CHAPTER 4

PLANT KINGDOM

Topics Discussed

1. Introduction

The food that we eat comes from the plants and trees. Basically all the green creatures on earth produce food that can be used by consumers. This green world is too big to study and discover. Thus the need for classification of this green creatures to understand them, know their use for human welfare. The organisms were classified in many kingdoms by various naturalist. The classification basis also changed each time. Plant kingdom is the kingdom of organisms that have chlorophyll pigment in the leaves. This kingdom includes class algae, bryophytes, pteridophytes, gymnosperms and angiosperms. All the class will have detailed characteristics and specific features being described in detail.The life cycle changes in the group and also individuals which is also discussed.

All the classification systems from Aristotle to present are broadly divided in two classifications:

- Historical classification: The systems from Aristotle to Candolle.
- Modern classifications: The classification pattern from Bentham to present time.

Objectives of this Chapter

At the end of this chapter, you will be able to:

- Establish the interrelation between plant species.
- Evaluate each phylum with their common features and characteristics.
- Review the plants clearly with better knowledge of the kingdom.

2. Plant Classification System

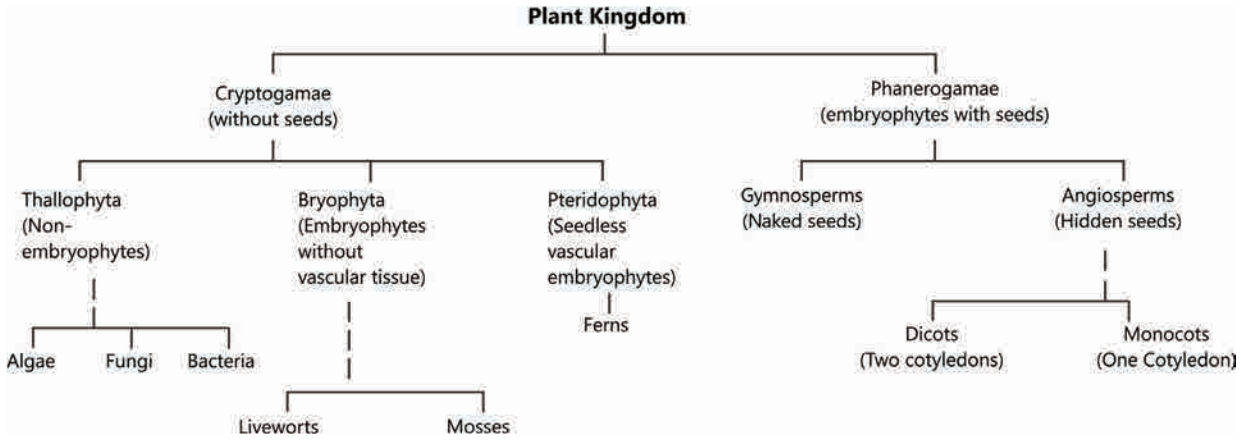
Traditionally, all the organisms in plant kingdom were divided into two sub-kingdoms named as phanerogames and cryptogames.

(i) Cryptogamae (kryptos-concealed, gamos-marriage): This kingdom includes all non-flowering plants e.g. algae, fungi lichen, mosses and ferns. There are three divisions of cryptogams namely thallophyta, bryophyte and pteridophyta.

(ii) Phanerogamae (phaneros-visible, gamos-marriage): This kingdom accumulates all flowering and seed bearing plants. The kingdom is also known as spermatophytes (sperma-seed, phyton-plant), since they produce seeds. These seed bearing plants are further divided into two divisions' gymnospermae and angiospermae. The division basis is the seed or ovule covering which is present in angiosperm as fruit or ovary and absent in gymnosperms.

2.1 Early Attempts for Classification

Aristotle with his Greek philosophers divided all the living organisms into two main groups: plants and animals. Aristotle further divided plants into 3 classes-herbs, shrubs and trees. Charaka also called the father of Ayurveda, in 1st century A.D., included 200 kinds of animals and 340 kinds of plants in his writings 'Charaka Samhita'.



Flowchart 4.1: Branches of Plant Kingdom

2.2 Artificial System of Classification

The basis of classification was on the few morphological characters in the vegetative nature, e.g., early systems of classifications by Aristotle, Theophrastus, Pliny, Bauhin, Linnaeus etc. Artificial classification was first given by Theophrastus for plants.The basis of grouping was habitat and the class were herbs, shrubs, undershrubs and trees.

Carolos Linnaeus (1707-1997) proposed the Sexual System of classification which was an artificial system. The basis of classification was the nature and number of stamens and carpels in a plant.

Classification by Linnaeus consisted of 24 classes, in which 23 classes included flowering plants (Phanerogamae) and 24th class had non-flowering plants (Cryptogamae). Details of this classification were published in Genera Plantarum (1737).

Total 24 classes given by Linnaeus were: Monandria, Diandria, Triandria, Tetrandria, Pentandria, Hexandria, Heptandria, Octandria, Enneandria, Decandria, Dodecandria, Icosandria, Polyandria, Didynamia, Tetradynamia, Monadelphia, Diadelphia, Polyadelohia, Syngenesia, Gynandria, Mcnoecia, Dioecia, Polygamia and Cryptogamia.

Drawbacks

- This system was based on less number of characters, hence the diverse animals or plants were grouped together in few groups.
- Natural affinities and phylogenetic relationships did not make place in the classification.
- The artificial system rated vegetative and sexual characters of plants with equal weightage which was not acceptable. The reason being the vegetative characters more prone to environmental changes.

2.3 Natural System of Classification

This is horizontal system of classification or 2 D system. The basis for classification is natural affinities. There are several taxonomic characters used as possible to classify organisms. This classification is mainly based on organism forms, relationship realising all information available at the time of collection of plants, internal features like ultrastructure, anatomy, embryology and phytochemistry.

The natural systems were proposed with several basis, major ones was from John Ray, de Jussiaeu, de Candolle, Bentham and Hooker etc. George Bentham and J.D. Hooker classified plants specifically angiosperms and published it in three volumes of ‘Genera Plantarum’. They described 202 families on the basis of their detailed studies and dissections. This system is followed in all British Commonwealth countries including India.

2.4 Phylogenetic System of Classification

Lamarck coined phylogeny and the concept of phylogeny came from E. Haeckel. Phylogeny is the evolutionary history of the organism. This system is named as ‘3D’ or vertical system also. In this system, plants are classified according to their evolutionary and genetic affinities. There is a common ancestor for the organisms that belong to same taxa which is easily represented in the form of family tree called Cladogram.

A.W. Eichler modified Bentham and Hooker's system of classification and placed gymnosperms in the beginning of chart. He is also called as the pioneer of phylogenetic system of classification.

Adolph Engler and Karl A.E. Prantl, two german botanists, adopted their system in "Die Naturalichen Pflanzen Familien" (1887-1915). The work was in 23 volumes in german language later being translated in English.

Merits: In this system families are arranged in increasing complexity of flowers.

Demerits: Monocots were considered primitive to dicots.

According to this system, primitive forms that had naked flowers were kept initially. The more advanced families have distinct perianth.

Hutchinson, Oswald Tippo, also proposed phylogenetic systems of classification.

John Hutchinson, an English botanist, proposed phylogenetic classification and published in a famous book 'Families of Flowering plants' in 1959.

In Hutchinson's classification:

(i) Trees and shrubs were believed to be more primitive than herbs.

(ii) Dicots were thought as more primitive than monocots.

(iii) Polypetalous, actinomorphic and solitary flowers are considered more primitive than gamopetalous, zygomorphic and inflorescences respectively.

The divisions include orders that include families. Division does not include classes.

3. Branches of Taxonomy

3.1 Classical Taxonomy

The basis of classification was natural affinities. These affinities or relationships indicate all information available at the time the plant sample was collected, e.g., natural systems of classification.

3.2 NumericalTaxonomy/Phenetics/Taximetrics/Adansonian Taxonomy

The numerical methods was used to evaluate the similarities and differences between the species. For this, all characters are assigned number and codes. Then, all possible characters are compared by sophisticated calculating machines and computers without giving emphasis on a particular character. All characters that were analysed are equally important. The organization and analysis of data forms the core of this taxonomy. The family tree prepared of the phenetics basis is called dendrogram.

3.3 Cytotaxonomy/Karyotaxonomy

Cytological information of the cell, chromosome number, structure and behaviour of chromosomes during meiosis is the basis for classification.

3.4 Biochemical (Chemotaxonomy)

It is related with the plant chemical properties, for example, aromatic compound giving fragrance, specific crystal structures of calcium oxalate (raphides) or calcium carbonate (cystolith) being present. The sequencing of DNA and chemical nature of proteins have also been used in this taxonomy.

Taxonomy is divided into three types by Turril.

- α (Alpha) Taxonomy: The collection and identification of organism is the basis of gross morphology.
- β (Beta) Taxonomy: The collection and identification of organism on the basis of morphology as well as all the possible evidences from cytology, anatomy, physiology and genetics.
- ω (Omega) Taxonomy: The basis is microscopic observation and biochemical evidences.

Try It Yourself

Provide one word for the taxonomic study that uses chemical constituent of the plants to resolve confusion.

1. _____ is based upon natural affinities among the organisms.
2. _____ system of plant classification was based on androecium structure.
3. The book “Families of Flowering Plants” was written by _____

The Classification System of Plant Kingdom

- Thallophyta
- Bryophyta
- Pteridophyta
- Gymnosperms
- Angiosperms.

4. Class Thallophyta or Algae

The branch of science that deals with algae is called algology or phycology.

The main characteristics of algae are:

- Usually aquatic, found in marine and fresh water, even on moist stones, soil and wood.
- Starch is the reserve food.

- Vascular tissues are absent. As they live in water, its conduction is a waste even for giant forms.
- Nutrition mode is autotrophic.
- Vegetative reproduction by means of fragmentation.
- Reproduction is with asexual mode by means of Mitospores like – Zoospores, Aplanospores, Hypnospores, Akinetes, and Palmella stage.
- Sex organs are non-jacketed, unicellular or multicellular (e.g., *Chara*) and each reproductive cell is fertile.
- Sexual reproduction is through the gametic fusion which can be isogamy, anisogamy and oogamy in different groups.
- Life cycle may be-haplontic, diplontic or diplohaplontic.

KNOWLEDGE BUILDER

Flowchart 4.1: Division of Algae

F.E.Fritsch (1935) in his book Structure and Reproduction of the Algae proposed a partial and sound classification of algae. Algae were divided in 11 classes on the basis of pigmentation, reserve food, flagellation, thallus structure and mode of reproduction.

KNOWLEDGE BUILDER

Kingdom Plantae of Whittaker (1969) includes mainly these types of algae- red algae, brown algae and green algae.

Table 4.1: Characteristics of some algae

Name of algae	Photosynthetic pigments		Cell wall	Type of reserve food	Flagella
	Chlorophyll	Other			
Red algae (Rhodophyceae)	*a* + *d*	Phycobilins (Phycoerythrin and Phycocyanin)	Cellulose and agar	Floridean starch	Absent
Brown algae (Phaeophyceae)	*a* + *c*	Fucoxanthin	Cellulose and algin	Laminarian starch, mannitol	2, Heterokont laterally inserted
Green algae (Chlorophyceae)	*a* + *b*	Beta-carotene and other carotenoids	Cellulose	Starch	2-8, Isokont & anterior position

4.1 Red Algae – Rhodophyceae

- Marine (in warmer areas) water growing in deep waters and surface waters.
- Autotrophic.
- Non-motile and hence no flagellate stage.
- The plant body varies from unicellular (e.g., *Porphyridium*), filamentous (e.g., *Asterocystis*), parenchymatous sheets (e.g., *Porphyra*), ribbons (e.g, *Chondrus*) to graceful lace-like sea weeds (e.g., *Gelidium*).
- Cell wall is made of cellulose, pectic compounds and sulphated polysaccharides that is called as phycocolloids. The important phycocolloids of Rhodophytes are agar and carrageenan.

