial.
- Generally, C-6 archegonia develop on one gametophyte.
- Each archegonium consists of a short two-celled neck, a ventral canal cell and an egg.
- Neck canal cells are absent.
- **Fertilization:**
- It is siphonogamous i.e., spermatozoids are carried by pollen tube.
- The spermatozoids are released into the archegonial chamber.
- One spermatozoid is released into the archegonial chamber.
- One spermatozoid is drawn into the archegonium.
- The cilia and membrane of spermatozoid are shed and cytoplasm and nucleus fuses with the egg forming zygote or oospore.
- **Development of embryo:**
- The diploid nucleus of oospore divides repeatedly.
- The wall formation starts from periphery to centre to form a multicellular proembryo.
- The proembryo consists of upper haustorial region (which absorbs food from endosperm)
- Embryo consists of radicle, plumule, two cotyledons, haustorium and suspensor.
- In *Cycas* polyembryony is often seen as egg of almost all the archegonia are fertilized that produce embryos.

PINUS: LIFE CYCLE

- The *Pinus* is monoecious *i.e.,* both male and female cones are borne by the same plant.
- It is heterosporous producing microspores and megaspores in microsporangia and megasporangia respectively.
- Each male cone has a central cone axis around which many microsporophylls are spirally arranged..
- Each female cone consists of many megasporophylls, arranged spirally around the cone axis.

- The bract scales are arranged spirally around the cone axis.
- On the upper side of the bract scale, a thick, large, woody and somewhat triangular ovuliferous scale is present.
- at the base of each ovuliferous scale, two sessile ovules are present.
- Each ovule is elongated and consists of nucellus, surrounded by a single integument made of three layers.
- Within the nucellus lies the megaspore mother cell that divides to form four megaspores.
- Out of these only one megaspore is functional and the other three degenerate.