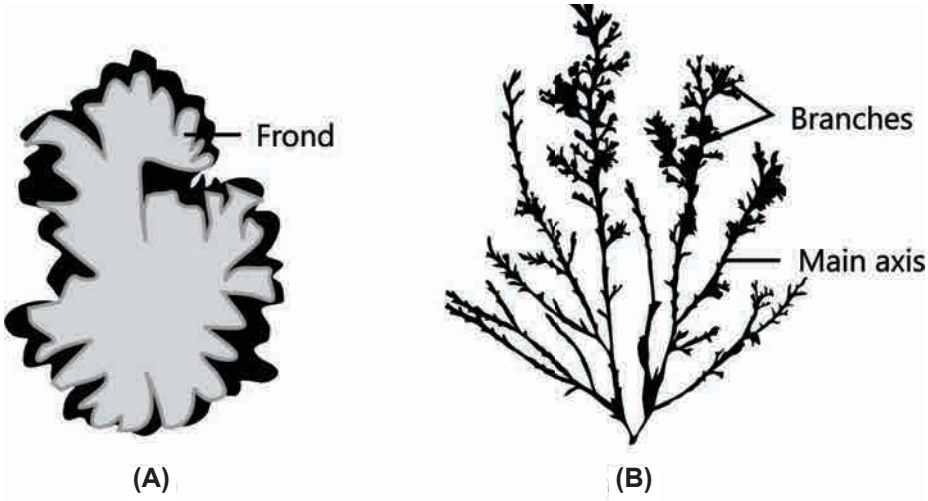


Figure 4.1: Red algae growing **A.** In clusters and **B.** A part showing main axis and branches

- The photosynthetic organelles unstacked or free thylakoids that are called as chromatophores.
- Photosynthetic pigments in red algae are chlorophyll *a*, *d*, carotenoids and phycobilins. Phycobilins are water soluble pigments like, red coloured phycoerythrin, blue coloured phycocyanin and allophycocyanin (similar pigmentsalso occur in blue green algae).
- Reserve food is in the form of floridean starch (in constitution, it is very much similar to glycogen). Soluble galactoside glycerol - fluoridoside is also found.
- The algae has its colour due to presence of phycoerythrin. It absorbs blue green wavelengths of light. These light are found in deep water because of their shorter wavelengths. Therefore, red algae are found to be growing in deep sea where photosynthetic organisms are unable to grow. However, rhodophytes are living in shallower water also where they have presence of normal light hence they do not synthesize much phycoerythrin that causes the red colour. They are greenish, violet or purplish on the surface water (e.g., *Batrachosperum* is bluish green in colour).
- Fragmentation constitutes vegetative reproduction.
- Asexual reproduction occurs with many non-motile spores like neutral spores, monospores, tetraspores, carpospores etc.
- Sexual reproduction is through oogamous formation which is highly advanced mode. Once the zygote is formed there is complex post fertilization changes that occur. The male sex organ is called spermatangium or antheridium which produces spermatium (non-flagellate male gamete). The female sex organ is called as carpogonium which is flask-shaped. Carpogonium possesses an elongated neck like receptor trichogyne. Spermatia are carried by water currents to trichogyne tips for affecting fertilization.

- Alternation of haploid and diploid multicellular generations occur in many algae.

Economic importance

- **Phycocolloids:** They include agar, carrageenan and funori. Agar is extracted from *Gelidium* and *Gracilaria*. Agar forms the solidifying laboratory culture media that is used for microbes. Also it is added as stabiliser or thickener in the industrial preparation of jellies, puddings, creams, cheese, bakery, etc. Carrageenan has clearing properties and thus is used in liquors, leather finishing and as emulsifier in chocolates, ice-creams, toothpastes, paints etc. It is extracted from *Chondrus*. Funori is a glue, used as adhesive and is sizing textiles, paper etc. It is obtained from *Gloiopeltis*.
- **Food:** Many red algae are edible, e.g., *Porphyra* (Laver), *Rhodymenia* (Dulse), *Chondrus* (Irish moss). *Rhodymenia* (also called sheep's weed) is also used in feeding animals.

Did You Know

Batrachosperum is a fresh water red algae.

Some red algae have deposits of $CaCO_3$ on their body surface, like *Corallina*, these contribute to coral reef formation.

Harveyella is a parasitic, colourless red algae.

4.2 Brown Algae - Phaeophyceae

- Marine habitat.
- The body has great variation in size and form. All of them are multicellular. The body may have a branched filamentous structure in lower forms (e.g., *Ectocarpus*) while parenchymatous structure in higher forms (e.g., *Saragassum*, *Laminaria*, *Fucus*, and *Macrocystis*).
- Brown algae have the largest algae among all. The large brown algae are called kelps having a height of 100 m. *Macrocystis* and *Nereocystis* are largest kelps.

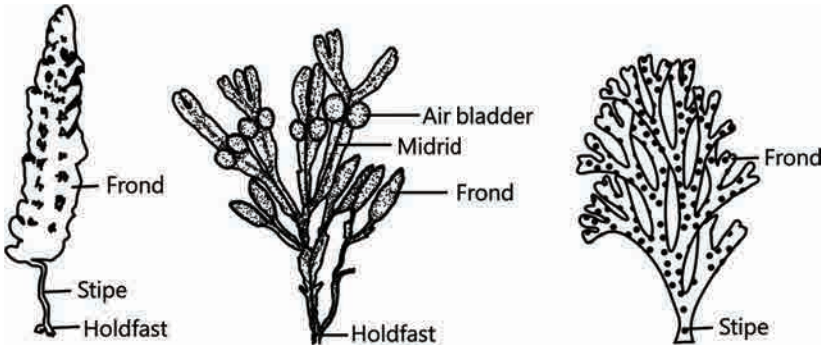


Figure 4.2: Brown algae showing differences among them.

Table 4.2: Characteristics of Brown Algae

Number	2000 species of multicellular organisms. Largest species are kelps, having size of 60-100 meters. Unicellular forms are absent.
Habitat	Marine water, on rocks in tidal zone
Appearance	Prominent brownish sea weeds with green touch.
Size	60-100 meters long
Pigment	Chlorophyll *a* and *c*, fucoxanthin (brown colour)
Colour	Brownish green
Storage product	Laminarin starch and mannitol
Flagella	Normal
Cell wall	Inner cellulose layer and outer mucilaginous layer, phycocolloid like algin forming gelatinous layer
Reproduction	Fragmentation, Sporulation, Isogamy, Anisogamy, and oogamy
Examples	*Sargassum*, *Dictyota, Ectocarpus*

- The plant body shows hold fast (for attachment), stipe (stalk) and lamina (frond leaf like photosynthetic organ). *Saragassum* and *Fucus* species are free floating. Free floating forms get attached to the bottom part of ships thus causing problem. The large forms have air vesicles or bladders on the surface for providing buoyancy.
- Phycocolloids prevents desiccation in low tide, freezing when temperature is low and injury against rock clashing. The brown colour of algae is due to the presence of large amount of xanthophyll called fucoxanthin.
- Cells contain refractile vesicles called as the fucosan vesicles. The vesicles contain a phenolic chemical named fucosan. Fucosan is colourless inside water but becomes brown or black on exposure to air.
- Conducting tubes or trumpet hyphae to transfer food from lamina to holdfast are present in larger brown algae or kelps.
- Vegetative reproduction occurs through fragmentation (e. g., *Sargassum*), adventitious branches, stolons (e.g., *Dictyota*) etc.
- Asexual reproduction occurs with the help of both motile and non-motile spores. The motile spores are zoospores having pear shaped heterokont flagellation with one smooth whiplash flagellum and the other similar to tinsel type (hairy). These are laterally inserted. Spores in Phaeophyceae are produced in different types of sporangia:

- Unicellular sporangia- Biflagellate zoospores are produced meiotically. These zoospores (n) then produce haploid plant or gametophyte after germination.
- Plurilocular or neutral sporangia- Diploid plants are the surfaces on which these multicellular sporangia are produced. Zoospores (2n) are formed by mitosis in large number and on germination gives rise to diploid plants.
- Sexual reproduction includes isogamy, anisogamy and oogamy.
- Gametes are non-motile in isogamy and anisogamy.
- Some brown algae show isomorphic alternation of generations, e.g., *Ectocarpus, Dictyota*. Haploid and diploid generations have similar structure. Dominant phase is diploid generation or phase. The haploid generation or phase is either microscopic or represented by gametes only (e.g., *Fucus* and *Sargassum*). Heteromorphic alternation of generation is found in *Laminaria*.

Did You Know

Saragassum species (gulf weed) in North Atlantic ocean are floating on the sea surface that cover a large area. This area is popularly called as Sargasso sea.

Economic importance

- Iodine: *Fucus* and *Laminaria* contain rich amounts of iodine while *Macrocystis* and *Nereocystis* contain abundant potash.
- Medicines: Sodium laminarin sulphate produced from *Laminaria* is used as blood anticoagulant. *Durvilea* has worm expelling properties.
- Food: A number of brown algae are food supplements in some countries, e.g., *Laminaria* (Kombu), *Macrocystis, Sargassum* and *Alaria* (Sarumen). The edible brown algae are also used as fodder.
- Alginic acid: It is phycocolloid which is obtained commercially from a number of brown algae including the giant ones (e.g., *Laminaria, Macrocystis, Nereocystis, Fucus, Sargassum*). Alginic acid and its salts are used in forming emulsions (ice creams, ointments, tooth pastes, Cosmetics, creams, shampoos, etc.), sizing textiles, flame proof plastics and sound proofing.

4.3 Green Algae – Chlorophyceae

Table 4.3: Characteristics of Green Algae

Number	7000 species of green algae live in this world. Largest are kelps having size of 60-100 meters. Unicellular forms are absent.
Habitat	Marine water, fresh water.
Appearance	Variety of shapes are there with greenish shade.
Size	Varying sizes from unicellular ones to large kelps.
Pigment	Chlorophyll *a* and *b*, carotene and xanthophylls
Colour	Green
Storage product	Pyrenoid: central protein and outer starch
Flagella	Present in motile species
Cell wall	Cellulose in microfibril is inner layer while pectone is outer layer
Reproduction	Isogamy, Anisogamy, and Oogamy
Examples	*Chlorella, Chlamydomonas, Volvox*

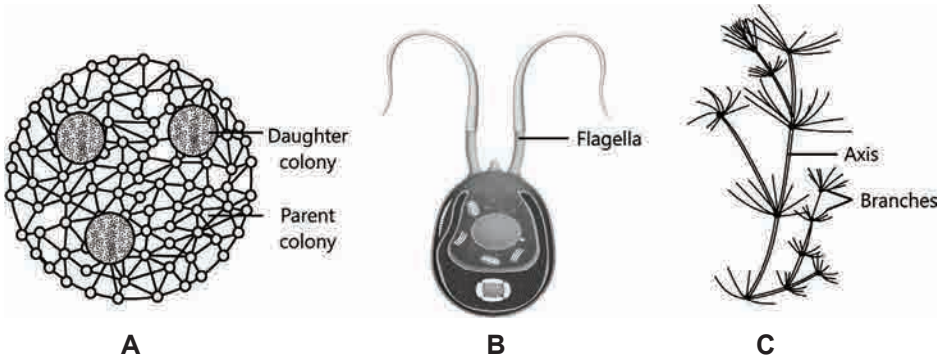


Figure 4.3: Image showing green algae. **A.** A colony of growing algae, **B.** Algal cell with flagella and **C.** Its branches and axis

- Chloroplast include variety of shapes like: Spiral in *Spirogyra*, Star shaped in *Zygnema*, Cup shaped in *Chlamydomonas*, Girdle / Horse shoe shaped in *Ulothrix* and Discoid in *Chlorella*.
- Fragmentation forms vegetative reproduction.
- Asexual reproduction occurs with formation of flagellated spores. The common asexual organs are zoospores, aplanospores, hypnospores, akinetes, autospores, etc.
- Life cycle has three phases in green algae –Haplontic, Diplontic and Diplohaplontic.
    - In haplontic life cycle, haploid condition of the chromosome is dominant phase. Zygotic meiosis occurs, e.g., *Ulothrix, Spirogyra*, and *Chlamydomonas*.

- In diplontic life cycle, the chromosome has diploid condition as the dominant phase in the alga. Haploid gametes are formed through meiosis (gametic meiosis, e.g., *Caulerpa*).
- In haplodiplontic life cycle, fully developed multicellular haploid and diploid thallus occurs. Sporic meiosis is the specific characteristic here, e.g., *Ulva*, *Cladophora*.

Knowledge Builder

Based upon habitat green algae may be:

Table 4.4: Characteristics of Green Algae based on Habitat

General name	Specific name	Habitat
Cryophyte	*Chlamydomonas nivalis*	Snow
Endozoic (inside body of animals)	*Zoochlorella*	Inside *Hydra*
Epizoic (on the surface of animals)	*Characium*	Crustaceans, Cladophora on molluscan shells
Symbiotic	*Trebouxia and Trentepohlia*	Lichen
Parasitic	*Cephaleuros sps*	Causing red rust of tea and coffee

Green algae have various forms of Thallus:

Table 4.5: Examples of Green Algae

Flagella	Organisms
Unicellular flagellate	*Chlamydomonas*
Unicellular nonflagellate	*Chlorella, Acetabularia*
Flagellate colonies	*Volvox*
Nonflagellate colonies	*Hydrodictyon*
Unbranched filament	*Ulothrix, Spirogyra, Oedogonium*
Simple branched	*Cladophora*
Heterotrichous	*Draparnaldia, Stigeoclonium, Coleochaete, Fritschiella*
Parenchymatous	*Ulva*

Scientist believe that Green algae are **ancestors of terrestrial plants**. There are various evidences to support this belief of the Chlorophyceae origin of land plants:

- Cell wall structure is similar with cellulose and pectic compounds present in both the groups.
- Chlorophyll *a* and *b* are reaction centres in photosynthesis for green algae and land plants. The carotenoid pigments are also similar.
- Storage compound is starch, a carbohydrate in both the groups.

Economic importance

- *Codium* and *Ulva* (Sea lettuce) are dried and salted then used as salad or vegetable in European countries.
- *Chlorella pyrenoidosa* (called space alga) is used in best and various ways by exobiologists. The main uses include for food, disposal of CO_2 making O_2 available to them and organic waste in prolonged space flight.
- *Cephaleuros virescence* – a parasitic green alga which cause red rust of tea disease.

Positive Importance

(i) Algae as Food

Constitutes an important food source for the fishes and aquatic animals, even mammals and other animals along with man directly or indirectly. Miller (1972) suggested that algae can be used in the production of protein rich human food. People in some countries like China and Japan have started using algae as a source of food. Algae food are, *Chlorella, Porphyra, Ulva, Chondrus, Laminaria, Alaria, Nostoc, Codium, Rhodymenia* and *Monostroma*.

(ii) Algae as Fodder

Many sea weeds such as *Ascophyllum, Fucus, Laminaria, Sargassum* and *Rhodymenia* are used to feed animals (sheep, goats, cattle and poultry) as fodder in many countries. The chopped kelps are given to sheep and chickens.

Planktonic algae constitute the major food for several fresh water and marine animals such as protozoans, crustaceans and fishes. Fishes form an important protein source for humans, which is why algae is an indirect food.

(iii) Algae in the Industry

Commercial products are obtained from algae. Some of them are as follows:

(a) Agar agar: Jelly like non-nitrogenous product, which is extracted in water from a number of red algae like *Gelidium, Gracilaria,* and *Chondrus*. A complex polysaccharide made up of agarose and agaropectin produced and stored in the cell walls along with the usual cellulose. It is soluble in hot water, and solidifies when the water cools. Agar is used as a stabilizer or emulsifier in industries like food stuffs, cosmetics, leather, medicines and paper. It is also used in textiles, baking, meat industry, preservation and canning of fish. Medicinally in lotions it is used as a laxative. Agar is used widely in the culture media preparation in several pathological and tissue culture laboratories.

(b) Carrageenin: Similar to agar with a complex polysaccharide that has esterified sulphate. Extracted from the cell walls of *Chondrus crispus* and *Gigartina*. It is widely used as a stabilizer in the emulsions present in paints and cosmetics. Also used in textiles, leather, breweries, food and pharmaceutical industry.

(c) Alginates**:** Salts of alginic acid are called as alginates. These are extracted from the cell walls of many brown algae like *Laminaria, Macrocystis, Ascophyllum, Facus, Lessonia,* and *Sargassum* etc. The polysaccharide is made up of glucuronic acid and manuronic acid. Alginates are used as stabilizers,

emulsifiers, gelling agents and filters. They have thickening properties and thus used in the preparation of soup, sauce, jelly's, creams, printing ink etc. Also used in the preparation of dental impression powder, ointments, dressing materials and to stop bleeding.

(d) Diatomite: The diatoms after death get fossilized and deposited in the sedimentary rocks called as known as diatomite. Big deposits of Diatomite are found at Lompoc in California. Diatomite is white, soft and porous substance which is insoluble, chemically inert and heat resistant. Its uses are common as filter, absorbent and insulator in oil and chemical industries, furnaces, refrigerators, sound proof rooms, tooth powder etc.

(e) Mucilage: Extracted from *Carrageenan* and *Chondrus* etc., used as stiffening agent in cosmetics, shaving creams, shoe polish, shampoos etc.

(f) Minerals and elements: Brown seaweeds like kelps are rich in some minerals. Soda and iodine are extracted from *Laminaria, Fucus* and *Macrocystis* etc. Bromine is obtained from *Rhodomella* and *Polyschiphonia*. Other important minerals such as copper, cobalt, iron, zinc, manganese, vanadium, potash, boron and chromium are also obtained from many seaweeds.

(iv) Algae in agriculture

(a) Nitrogen fixation: Many blue green algae fix atmospheric nitrogen into soil and enrich the nitrogen content of soil. E.g. *Nostoc, Anabaena, Oscillatoria* and many others.

(b) Soil reclamation: The barren and alkaline soils is made fertile with the help of the growth of blue green algae. They decrease the pH and increase the nitrogen, phosphorus, organic matter and water holding capacity of the soil.

(c) Soil formation and conservation: Some algae grow symbiotically in the thallus of lichens. The lichens are the pioneers of plant succession on barren rocks forming primary soil. Some algae like *Anabaena*, *Tolypothrix* and *Lyngbya* help in soil conservation by preventing soil erosion.

(d) Fertilizers and manures: Seaweeds are widely utilized as manures around the coast as they are rich in potassium, phosphorus, microelements and some growth substance. The blue green algae have higher nitrogen and phosphorus amounts. Hence a mixture made from seaweeds and blue green algae can be a good fertilizer source. In India, *Turbinaria, Anabaenopsis* and *Spirulina* are used as fertilizers and green manure.

(v) Algae in sewage disposal

Direct sewage disposal affects the water bodies and environments badly. Sewage includes organic and inorganic materials while less oxygen. It can be decomposed in presence of oxygen with the help of unicellular algae like *Euglena, Chlorella,* and *Scenedesmus* etc. The sewage is rich in sulphur, phosphorus, nitrogen, potassium and other mineral nutrients and free from harmful substances. The algae perform photosynthesis that produce oxygen which can be utilized by the bacteria for further sewage decomposition. The treated sewage water can be used in irrigation and as fertilizer.

(vi) Algae in medicine

(a) Algae produce antibacterial substances which are effective against a number of Gram-positive and Gram negative bacteria. Chlorellin is the first antibiotic extracted from *Chlorella* in 1944. Some other algae like *Ascophyllum, Halidrys, Laminaria, Cladophora, Lyngbya* and *Polysiphonia* can also yield antibiotics.

(b) Many seaweeds have high content of iodine which makes its uses in the preparation of various goitre medicine.

(c) The members of *Chorales* can kill larvae and thus prove as helpful in checking the mosquitoes.

(d) Agar agar is also used in medicines in pills and ointments as a laxative in a number of medicines.

(e) *Carrageenan* is used as a blood coagulant.

(f) Many algae like *Corallina* and *Codium* are used in the preparation that are commonly used in the treatment of kidney, bladder and lung diseases.

(vii) Algae in space research

Recently, unicellular green algae *Chlorella* and *Scenedesmus* have made a place which is useful in the space research programme. Carbon dioxide and other body wastes like urine and faces of astronauts are produced in the space which can be decomposed by these algae and produce oxygen and food.

(viii) Algae in natural fuel resources

The petroleum and natural gas resources are organic substances which are also contributed from the marine algae. The planktons feed upon the marine animals and the dead remains of marine animals and plants and then, get accumulated at sea bottom lastly buried in the sedimentary rocks. These molecules were decomposed anaerobically which were converted into oil and gas.

Negative

(i) Toxicity

Many algae produce toxins which can affect aquatic animals to an extent of even death. Toxins produced by *Pymmensium parvum, Gymnodinium veneficum, Microcystis* and *Gonyaulax* are poison for fishes and other aquatic animals. Some toxin producing planktonic algae can also be consumed by human beings through drinking water and affect health with diseases. *Anabaena* and *Microcystis* cause gastric troubles, *Gymnodinium brevis* cause respiratory disorders and *Lyngbya* and *Chlorella* cause skin infections.

(ii) Parasitism

Cephaleuros which is a green algae, is parasitic in nature and cause red rust of tea. *Polysiphonia fastigata* is a parasite on a brown alga-*Ascophyllum nodosum*.

(iii) Damage

Some seaweeds have ability to grow on metallic and wood-work in the ships and boats causing fouling, corroding and destruction. Some algae also grow on the walls of historical buildings and monuments and affect the appearance thus spoil them. Some algae destroy textiles and also reduce the quality of water through contamination. *Anacystis* and *Chaetophora* corrode the concrete and metallic walls commonly found in pipes and boilers as they secrete carbonic acid, oxalic acid and silicic acid on them during their growth.

(iv) Other effects

Algal growth in water reservoirs (ponds, pools and lake) causes the loss of aesthetic and fishing values. *Oscillatoria, Spirogyra* and *Diatoms* grow in water changing its taste and colour, foul odour and clog the water filters. Some excrete toxins in water to make it unfit for drinking. Algae contamination cause changes in pH, concentration of CO_2, bicarbonate and oxygen in water.

4.4 Life Cycle Patterns of *Chlamydomonas*, *Ulothrix* and *Spirogyra*

4.4.1 Life Cycle of *Chlamydomonas*

Chlamydomonas has these special characteristics: eukaryotic, unicellular, micrometres size, pyriform, biflagellate green algae. The common habitats are stationary fresh water and marine water that is rich in ammonium salts. The alga shows presence of: apical papilla, two contractile vacuoles used in osmoregulation and excretion, a basin-shaped or cup-like chloroplast that performs photosynthesis, it has a red eye spot that has photosensitivity. Cell wall is made up of glycoproteins with hydroxyproline and not the usual cellulose.

Neuromotor apparatus causes the cells locomotion, and the structure has – Rhizoplast, Paradesmos, Basal granule and Centrosome. Both the flagella are whiplash type. The chloroplasts is cup shaped which has a single Pyrenoid.

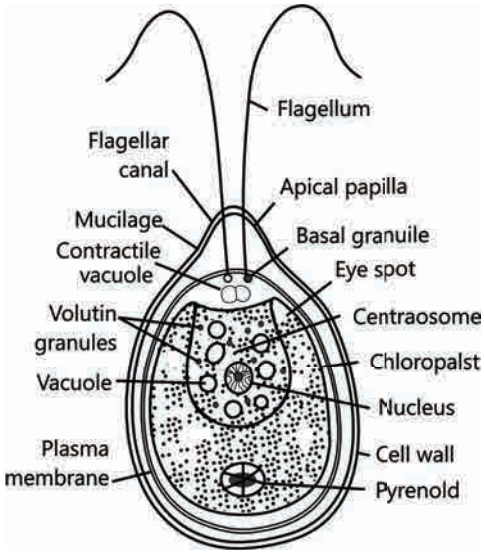


Figure 4.4: Cell structure of *Chlamydomonas*

(i) Asexual Reproduction

Asexual reproduction involves four methods:

- Zoospores:
  - Formed under favourable conditions.
  - A mature algae after losing its flagella comes to rest.

- The protoplasm contracts and then forms 2 – 16 daughter protoplasts after longitudinal division.
- Then daughter protoplasts have flagella developed and get transformed into zoospores.

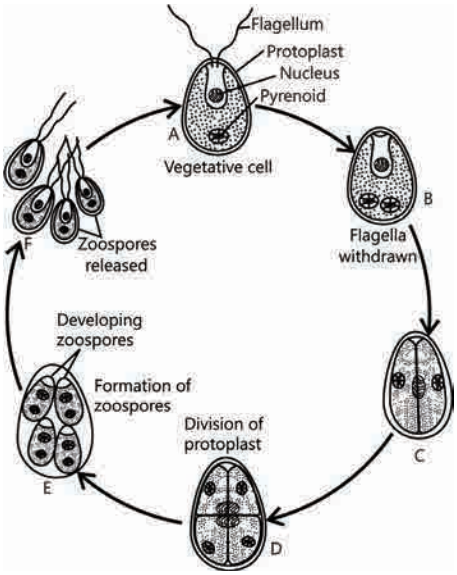


Figure 4.5: Zoospore formation in *Chlamydomonas*.

A. Vegetative cell, **B – E.** Zoospore formation. **F.** Zoospore liberation

- **Palmella stage:** It is formed when there is water insufficient,the cells lose their flagella.
  - Their cell walls undergo gelatinisation to form mucilage.
  - The cells now become almost naked and grow, divide repeatedly to form large number of cells inside the mucilage.
  - When they get enough water, the mucilage then gets dissolved and release the cells that transform into new flagellate individuals.

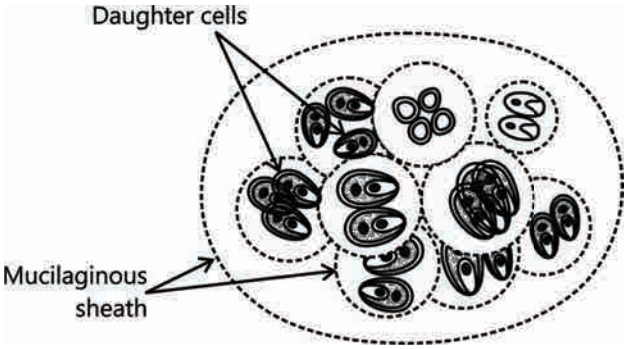


Figure 4.6: Cell division in Palmella stage in a *Chlamydomonas*

- **Aplanospores and hypnospores:** They are formed when encounter drought conditions.
  - The protoplasts of each cell contracts, separates from the cell wall, circulates itself and secretes a thin (aplanospores) or thick (hypnospores) wall around itself which is then called as a spore.

Did You Know

Red snow is sometimes visible in cold regions. This is the colour given by abundant occurrence of hypnospores produced from *C. nivalis*. Hypnospores contain a red pigment called as the haematochrome.

(ii) Sexual Reproduction

The last stage of growing season.

Various types of fusion occurs – isogamy (similar gametes fusion, e.g., *C, debaryana*), hologamy (young cells fusion, e.g., *C. media*), anisogamy (gametes of different sizes fusion, e.g., *C. braunii*) and oogamy (fusion involving a small motile gamete and a non-motile larger female gamete or egg, e.g., *C. coccifera*).

The gametes that are compatible undergo fusion and form a diploid zygote. This zygote secretes a thick wall around itself to form a resting diploid spore called as the zygospore. Under favourable conditions, haploid zoospores are formed in the zygospore after meiosis (meiospores or meiozoospores).