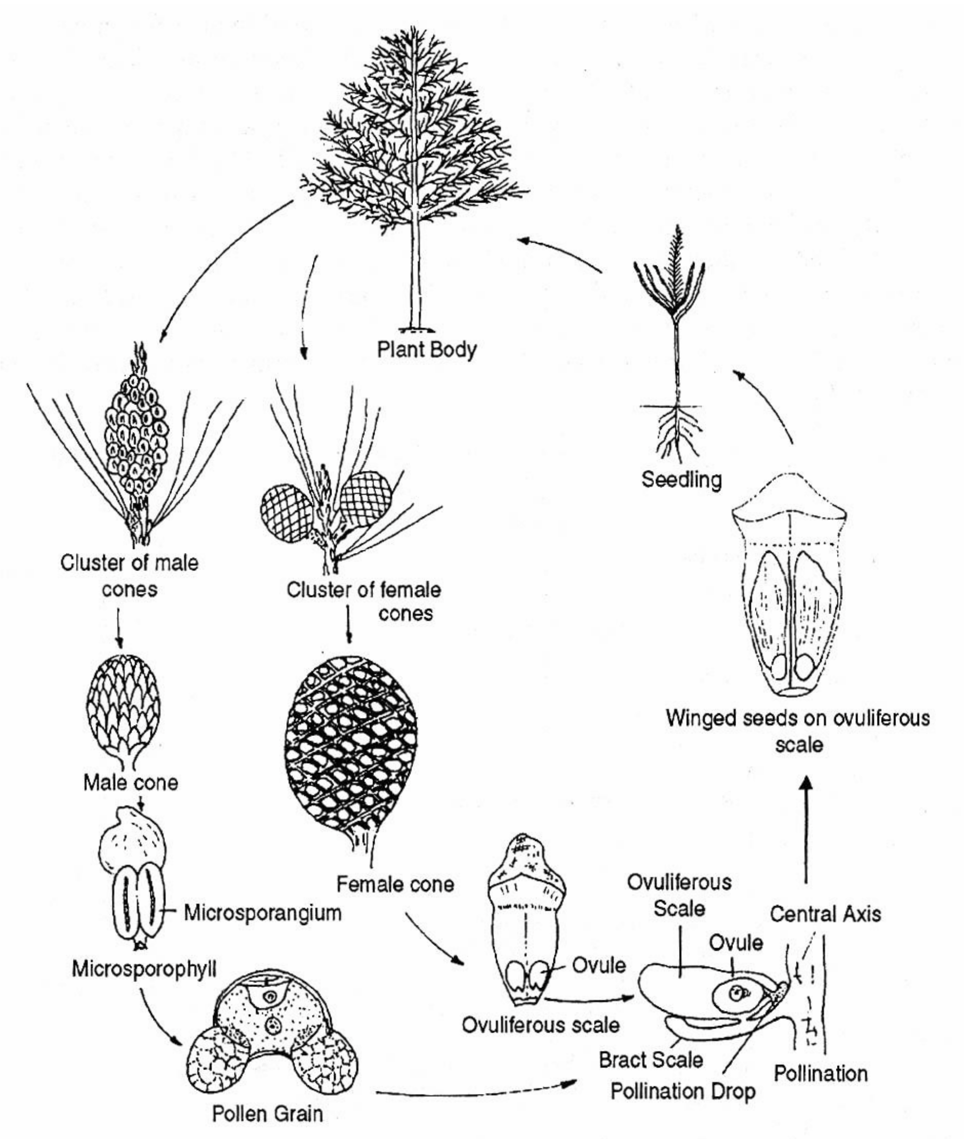


Fig. Diagrammatic representation of the life cycle of *Pinus*

Male gametophyte:

- The microspore is the pioneer stage of male gametophyte.
- It starts germination, within the microsporangium.
- The nucleus of microspore divides into two, first prothallial cell and a large apical cell.
- The apical cell again divides to form second prothalial cell and antheridial cell and tube cell.
- At this four-celled stage microspores are shed from the microsporangium for pollination.

Pollination:

- In *Pinus* pollination is anemophilous type.
- The pollen grains or microspores reach the ovule through the agency of the wind.
- The pollen sacs burst, and the winged pollen grains are blown about by the wind like a yellow cloud of dust that is also called **sulphur shower.**

Development of male gametophyte after pollination:

- Pollen germinates in pollen chamber of ovule.
- Each pollen grain or microspore consists of two prothallial cells, generative cell and a tube cell.
- The exine of microspore burst and intine comes out in the form of a pollen tube.
- The generative cell divides into stalk cell and body cell.
- The body cell divides and produces two male gametes.
- The male gametes are oval and not ciliate.

Development of female gametophyte:

- By repeated divisions of functional megaspore, female gametophyte is formed.
- at the micropylar end of female gametophyte B-5 archegonia are formed.
- Each archegonium consists of eight neck cells arranged in two tiers of four each and a venter having a ventral canal cell and a large egg.
- Neck canal cells are absent.

Fertilization:

- The pollen tube bursts at the apex and the two male gametes are liberated.
- The nucleus of the functional male gamete unites with that of the egg to accomplish fertilization.

Development of embryo:

- Development of embryo is meroblastic and first a proembryo of a6 cells arranged in D tiers, is formed. These D tiers from base are called the embryo tier, the suspensor tier, the rosette tier

EXERCISE

1. algae differ from bryophytes in possessing
(A) aerobic respiration
(B) chlorophyll a and b
(C) sex organs covered with sterile covering
(D) naked sex organs

2. Red snow is caused by which of the following in alpine region
(A) *Hematococcus*
(B) *Oscillatoria*
(C) *Volvox*
(D) *Lyngbya*

3. The female reproductive structure in Rhodophyceae is
(A) Oogonium
(B) Archegonium
(C) Carpogonium
(D) None of these

4. A red alga, which is not red in colour is
(A) *Polysiphonia*
(B) *Gracilaria*
(C) *Batrachospermum*
(D) None of these

5. Which among the following algae is used in space programme to regulate the supply of oxygen
(A) *Ulothrix*
(B) *Oedogonium*
(C) *Chara*
(D) *Chlorella*

6. Movable structure is not found in
(A) *Ulothrix*
(B) *Chlamydomonas*
(C) *Nostoc*
(D) *Volvox*

7. *Spirogyra* differs from *Rhizopus* in having
(A) Uninucleate gametangia
(B) Multicellular g ametes
(C) Single celled gametangia
(D) Sexual reproduction

8. Gametes are motile in
(A) *Rhizopus*
(B) *Anabaena*
(C) *Cladophora*
(D) *Nostoc*

9. When several male gametes cluster around a passive female gamete in algae, this phenomenon is known
(A) Heterospory
(B) Clump formation
(C) Isogamy
(D) Oogamy

10. In which of the following groups would you place a plant, which produces spores and embryos but lacks seeds and vascular tissues
(A) Angisoperms
(B) Gymnosperms
(C) Pteridophytes
(D) Bryophytes

11. The leaves surrounding the antheridial cluster are known as
(A) Perigonial leves
(B) Perichaetial leaves
(C) Foliage leaves
(D) Scale leaves

12. Which one of the following is gametophytic?
(A) Spore mother cell
(B) Elater mother cell
(C) Calyptra
(D) Elater

13. apophysis is the
(A) Lower portion of the capsule
(B) Middle portion of the capsule
(C) Upper portion of the capsule
(D) None of the above

14. In *Funaria*, which of the following is helpful in dispersal of spores
(A) Apophysis (B) Columella
(C) Trabeculae (D) Peristome

15. Chloroplast is present in the spores of
(A) *Riccia* (B) *Marchantia*
(C) *anthoceros* (D) *Funaria*

16. Elater mechanism for spore dispersal is exhibited by
(A) *Riccia* (B) D*ryopteris*
(C) F*unaria* (D) *Mrchantia*

17. *Funaria* and *Marchantia* differ from each other because *Funaria* posses
(A) Ventral canal cell (B) Foot
(C) Calyptra (D) Protonema

18. Gametophyte generation is dominant in
(A) Pteridophytes (B) Bryophytes
(C) Angiosperms (D) Gymnosperms

19. Rhizophore of *Selaginella* is
(A) Root (B) Stem
(C) Organ sui generis (D) None of these

20. Prothallus is monoecious (homothallic) in
(A) *Marsilea* (B) *Salvinia*
(C) *Azolla* (D) *Adiantum*

21. In ferns large photosynthetic leaves are called
(A) Sori (B) Fronds
(C) Indusium (D) Ramenta

22. Which of the following venation is characteristic of fern?
(A) Parallel (B) Open furcated
(C) Dichotomous (D) Reticulate

23. A fern differs from moss in having
(A) An independent gametophyte (B) An independent sporophyte
(C) Swimming antherozoids (D) Archegonia

24. AC-celled male gametophyte in *Selaginella* is
(A) A0 cells of antheridium + C prothallial cells (B) AB cells of antherdium + a prothallial cell
(C) 9 cells of antheridum + D prothallial cells (D) 7 cells of antherdium + 6 prothallial cells

25. The wood is porous and loose due to presence of large amount of parenchyma and broad medullary rays. It is called as
(A) Manoxylic (B) Monoxylic
(C) pycnoxylic (D) None of these

26. In gymnosperms archegonia lack
(A) Neck canal cells (B) Venter canal cell
(C) Both (D) None of these

27. Gymnosperms resemble angiosperms in having
(A) Vessels (B) archegonia
(C) Ovules (D) Ovary

28. Gymnosperms differ from angiosperms in having
(A) Haploid endosperm (B) Diploid endosperm
(C) Triploid endosperm (D) Tetraploid endosperm

29. 'Monkey puzzle' is common name of
(A) *Pinus roxburghii*
(B) *Cedrus deodara*
(C) *Araucaria imbricata*
(D) *Cycas revolute*

30. The wood of old *Cycas* stem is
(A) Diploxylic
(B) Monoxylic
(C) Monoxylic and manoxylic
(D) Manoxylic and polyxylic

31. Which character in a *Cycas* leaf indicates its xerophytic nature?
(A) Epidermis with thick cuticle
(B) Presence of sunken stomata
(C) Well developed xylem
(D) All the above

32. In *Cycas* male gametes are produced in the pollen tube by the division of which of the following cell
(A) Body cell
(B) Stalk cell
(C) Tube cell
(D) Prothallial cell