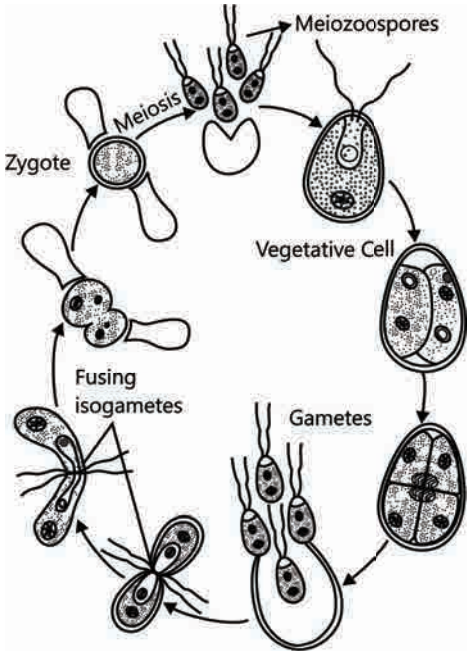


Figure 4.7: Sexual reproduction in *Chlamydomonas* showing various phases

4.4.2 Life Cycle of *Ulothrix* (Winter Alga)

Ulothrix is a green algae with an unbranched filament,algae grows in aerated fresh water of rain puddles, lakes and slow moving streams. The filament consists of a large number of rectangular cells arranged in a single row. The lowermost cell in the arrangement is non-green, non-dividing, rhizoidal cell that takes care in attachment of the cell to substratum. The cells above this layer are green in colour as they have single girdle-shaped chloroplast at parietal position in the cellthat has a few pyrenoids. The somatic cells lack an eye spot. Cell wall have inner cellulosic layer and outer protopectin layer which is insoluble in water and hence their filaments appear like wet threads.

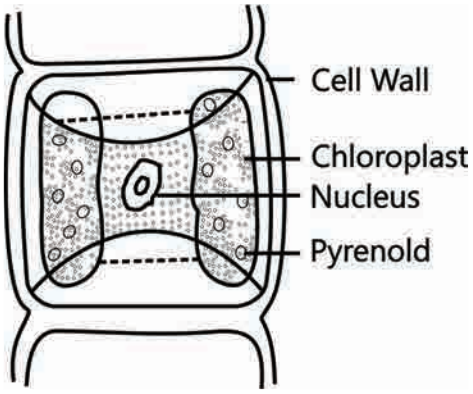


Figure 4.8: Cell structure of *Ulothrix*

Reproduction

The algae multiplies by several means i.e., vegetatively, asexually and sexually.

(i) Vegetative reproduction

Fragmentation.

(ii) Asexual reproduction

Zoospores, aplanospores, hypnospores, akinetes and palmella stage.

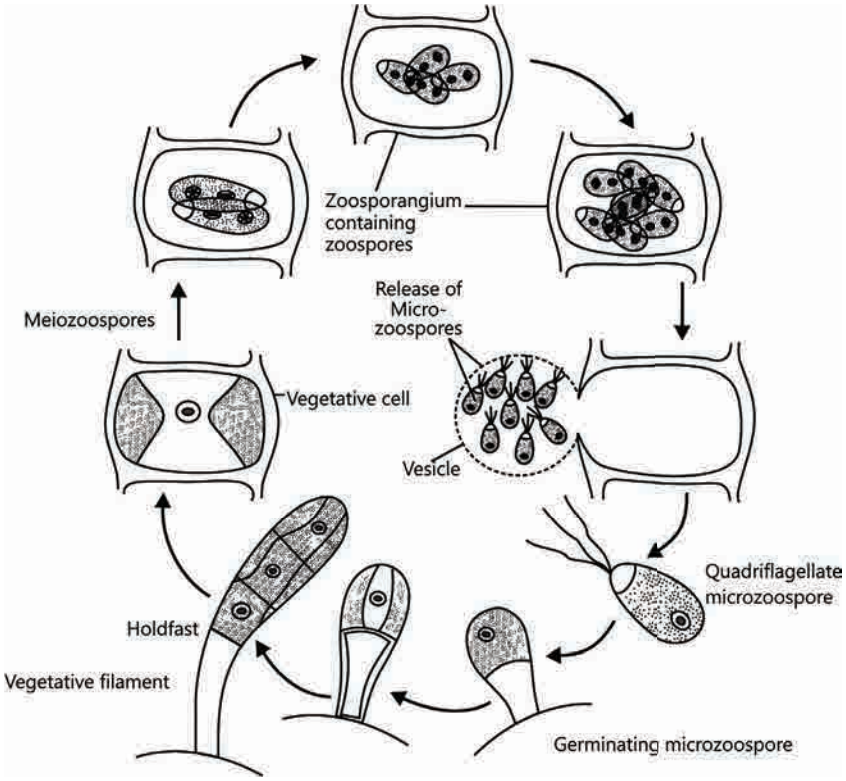


Figure 4.9: Asexual reproduction in *Ulothrix*

Zoospores are produced only when the cell is in favourable conditions. Any green cell is able to function as zoosporangium. The protoplasts contracts and moves away from the cell wall. It undergoes bipartition division and forms 2-32 similar daughter protoplasts. The protoplasts may transform into quadriflagellate macro, quadriflagellate micro or biflagellate micro zoospores. Zoospores contain eye spot and contractile vacuoles. Zoospores are liberated through a lateral pore in the wall. Each zoos pore gives rise to a new filament after its germination.

(iii) Sexual reproduction

The end phase of growing season. Each green cell behaves like a gametangium and produces 8 – 64 biflagellate gametes that is similar to zoospore formation. There is diploid zygote formation with compatible isogametes that fuse in pairs. The zygote then circularizes and secretes a thick wall around itself to produce diploid resting spores called as the zygospore. Under favourable conditions, each zygospore produces 4 meiospores (meiozoospores or meioaplanospores) which on germination give rise to new filaments.

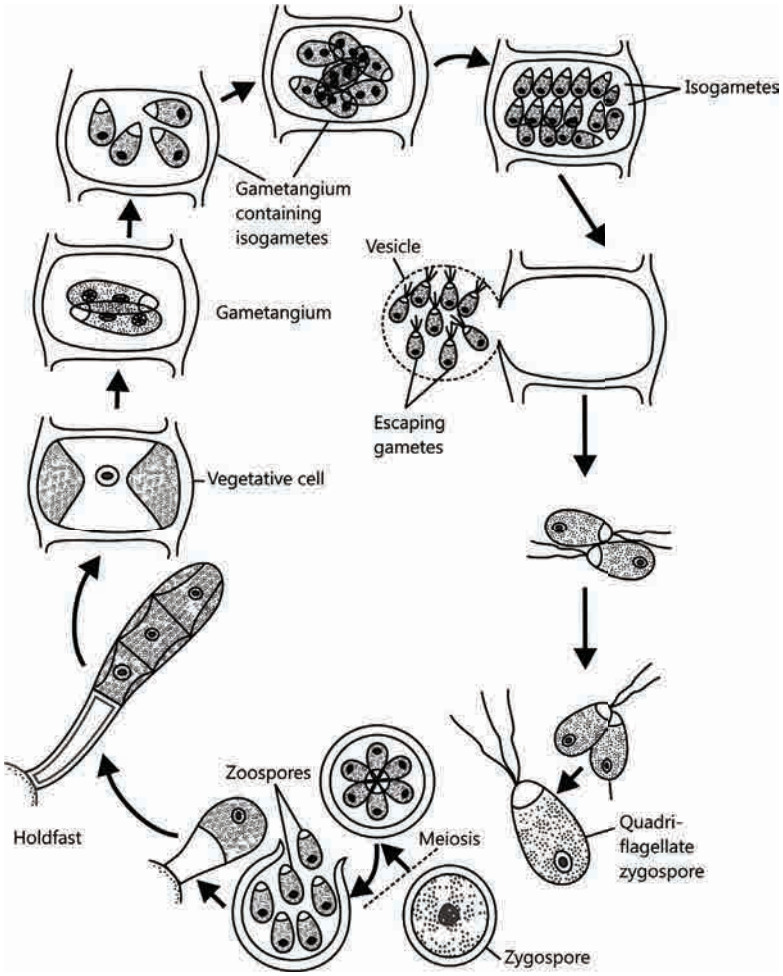


Figure 4.10: reproduction phases of *Ulothrix*

4.4.3 Life Cycle of *Spirogyra* (Summer Algae)

Spirogyra:It has common names as pond scum, summer algae, princess hairs or water silk. Unbranched green filamentous algae, which is freely floating on the fresh water ponds. The algae has mucilage layer covering. The filament consists of a large number of green cells that are cylindrical in shape attached at the ends in a single row. All the cells are similar in size and shape, autotrophic mode, and capable of growth and division. A non-green holdfast or hapteron occurs for attachment with the substratum in species such as *S. jogensis, S. adnata*. A cell contains 1 – 16 chloroplasts which is spirally coiled (left handed) and ribbon shaped. Each chloroplast contains a row of pyrenoids arranged linearly. The nucleus is present attached with the cytoplasmic strands in the central vacuole. Cell wall is double layered which consists of inner cellulose and outer pectin layers. This pectin forms a slimy sheath in water as it dissolves to make the filament slippery when touched.

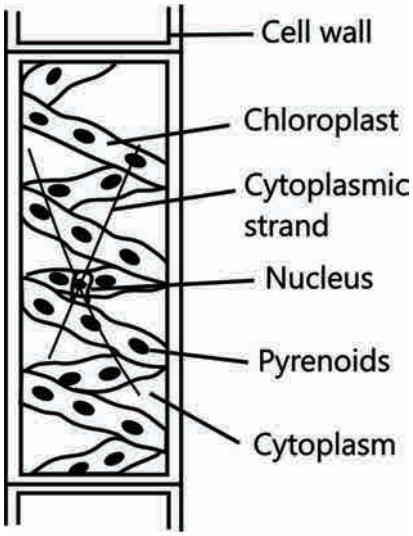


Figure 4.11: Cell structure of *Spirogyra*

Reproduction

(i) Vegetative reproduction

Reproduces vegetatively through fragmentation.

(ii) Asexual reproduction

Generally absent, except following means –

- Parthenospores / Azygospores formation in *S. varians* (if placed in sugar solution).
- Akinetes formation in *S. fariowi*

(iii) Sexual reproduction

Reproduce through conjugation i.e. fusion of gametangia. Conjugation of two main types takes place – Scalariform and Lateral.

Knowledge Builder

Scalariform Conjugation: This is more familiar type in both homo and heterothallic species. At least two opposite filaments are involved. The two young cells of the opposite filaments develop a tube that is purely for conjugation processes. The common cell wall between the two conjugating cells dissolves to form a transverse conjugation tube between both the cells. The two protoplasts of the cells function as non-motile gametes. From the two gametes, one gamete is more active which is called as the male gamete, while the other gamete is less active called as female gamete. The male gamete travels in the conjugation tube, reaches and fuses with the female gamete in the cell. The fusion product is the diploid zygote that develops a wall around itself and attains a resting zygospore, e.g., *Spirogyra tuwensis*.

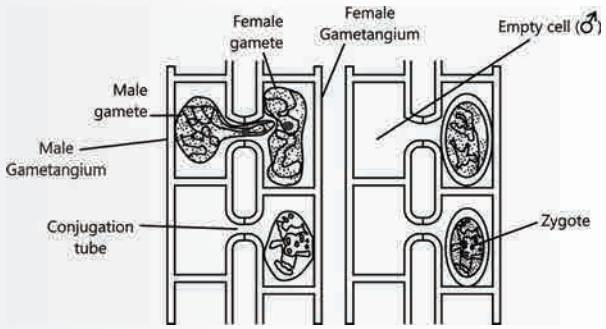


Figure 4.12: Reproduction and exchange of gametes in *Spirogyra*

Lateral Conjugation: Less common and primitive method. Two adjacent cells that have the same filament function as gametangia. A lateral passage can be developed between the two cells (indirect lateral conjugation) or the common septum may create a pore in it (direct lateral conjugation). The protoplasts along with the gamete of male cell migrate into the female cell through the tube. They fuse into one cell to form diploid zygote and then zygospore.

Knowledge Builder

When this zygospore meets the favourable conditions it germinates. The diploid nucleus forms four haploid nuclei after the meiosis division of the spore. From all the haploid nuclei, threedegenerate and one is intact. The protoplast and the haploid nucleus enlarges with growth, breaks the wall around it and emerges outwards as a germ tube. The germ tube formed then develops into a new filament.

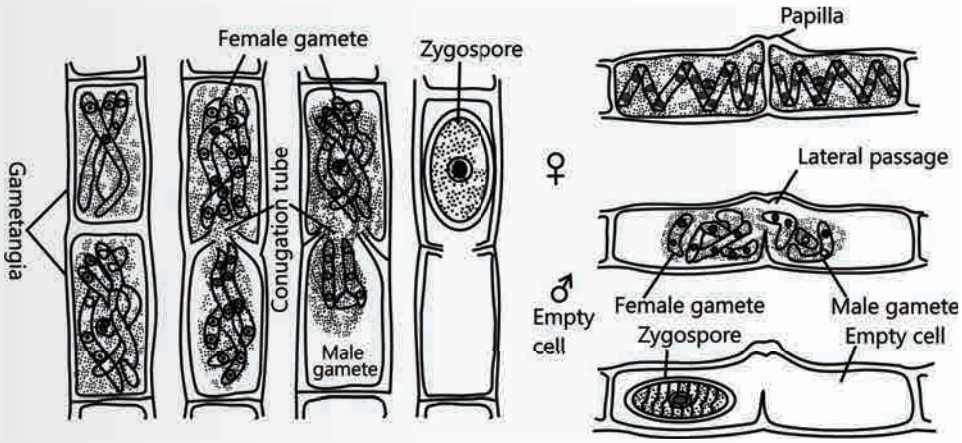


Figure 4.13: Reproduction and exchange of gametes in *Spirogyra* through lateral conjugation

Try It Yourself

1. _____ apparatus regulates the locomotion in *Chlamydomonas*.
2. Pond scum is the common name for _____.
3. Eye spot is present in the somatic cells of *Ulothrix*. True or false
4. _____ conjugation is primitive type and quite uncommon in *Spirogyra.*

5. Class Bryophyta

Small group of plants that have multicellular diploid sporophyte.

The evolutionary evidences indicate that Class bryophytes are intermediate to Class algae and pteridophyta.

They constitute the first amphibians in the plant kingdom. The oldest fossils of bryophyte found are about 350 million years old.

General Characters of Bryophyta

- Damp, humid and shaded habitats are favourite for bryophytes.
- They grow over the surface of damp soil, rocks, walls, tree trunks in rainy seasons and form green carpets or mats on them.
- The dominant phase is the plant body which is a free living gametophyte (haploid). The plant body has thallus like structure which can be prostrate or erect.
- They lack well developed vascular tissues (xylem and phloem).
- They contain simple thin walled parenchymatous cells in the body.
- Rhizoids are present for the attachment to the surface instead of true stem, leaf and roots.The rhizoids may be unicellular (e.g., *Riccia* and *Anthoceros*) or multicellular (e.g., mosses).
- Vegetative reproduction occurs through fragmentation, tubers, gamete formation, budding, adventitious branches etc.
- Asexual reproduction with mitospores does not takes place.
- Sex reproduction is oogamous type. The organs are different, covered and multicellular. Antheridium is the male organ and archegonium the female one. The jacket / covered cells are sterile (Bryophytes are first archegoniate).
- Antherozoid is the male gamete produced from antheridium. It has twisted and comma shape and two flagella for motion.
- The male gamete require an external layer of water for it to swim and reach the archegonia. Hence, the class is called as amphibians of plant kingdom.
- Zygote undergo reduction division after a while following fusion. Zygote divides by mitosis after the development inside the archegonia to produce embryo (so these are considered as first bryophytes). The embryo then develops into a sporophyte and transforms into parasite over the gametophyte (may be partial parasite as in mosses).
- The sporophyte in the bryophytes is also called as the sporangium. It consists the following three parts: capsule, seta and foot. It remains attached to the gametophyte and produces meiospores or haploid spores while being inside the capsule part (after meiosis in spore mother cells).
- All bryophytes produce similar / one type of spores (homospores).
- Each spore produces a gametophyte when it germinates. This is either directly or indirectly through formation of a juvenile filamentous stage that is called as protonema, e.g., in mosses).
- The life cycle of bryophytes have heteromorphic or heterologous alternation in the new generations which is called as the haplodiplontic life cycle.

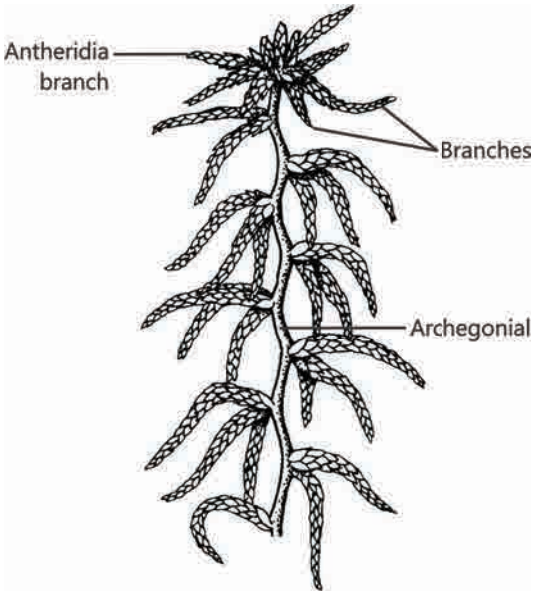


Figure 4.14: Diagram of a Bryophyte

Did You Know

Robert Braun coined the term Bryophyta. The scientific study of bryophytes is called as bryology.

Hedwig is called the "Father of bryology". Prof. Shiv Ram Kashyap is called as the "Father of Indian Bryology".

Examples of Aquatic bryophytes are:*Riccia fluitans, Ricciocarpus, Fontinails* and *Riella*.

Examples of Saprophytic bryophytes are *Buxabaumia* and *Cryptothallus*, while *Frullania* is an epiphytic form.

Economic Importance of Bryophytes

- Peat: *Sphagnum* is a bryophyte grows in acidic marshy areas. The dead parts of mosses and other marshy plants decay slowly and get carbonised, compressed and finally fossilised over a long period. This produces a dark spongy carbon mass called as peat. This Peat is extracted from ores and then dried, compressed and cut to form small blocks. The peat blocks are then used as fuel and good manure. It helps to overcome soil alkalinity and also increases its water retention and aeration capacity.
- Water retention: Dry *Sphagnum* can absorb and retain good amounts of water. This characteristic is best used by gardeners during transportation and propagation in order to keep seedlings and cut plants moist. *Sphagnum* moss replaced absorbent cotton and hence is also called as the cotton moss.

- Prevention of soil erosion: Bryophytes specifically mosses, form dense matt layer on the soil surface. This layer of mosses prevent soil erosion in rains, flowing water.
- Soil Formation: In rocky areas, Mosses create an important link in plant succession. They also take part in building soil as they enter rock crevices which is formed by lichens. Growth of *Sphagnum* (Bog moss) ultimately releases rocks particles and fills ponds and lakes with soil.

5.1 Classification of Bryophyta

Some characteristic features of these classes are given below:

5.1.1 *Hepaticopsida or Liverworts*

(e.g., *Riccia, Marchantia*)

Structure

- The plant body shows thalloid structure and dorsiventral symmetry.
- The ventral side of the thallus contains multicellular scales and unicellular rhizoids.
- The dorsal side of thallus has rhomboidal or polygonal mass.
- Thallus has two distinct zones: assimilatory and storage.
- Leafy members like *Porella* show leaf like tiny outgrowths in two rows on the stem like structures.

Asexual reproduction

- Fragmentation or by gametes (e.g., *Marchantia)*.
- The gametes have shape similar to number '8'. The gametes are stalked, green and multicellular asexual buds developing in small receptacles called as gemma cups present on dorsal surface of thallus.
- Each gemma germinates to produce two thallus in *Marchantia*.
- Antheridia and archegonia are scattered in the thallus and found embedded in the dorsal side of thallus (e.g., *Riccia*). It may be projected from the thallus as stalked receptacles,called as the antheridiophore and archegoniophore respectively (e.g., *Marchantia*).

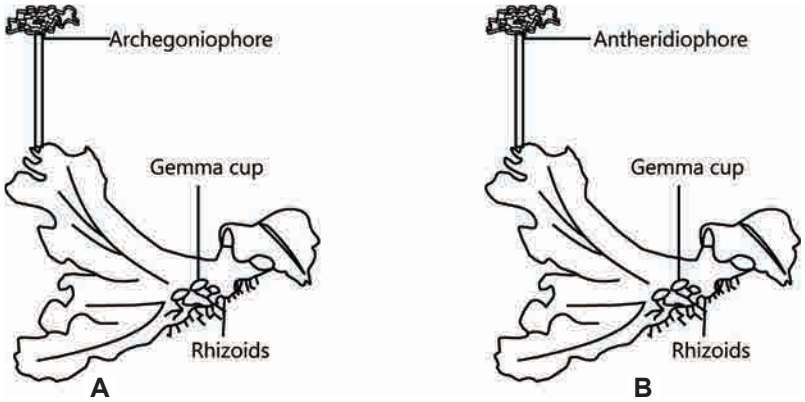


Figure 4.15: Bryophytes: A liverwort – *Marchantia* **A.** Female thallus **B.** Male thallus

- Sporophyte can be capsules only (e.g., *Riccia*) or have differentiation of foot, seta and capsule (e.g., *Marchantia*).
- Capsule show presence of only spores (e.g., *Riccia*) or spores along with elaters (e.g., *Marchantia*). Elaters are diploid, hygroscopic structures that have spiral thickenings to help spores in dispersal.
- Sporophyte does not have assimilatory tissue and thus is a complete parasite over the gametophyte.
- Spores (n haploid) germinate and the thalloid gametophyte is formed.

KNOWLEDGE BUILDER

Anthoceropsida or Hornworts (Members of family Anthocerotae)

Anthoceros, Notothylas possess elongated horn like sporophytes, which are called as hornworts.The capsules of these members contain spores and pseudo elaters (elater like structures without spiral thickenings). Anthoceros cells have one chloroplast and one pyrenoid structure and thus, it resembles algal thallus.

5.1.2 Bryopsida – Musci or True Mosses

- Gametophytic phase includes two stages – the first one is protonema (juvenile stage), and second one is gametophore or leafy stage (mature).
- Protonema develops through the spore germination. It is filamentous, green coloured, creeping and branched structure.
- Gametophore has erect stem with one branch in axillary way that contains leaves and sex organs arranged spirally.
- Rhizoids are branched multicellular structures with oblique septa present at the base of stem.
- Leaf has green colour and ovate shape with acute apex. It shows a mid-rib and margin is slightly serrated.
- Fragmentation and secondary protonema are vegetative reproductive methods (the filament emerging from structure other than the spore).
- Sex organs develop in the leave axis.
- Male is the main branch in young gametophore while female is the side branch.
- The mosses have an elaborate mechanism for spore dispersal from the capsule.
- Mosses are common with different names: Cord moss (*Funaria*), Maiden hair moss (*Pogonatum*), Peat / Bog moss (*Sphagnum*) and hair cap moss (*Polytrichum*).

Life Cycle of Moss

Funaria hygrometrica

- A moss similar to plant.
- In the rainy season, it forms a dense carpet on surfaces of soils, rocks, tree trunks, etc.

- Usually grows under shade and moist places.
- The body has radial symmetry which is differentiated into 3 parts namely stem or axis, leaves or phylloids and rhizoids (multicellular). Vegetative reproduction is common in Moss plants.

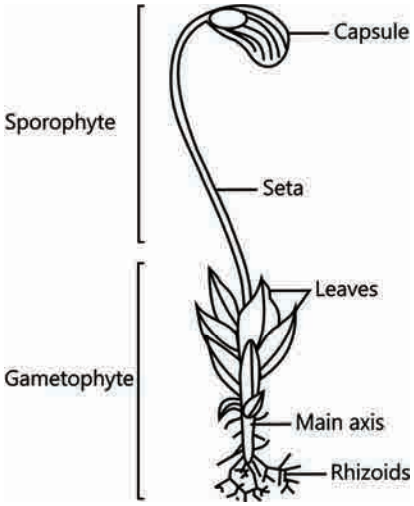


Figure 4.16: Labelled diagram of a *Funaria*

Reproduction in *Funaria*

(i) Vegetative Reproduction: There is two ways of it as:

- Apospory –The process of formation of gametophytes or the plant body without meiosis from sporophyte.
- Protonema buds –The spore germinates and a short tube like structure called as the primary protonema is formed. It divides to gives rise to filamentous multicellular septate structures called as buds. These buds get separated from the parent moss and give rise to new plants.

(ii) Sexual reproduction:

- *Funaria* is monoecious and autoicous plant. This means that one plant bears both male and female sex organs however they are on different branches. The male branch is called as antheridial and the female branch is called as archegonial branch.
- **Antheridium:** Male sex organ is cluster of antheridia, which has many closely arranged perigonial leaves around itself. It is a club-shaped structure. Along with antheridia, a multicellular green filament called as paraphyses are inter mingled. A small multicellular stalk bears the terminal cell of paraphyses which is a capitate. The sperm mother cell mass is enclosed in a single layered jacket. In the jacket cell there is a cell present at the top which produces sperms. Androcyte produces two biflagellate sperms that are differentiated by curved body.
- **Archegonium:** Archegonia are intermingled with paraphyses that have surrounding of a cluster of perichaetial leaves. It has a flask-shaped structure (tubular neck and swollen base) with multicellular

stalk. The base venter includes a venter canal cell and an egg or oosphere enclosed in double layer. The tubular neck is single layered wall which is made of 6-spirally twisted rows of cells. The cells in neck canal (NCC) gelantinises at maturity and the lid cells separate. The archegonia open, its mucilage has sucrose and K^+ ions which attracts sperms. The sperm enters archegonium and then fuses with the oosphere to form a diploid zygote or oospore.