33. Largest ovule is of
(A) *Pinus*
(B) *Gnetum*
(C) *Cocos*
(D) *Cycas*

34. Which of the following structures in *Pinus* are haploid
(A) Megaspore, integument, root
(B) Endosperm, megaspore, pollen grain
(C) Pollen grain, leaf, root
(D) Megaspore, endosperm, and embryo

35. P3roembryo of *Pinus* is
(A) Two tiered
(B) Three tiered
(C) Four tiered
(D) Five tiered

36. In the embryo of *Pinus*, the rosette tier lies
(A) Between the suspensor their and embryonal tier
(B) Above the nutritive tier
(C) Between the nutritive tier and suspensor tier
(D) Below the embryonal tier

37. Sea weeds are generally
(A) phaeophyceae and rhodophyceae
(B) chlorophyceae and phaeophyceae
(C) chlorophyceae and rhodophyceae
(D) phaeophyceae and Bacillariophyceae

38. Structure common among Bryophyta, Pteriodophyta and Gymnosperm is
(A) Antheridium
(B) Motile male gamate
(C) Archegonium
(D) Both antheridia & archegonia

39. Leaves are photosynthetic as well as "reproductive" in
(A) *Funaria*
(B) Gymnosperms
(C) *Dryopteris*
(D) None of these

40. Which of the following causes "Sulphar shower"?
(A) Moss
(B) Fern
(C) *Pinus*
(D) *Cycas*

41. Rhodophyceae is called red algae because of the pigment
(A) Fucoxanthin
(B) Phycoerythrin
(C) Carotenoids
(D) Chlorophyll c

42. Which of the followings plant material is an efficient water imbibant?
(A) Agar
(B) Cellulose
(C) Lignin
(D) Pectin

43. In a monoecious plant
(A) Male and female sex organs are on the same individual
(B) Male and female gametes are of two morphologically distinct types
(C) Male and female sex organs are on different individuals
(D) All the stamens are fused to form one unit

44. Isogamous condition with non-flagellated gametes is found in
(A) Chlamydomonas
(B) Spirogyra
(C) Volvox
(D) Fucus

45. Gymnosperms produce neither flower nor fruit because they do not possess
(A) Embryo
(B) Ovary
(C) Ovule
(D) Seed

46. Rhodophyceae is called red algae because of the pigment
(A) Fucoxanthin
(B) Phycoerythrin
(C) Carotenoids
(D) Chlorophyll c

47. The gametophyte is not an independent, free-living generation in
(A) Pinus
(B) Polytrichum
(C) adiantum
(D) Marchantia

48. antheridia and archegonia are sex organs of
(A) Moss
(B) Mucor
(C) Spirogyra
(D) Puccinia

49. Bryophytes are called amphibians of plant kingdom because
(A) These plants live in soil and depend on marine organisms for asexual reproduction.
(B) These plants live in soil and depend on water for sexual reproduction.
(C) These plants live in water and depend on land animals for sexual reproduction.
(D) These plants live near water bodies.

50. Which one of the following is a vascular cryptogram?
(A) Cedrus
(B) Equisetum
(C) Ginkgo
(D) Marchantia

ANSWER KEY

1	(D)	**2**	(A)	**3**	(C)	**4**	(C)	**5**	(D)
6	(C)	**7**	(A)	**8**	(C)	**9**	(B)	**10**	(D)
11	(A)	**12**	(C)	**13**	(A)	**14**	(D)	**15**	(A)
16	(D)	**17**	(D)	**18**	(B)	**19**	(C)	**20**	(D)
21	(B)	**22**	(B)	**23**	(B)	**24**	(B)	**25**	(A)
26	(A)	**27**	(C)	**28**	(A)	**29**	(D)	**30**	(C)
31	(D)	**32**	(A)	**33**	(D)	**34**	(B)	**35**	(C)
36	(C)	**37**	(A)	**38**	(C)	**39**	(C)	**40**	(C)
41	(B)	**42**	(A)	**43**	(A)	**44**	(B)	**45**	(B)
46	(B)	**47**	(A)	**48**	(A)	**49**	(B)	**50**	(B)