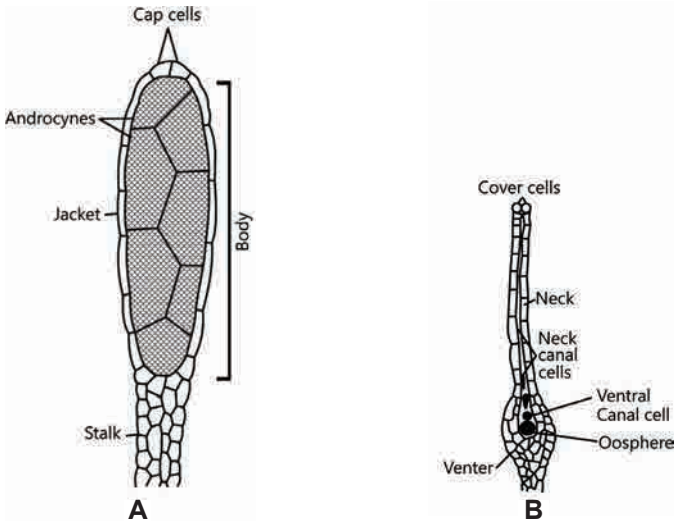


Figure 4.17: Labelled diagram of reproductive organs in a *Funaria.* **A.** Antheridium and **B.** Archegonium

Development of Sporophyte

The venter cells in archegonia arrange to make a cover on the zygote called as the calyptra (haploid-gametophytic tissue). The diploid oospore then develops into a sporophyte which consists of– foot, seta and capsules. The foot is embedded in the plant tip. It fixes sporophyte and absorbs water and mineral salts from the gametophyte. Seta, a narrow stalk lifts the capsules above it in air.

The capsule has 3 parts-apophysis, theca and operculum. Apophysis has assimilatory tissue and stomata (having a single circular guard cell). Theca has a central sterile column, assimilatory tissue, two spore sacs and air cavity. Operculum is linked with thin walled cells called as annulus to the theca. Peristome consists of two rows of triangular teeth and each row includes 16 teeth. The teeth in outer row (exostome) have transverse bands of cellulose, are dark brown and hygroscopic. On contrary, inner row teeth (endostome) are thin, light brown and hrygrophilic. Diploid spore mother cells are formed inside the spore sac. They produce haploid spores followed by meiosis. The operculum is removed from the capsule and haploid spores are liberated and hygroscopic movement of peristomial teeth.

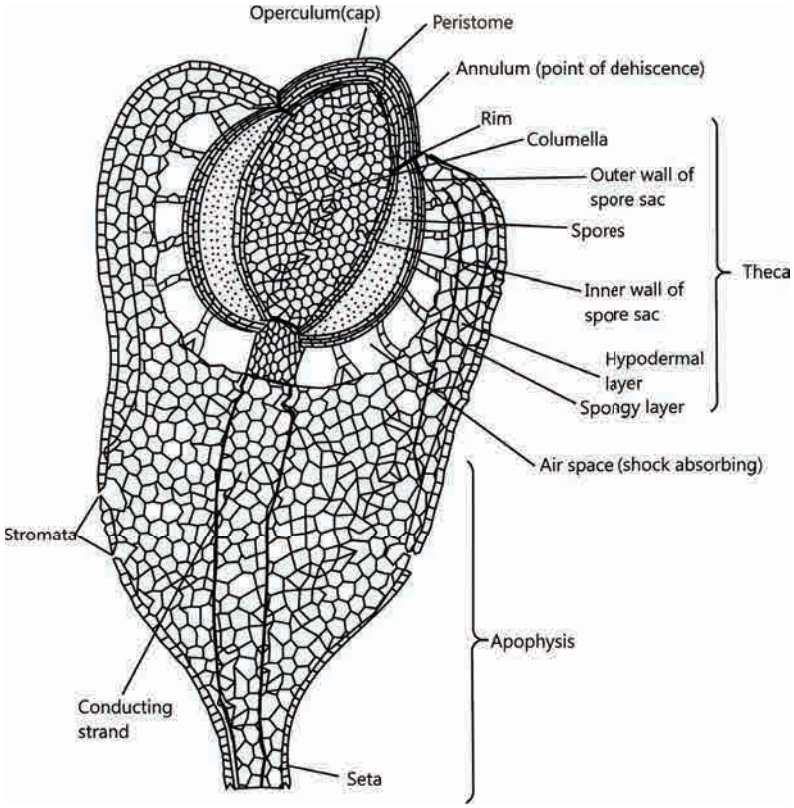


Figure 4.18: Sporophyte in a *Funaria*

Funaria like mosses contain chloroplasts in some assimilatory tissue or cells in their sporophyte, unlike liver worts (parasites), they are often called as semiparasite over the gametophyte. Such cells are present in the apophysis, capsule wall and in the spores.

Each haploid spore germinates and produces a filamentous juvenile gametophyte called as the protonema. Protonema has two branches, green (chloronema are epiterranean) and non-green (rhizonema are subterranean). The protonema works like rhizoids. Protonema can multiply vegetatively by budding where buds present on its green branches. The buds grow, mature and separate to form moss plants.

6. Class Pteridophyta (Ferns)

E. Haeckel termed these plants with **feather like leaves** as pteridophytes.

The study of Pteridophytes, their structure and life cycle is called as Pteridology.

Pteridophytes are known as reptiles of plant kingdom or vascular amphibians or botanical snakes.

The plants then moved on the land and survived successfully from outside water and had water absorbing capacity from soil. The first plants to have well-defined vascular system. They are most primitive plants which do not produce flowers, seeds, and spores.They are cryptogamic (no flower seed) terrestrial plants. They need water for fertilisation and hence are not complete terrestrial plants.

General Characters of Pteridophyta

- These plants are found growing on land which has soil surface and ground water.
- The dominant phase of the plant body is the sporophyte.
- Plant body shows presence of true stem, leaves and roots.
- The Vascular tissues present are of two types: xylem and phloem. True vessels are absent in xylem. In phloem, companion cells and sieve tubes are absent whereas sieve cells are present. Secondary growth is unusual as they lack cambium cells and found exceptionally in *Isoetes* and *Botrychium*.
- There are leaves size variation among pteridophytes and they are of two types. When the leaves that are larger than the stem and leaf gaps break the leaf trace then plant is called as megaphyllous plants e.g., ferns. When the leaves are shorter with a single leaf trace that is intact then plant is called as microphyllous forms, e.g., club moss and horsetails.
- Plants have dorsiventral or radial symmetry and dichotomously / laterally branched stem. The roots are adventitious in nature. The stem when underground is called as rhizome and can be aerial erect like in tree ferns e.g. *Cyathea*, *Alsophyla*.
- The leaves are long and large called as fronds. They can be pinnate or simple. The leaves that produce sporangia are called as the sporophylls. The usual photosynthetic leaves are called as trophophylls. Meiospores are produced inside the sporangia. Sporophytes may also form distinct compact structures called as the strobili or cones (*Selaginella*, *Equisetum*). Sporangia are present in groups is called as sorus. Many sorus are found on sporophylls. They are called sori.
- Young leaves have circinate ptyxis, and are coiled like a watch spring. This coiling brings growing point in centre and protects it.
- Younger parts of stem, young leaves, petiole and rachis of mature leaves contain brown stiff hairs called as the ramenta. It protects these parts from mechanical injury and desiccation.
- Sporesgerminate and produce small, reduced, independent, multicellular, non-vascular, haploid gametophytic structures. The thalloid gametophyte is called as the prothallus. The prothallus requires cool, damp shady places for growth. This is the reason they fertilize in water. The gametophyte may develop in endosporic (inside the spore wall) or exosporic (outside the spore wall) way.
- Sex organs are multicellular and in a jacket. Number of NCC (neck canal cells) in archegonia is variable: one uninucleate (*Selaginella*) or one binucleate (ferns).
- Sperms are flagellated, which helps them to swim and reach archegonia with the help of water. The malic acid provides chemical stimulus.
- Formation of Embryo occurs.
- Alteration of generations between heteromorphic and heterologous takes place in the life cycle.

- Pteridophytes have four distinct groups, viz, Psilophyta (*Psilotum*), Lycophyta (*Lycopodium, Selaginella*), Sphenophyta (*Equisetum*) and Pterophyta/Filicophyta (*Dryopteris, Adiantum, and Salvinia*).
- True ferns are leptosporangiate members of filicophyta and are most conspicuous of the pteridophytes.

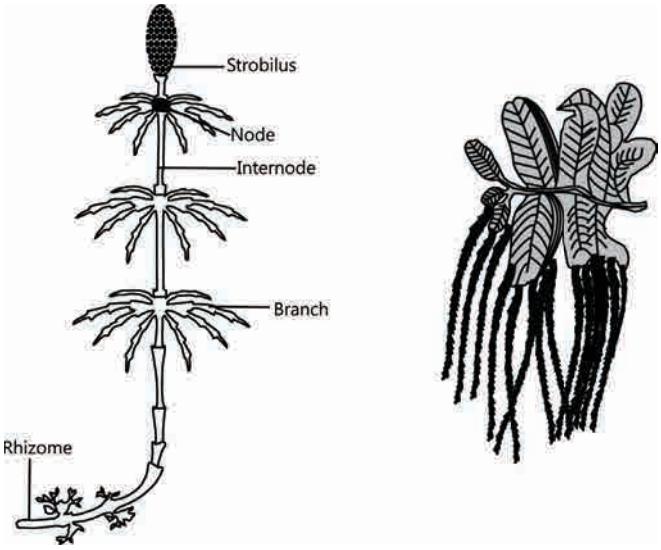


Figure 4.19: Parts of a branch in Pteridophyta

Knowledge Builder

- **Sporangium develops in two ways in pteridophytes:**
  - Leptosporangiate: The development of sporangium from a single superficial cell, e.g., *Pteris, Dryopteris, Adiantum*.
  - Eusporangiate: The sporangium development occurs from a group of cells, e.g., *Selaginella, Equisetum.*
- **Spores:**
  - Homosporous: Pteridophytes that produce similar spores e.g., ferns *Adiantum, Pteris, Dryopteris*.
  - Heterosporous: Only few pteridophytes produce different spores, namely megaspores and microspores e.g., *Selaginella, Marsilea, Salvinia, Azolla* etc.
- **Embryogeny in pteridophytes is of two types:**
  - Exoscopic embryogeny: Axis of embryo is directed towards the archegonial neck, e.g., *Equisetum*.
  - Endoscopic: Axis of embryo is directed inward towards the swollen venter, e.g., *Selaginella*.

KNOWLEDGE BUILDER

- **Development of embryo may be:**
  - Holoblastic- When the entire zygote itself develops the embryo, e.g., Ferns.
  - Meroblastic- When some part of zygote helps in embryonic development, e.g., *Selaginella*.

Stelar System

The central vascular cylindrical axis in the pteridophytes is called as the stele. It is a primary vascular tissue that includes pith, xylem, phloem and pericycle. It first appeared in pteridophytes like *Rhynia*. Van Teigham and Douliot proposed the theory of various stele systems.

Types of Stele

(i) Protostele: Simplest type, without pith

- Haplostele: e.g., *Rhynia*
- Actinostele: e.g., *Lycopodium serratum*

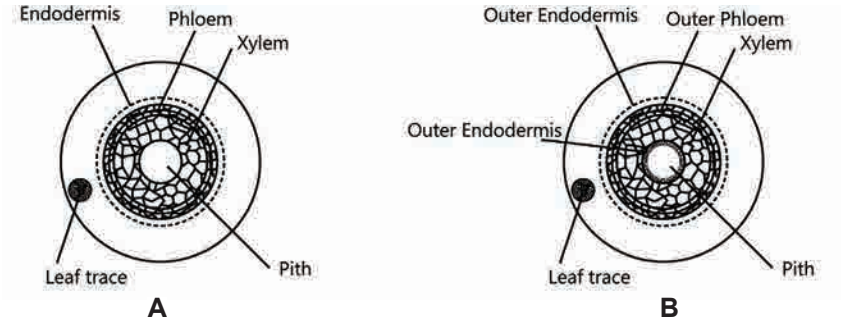


Figure 4.20: Stelar arrangement in **A.** *Rhynia* and **B.** *Lycopodium serratum*

- Plectostele: e.g., *Lycopodium clavatum*
- Mixed protostele: e.g., *Lycopodium cernum*

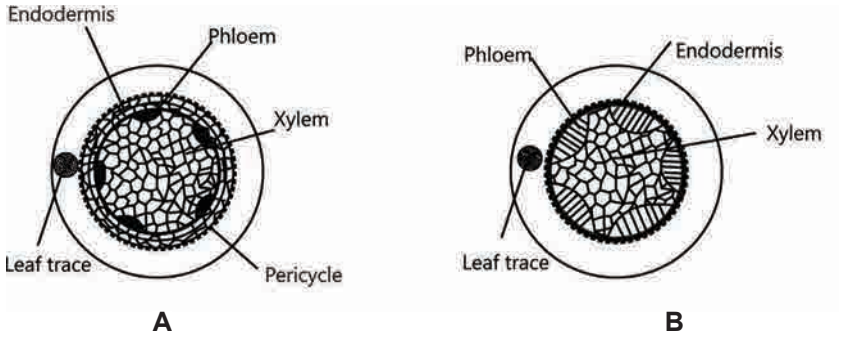
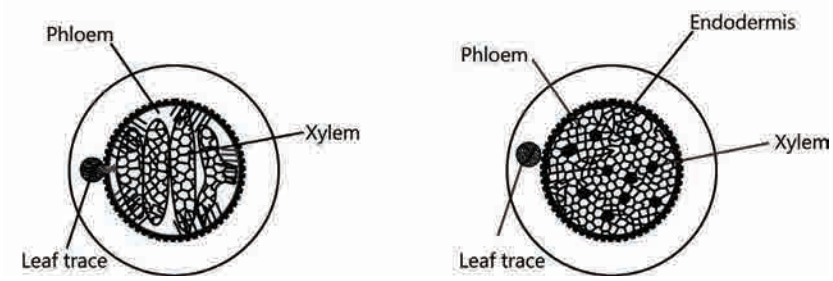


Figure 4.21: Stelar arrangement in **A.** *Lycopodium clavatum* and **B.** *Lycopodium cernum*

(ii) Siphonostele: With pith

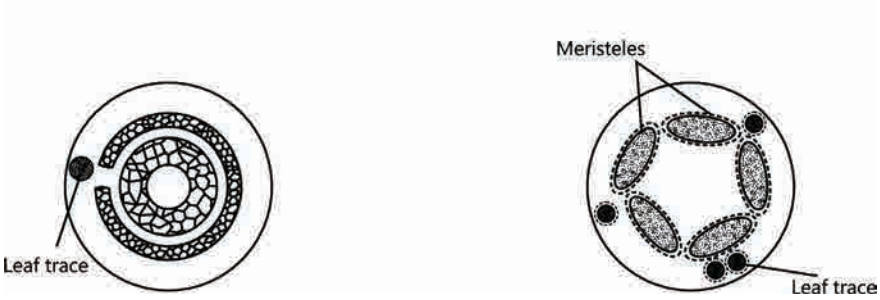
- Ectophloic siphonostele: Phloem on one side of xylem only, e.g., *Osmunda, Equisetum*
- Amphiphloic siphonostele: Xylem is having phloem on its both sides, e.g., *Marsilea*



A B

Figure 4.22: Stelar arrangement in **A.** *Osmuda* and **B.** *Marsilea*

(iii) **Solenostele**: Stele with one or few non overlapping leaf gap, e.g., *Adiantum caudatum*



A B

Figure 4.23: Stelar arrangement in **A.** *Adiantum caudatum* and **B.** *Dryopteris*

(iv) **Dictyostele**: Stele with large number of overlapping leaf gaps, e.g., *Dryopteris*, *Pteris* etc.

6.1 Life Cycle of a Fern (*Dryopteris*)

- A perennial, independently living evergreen sporophyte.
- Plant is divided into stem, leaves and roots.
- Roots are adventitious.
- Stem is in rhizome form having dark brown colour.
- The large aerial leaves or fronds are found originating acropetally in spiral way from the upper surface of the rhizome.
- The young leaves are circinate ptyxis.
- Older parts of rhizome show persistent leaf bases of the dead leaves.

- Venation is upon furcate in leaflets.
- Ramenta or paleae present.

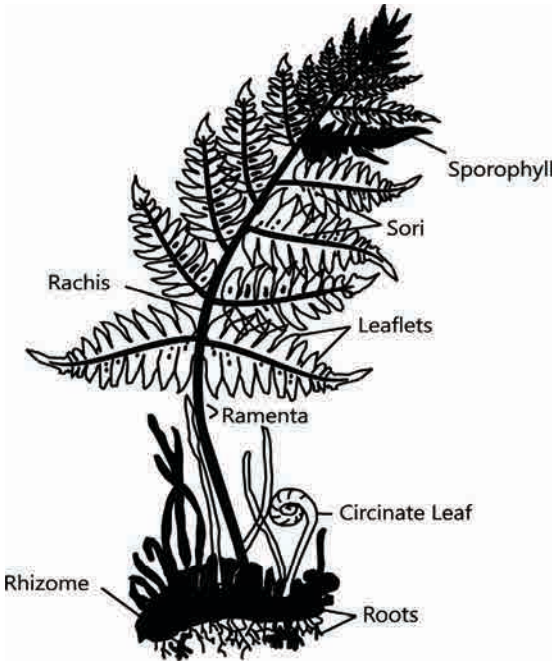


Figure 4.24: Diagram of a fern

6.1.1 Reproduction

The fern reproduces by fragmentation of rhizome and then development of adventitious buds. In *Dryopteris*, the adventitious buds that are at the base of leaf separate to grow in a new plant. In *Adiantum caudatum* and a few other species, adventitious buds start their development at leaf tips without separation. The buds with leaf tips when touch the soil, they produce new plants. This way the fern spreads over a large area.

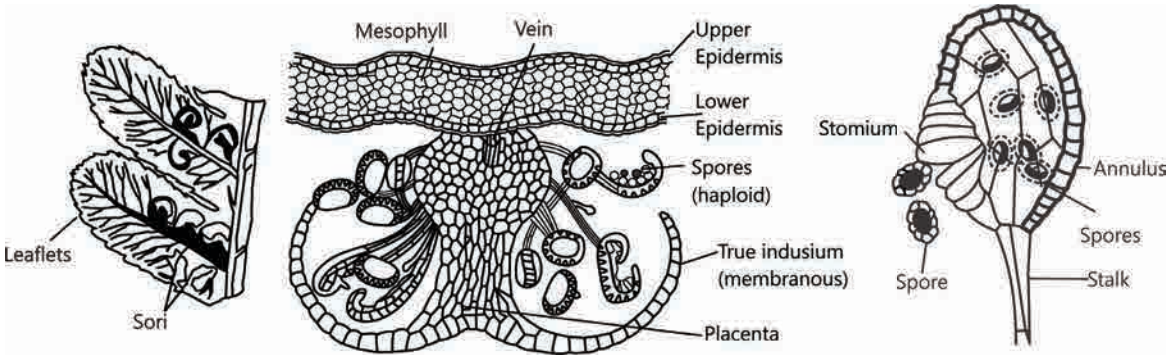


Figure 4.25: Parts of a fern: **A.** Fern leaflet (Sporophyll) showing sori, **B.** V.S. Sporophyll, **C.** A. Sporangium

Thus *A. caudatum* is also called a walking fern.

Ventral surface of a mature leaf have clusters of sporangia yellowish brown in colour called as sori. Each sorus has membranous sheath covering called as true indusium. The covered sori are kidney shaped in *Dryopteris*. This has given the name of male shield fern to *Dryopteris*.

A sorus has a parenchymatous cushion of placenta. The placenta has a number of stalked biconvex sporangia. There is a single layered jacket with 12-16 diploid spore mother cells in each placenta.

A marginal row of jacket cells are thicken enough to make up the annulus. The rest of the marginal cells make the stomium. The diploid spore mother cells grow after they divide meiotically to produce haploid spores that shrivel indusium after maturity. The exposed sporangia spread in the stomium region due to annulus contraction. The spores are thrown away and get dispersed by air currents.

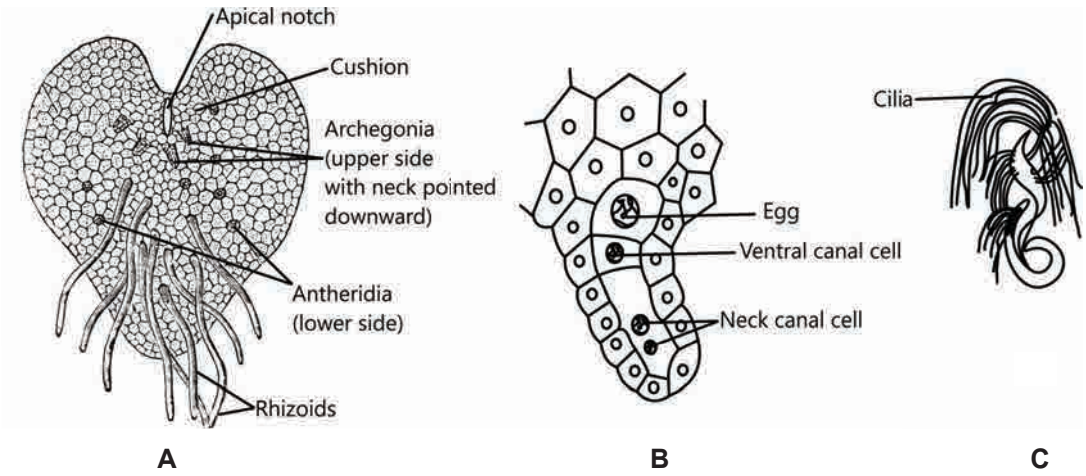


Figure 4.26: *Dryopteris* diagram: **A.** Structure of Prothallus (Ventral view), **B.** One archegonium and **C.** One antherozoid

After falling on a suitable soil, each spore germinates. The spores form a flat, heart like structure, green coloured, thalloid gametophyte called as the prothallus. The prothallus is monoecious or bears both the types of sex organs, male antheridia and female archegonia on same branch. They are ventrally placed. Antheridia occur in the rhizoids, while archegonia occur behind the apical notch in an area called as the apical cushion. Antheridium consists of 3 celled jacket and around 32 sperm mother cells. The sperms are multiflagellate and spirally twisted.

6.2 Life Cycle of *Selaginella*

Salient features

- Evergreen sporophyte, differentiated into stem, leaves and roots. The roots often develop at the tips of special structures called as the rhizophores.

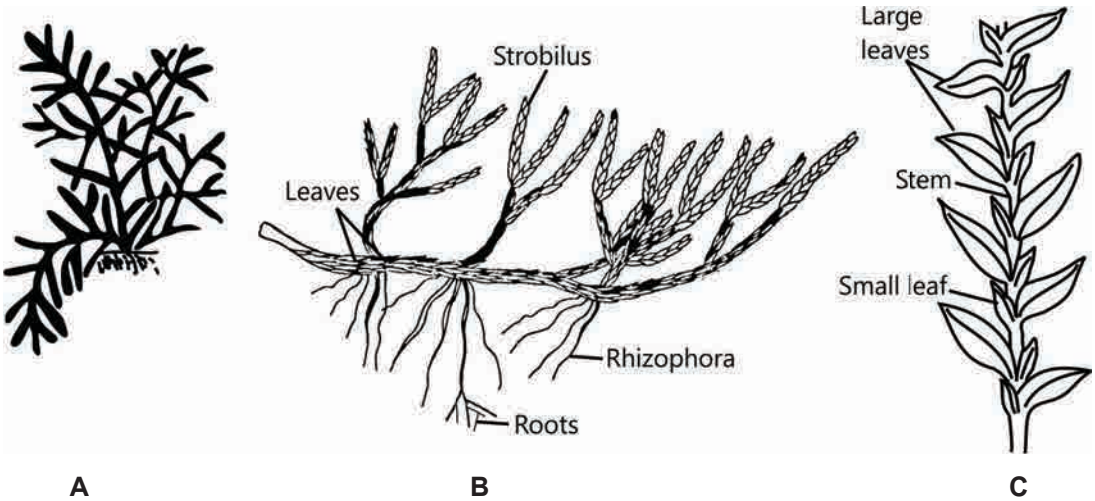


Figure 4.27: *Selaginella kraussiana* – **A.** General habit, **B.** A part of the plant **C.** Arrangement of leaves

- Plant body is erect for *Selaginella chrysocaulos* and *S. selaginoides*. The leaves are arranged in two rows and are isophyllous. *S. kraussiana* has prostrate plant body with the leaves anisophyllous or dimorphic that are arranged in four rows.
- Bower and Goebel called rhizophore of *Selaginella* as an organ sui-generis, i.e., an organ having roots and stem characters that are in independent origin.
- The stem is distelic can be rarely monostelic.
- The plant body has ability to reproduce vegetatively by fragmentation, bulbils and tubers. Bulbil and tubers also help in perennation.
- In the axil of fertile leaves sporangia develops or at the tips of small branches sporophylls develop called as spikes. The plant is heterosporous as there are two types of sporangia, microsporangia and megasporangia present in it.
- Each microsporangium generates large number of small haploid microspores. A megasporangium produces only four haploid megaspores. Growth of these gametophytes is precocious.
- Microspore produces an endosporic 13-celled male gametophyte which has one prothallial cell, eight jacket cells and four adrogonial cells. The androgonial cells further produce 128-256 androcytes or sperm mother cells. A sperm mother cell produces a sperm that is biflagellate.
- Megaspore produces a partially exosporic female gametophyte. The female gametophyte is made of an exposed generative apical cushion and a storage tissue. Both of them have a partition of a diaphragm. The apical cushion produces archegonia and rhizoids. Each archeogonium contains a single female gamete or oosphere. In *Selaginella* the mucilage oozes out from the neck of archegonium and it has malic acid. There is only one NCC in the neck of archegonium in *Selaginella* and the fern. Water is required for the fertilisation of sperm and then it produces diploid oospore.

- Oospore produces a suspensor and embryo after division. The development of embryo is meroblastic. Suspensor pushes the embryo into food laden storage tissue. Embryo shows presence of a foot for absorption of nourishment, a shoot tip and a root tip. The root and shoot elongate and produce an independent sporophytic plant body.
- *Selaginella* shows two distinct generations, sporophytic and gametophytic, one producing the other. They are morphologically different. The phenomenon is called heteromorphic alteration of generations.

Did You Know

- Common names
  - Spike moss (*Selaginella*)
  - Bird's nest moss (*Selaginella rupestris*)
  - Club moss (*Lycopodium*)
- Smallest pteridophyte = *Azolla pinnata* (an aquatic fern) commonly used as a biofertilizer.
- Largest pteridophyte = *Cyathea* (tree fern)
- Apogamy: The development of haploid sporophyte from gametophyte without fertilisation. It was reported by Farlow in Pteris cretica.
- Apospory: The development of diploid gametophyte from sporophyte without meiotic division. It was published by Druery in *Athyrium*. Due to apospory, polyploidy is common in ferns.
- Psilotales like *Rhynia* (fossil) were first tracheophytes.
- Psilotales has rhizoids and dichotomous branching of stem.
- The xerophytic species of *Selaginella* in dry conditions roll into brown balls which is called as the cespitose habit. It may be uprooted. The brown balls turn green and unroll again when they are in moist conditions. Because of this characteristic, these plants are known as resurrection plants, e.g., *S. lepidophylla*, *S. bryopteris.*
- *Selaginella rupestris* shows a near approach to seed habit.

Try It Yourself

1. *Salvinia* and *Selaginella* both are _____ genera.
2. In *Selaginella*, the apical cushion of female gametophyte produces _____ only.

7. Class Gymnosperms (Naked Seed Bearing Plants)

Theophrastus (300 BC) in his book Enquiry into plants was the first to use the term gymnosperm. They are popular for their property of naked seed bearing vascular plants. Goebel called gymnosperms as phanerogams lacking ovary.

The class makes up the smallest group of plant kingdom.

Gymnosperm and angiosperms are included in the division spermatophyte i.e. seed producing plants..

General characters of gymnosperms

- There are 900 living species of gymnosperms, including ancient forms of plants.
- Many gymnosperm plants are perennial woody plants making up either shrubs or trees. *Ephedra* is a climber, an exception. Some of the plants are very large and can grow and survive for thousands of years, e.g., *Sequoia*.
- Gymnosperms do not have the male and female gametophytes living freely as independent structures.
- Roots are in tap root system. *Cycas* shows presence of azeotropic N_2 fixing coralloid roots which are in association with *Anabaena cycadae* (BGA) for nitrogen fixation. *Pinus* roots are in symbiotic relation with ectomycorrhiza.
- Stem is perennial, woody can be branched (*Pinus*, *Cedrus*) or unbranched (*Cycas*).
- The leaves are varied in size and arrangement, ranging from small (*Ephedra*), needle like (*Pinus*) to pinnately compound (*Cycas*) pattern, scale like (*Cupressaceae*). The leaves arrangement are well adapted so that the plant can withstand extremes of temperature, humidity and wind, e.g., Needle leaf of *Pinus*.

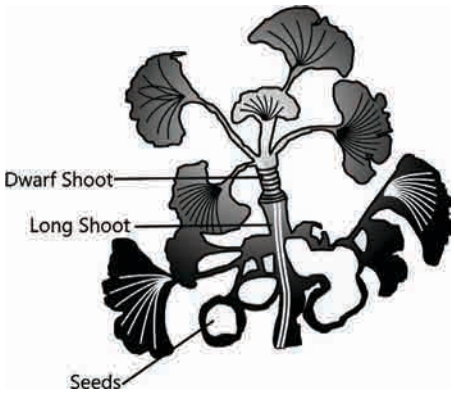


Figure 4.28: Leaf arrangement on a shoot in Gymnosperms

- These are heterosporous i.e. sex organs are different in size and form. The sporophylls are of two types; microsporophylls and megasporophylls. These sporophylls usually aggregate and form lax or compact cones (strobili) i.e., pollen cones (male cones) and seed cones (female cones).

- Microsporophylls lack the difference between the filament and anther.
- The microspores are produced in the microsporangium that make up a male gametophyte. It is highly compressed and confined to form a few number of cells. The male gametophyte is called as the pollen grain. The pollen grains develop inside the microsporangium.
- Megasporophylls (nucellus) are not similar to carpels i.e. are not rolled.It lacks the distinction between the ovary, style and stigma.
- Ovules (integumented megasporangium) are naked and present on the megasporophyll. Each ovule has a 3-layer single integument covering (Bitegmic in *Gnetum*).
- Female gametophyte has archegonia (not found in few plants of order *Gnetales*)
- Pollination of ovary by pollen grains is a direct process, as stigma is absent and thus pollen grains directly attach to the microplyar end of ovules. Pollination is due to wind (anemophily).
- Male gametophyte produces two male gamete or sperms out of which one is functional.
- External water for fertilization is not essential. Instead, the male gametophyte produces a pollen tube that makes fertilization to take place (siponogamy).
- Seeds contain a tissue or endosperm that has nourishment that can be used by embryo for into seedling. This tissue is haploid as it is similar to female gametophyte.
- Xylem lacks vessels, except in some Gnetales.
- Phloem lacks companion cells however, albuminous cells function like companion cells. Sieve cells are not arranged end to end in rows and thus sieve tubes are not formed.
- Vascular bundles have vascular tissues with xylem having trachieds and wood parenchyma, phloem lacks companion cells, the fibres in wood are absent and thus gymnosperms are called as soft woods.
- Foliage leaves lack the lateral veins. Internal transfusion tissue (hydrostereom) is present to transport laterally.
- Types of wood:
    - Manoxylic: Soft wood having vascular tissues showing medullary rays, which is commercially less important, e.g., *Cycas*.
    - Pycnoxylic: Compact wood whose tissues may show narrow medullary rays, commercially more important, e.g., *Pinus*.
    - Monoxylic: Wood with tissues having single persistent cambium ring and bundles, e.g., *Pinus*
    - Polyxylic: Tissues with many persistent cambium rings and bundles, e.g., *Cycas*
    - Gymnosperms are seed bearing plants where the ovule remains exposed / naked over the surface of the megasporophylls in pre and post fertilisation events.

Did You Know

- Smallest gymnosperm = *Zamia*
- Largest gymnosperm = *Sequoia*
- The three generations in the seed are: Testa, tegmen and perisperm that represent the parental sporophyte, Endosperm is originated from female gametophyte; and plumule, radicle, suspensor and cotyledons (embryo) represent the future sporophyte.
- Polyembryony: The process where the seed has production of more than one embryo inside itself is polyembryony. Leeuwenhoek discovered it in oranges. Fertilisation of many eggs leads to simple polyembryony, e.g., *Pinus* where the ovule has 2 – 8 archegonia. Cleavage polyembryony is splitting of embryo tissue and thus is true polyembryony which is very common. Adventive polyembryony occurs due to the formation of extra embryos directly from diploid cells (e.g., rosette cells) that are other than embryonal cells.
- Order Gnetales consists of *Gnetum, Ephedra* and *Welwitschia*. These plants are similar to flowering plants as they have arrangement of sporophyll like a flower and the xylem has primitive vessels thus wood is called heteroxylous. Plants of Cycadales and Coniferales are commonly called Cycads and Conifers respectively.
- *Cycas*, *Ginkgo* and *Metasequoia* are living fossils.
- *Ginkgo biloba* (Pagoda tree or Maiden hair tree) is the oldest living fossil and it is intermediate link between cycades and conifers.
- Largest ovule (in *Cycas revoluta*)
- Largest male cone (in *C. circinalis)*
- Largest male gamete (sperm) in *Cycas*
- Largest female gamete (egg) in *Cycas*
- Independent free living, photosynthetic gametophyte is not found in gymnosperms and angiospersm.
- Gymnosperms are divided into four orders-*Ginkgoales*, *Gnetales*, (e.g., *Ephedra*, *Gnetum*, *Welwitschia*), *Cycadales* and *Coniferales*. *Ginkgoales* is represented by maiden hair tree (*Ginkgo biloba*) where *Ginkgo biloba* happens to be only living member, rest all are extinct. So it is also called as living fossil.

Economic Importance

- Edible Seeds: The seeds of *Pinus gerardiana* are called as chilgoza which are edible.
- Timber: Gymnosperms possess soft wood which is used to prepare light furniture, plywood, packing cases, match sticks, railway sleepers, etc, e.g., *Cedrus deodara*.
- Resin: Resin is a semifluid which solidifies when contacts air, is secreted from special resin canals. Therefore it seals the injured areas which seals the female cones after pollination. Resin is commercially extracted from the plants and distilled to obtain turpentine and resin. Resin is commercially used in water proofing, sealing joints and in writing paper preparation. Turpentine is used as solvent in paints, polishes and wax, e.g., *Pinus*.
- Ephedrine: Drug ephedrine has curing respiratory abilities and thus used in ailments even for asthma. It is obtained from *Ephedra.*
- Sago: *Cycas revolute* has a starchy food sago in its stem and this is why plant is also called as sago palm.
- Canada balsam: A mounting agent that is used in the preparation of permanent slides of samples is obtained from *Abies blasmaea*.
- Cedar wood oil: Used on the slide samples for microscopy is obtained from *Juniperus virginiana*.
- Taxol: Anticancerous chemical obtained from *Taxus*.

Classification of Gymnosperms:

Division – Pinophyta

Division - Cycadophyta

Division - Ginkophyta

Division - Gnetophyta

7.1 Life Cycle of *Pinus*

- A coniferous gymnosperm.
- A large tree that has pyramidal or excurrent shape similar to a “Christmas tree”.
- The plant body is sporophytic showing stem, leaves and roots.
- The main stem is straight and erect.
- Stem branches are dimorphic (of two types) long and dwarf.
- Long stem have unlimited growth with only scale leaves.
- The dwarf branches have 1 – 5 needle-like foliage leaves that have a cover of sheath of scale leaves at the base.

- It has a horizontally growing tap root system that has peg-like downward roots present at small intervals. Finer roots are of two types – usual (with root and root cap) and mycorrhizal (roots without root cap, hairs and with fungus). The mycorrhizal roots spread near the soil surface. Mostly *Boletus* (fungus) forms an ectomycorrhiza with roots of *Pinus*.The sporophytic plant body is a monocecious tree. It has microsporophylls and megasporophylls in two types of cones, one a male and other a female.

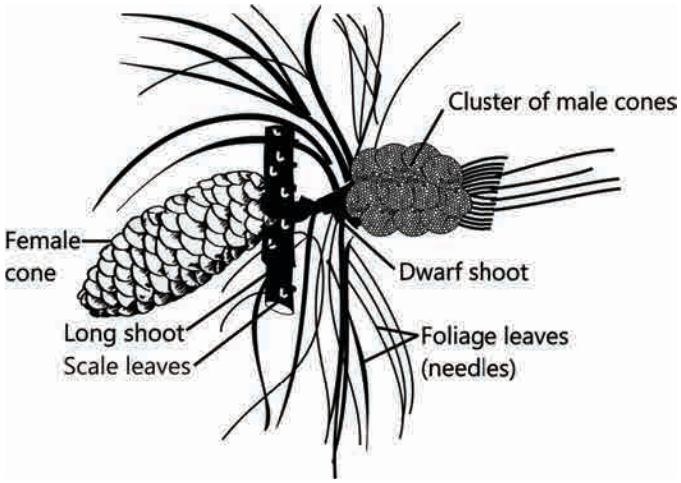


Figure 4.29: Reproductive organs of a Pinus

7.1.1 Reproduction of *Pinus*

(i) Male or Pollen Cones

- Non-woody structures that are sub-terminal in clusters on the lower long branches.
- Cones are homologous with dwarf shoots.
- A short stalk, a central axis and a number of spirally arranged microsporophylls is present.
- A microsporopyll has two long and parallel microsporangia at lower surface.
- The diploid microspore mother cells grows by meiosis to form haploid microspores or pollen grains.
- The pollen grains released from the male cones are 4 celled, having two prothallial cells, one generative cell and one vegetative cell that get dispersed with air currents.
- The pollens form yellow clouds in the pine forests that are called as ‘sulphur shower’.
- A pollen grain includes two air sacs or wings made from its exine for making it light.

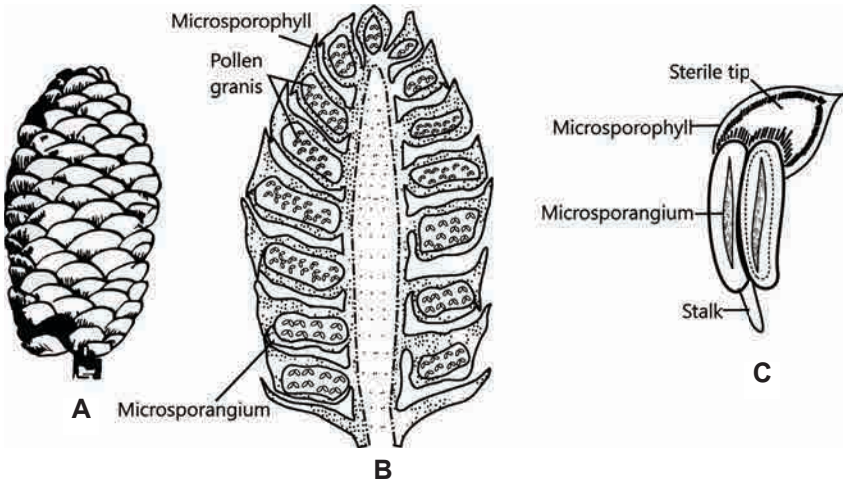


Figure 4.30: *Pinus*: **A.** A young male cone, **B.** Male cone in radial longitudinal section; **C.** Microsporophyll ventral view

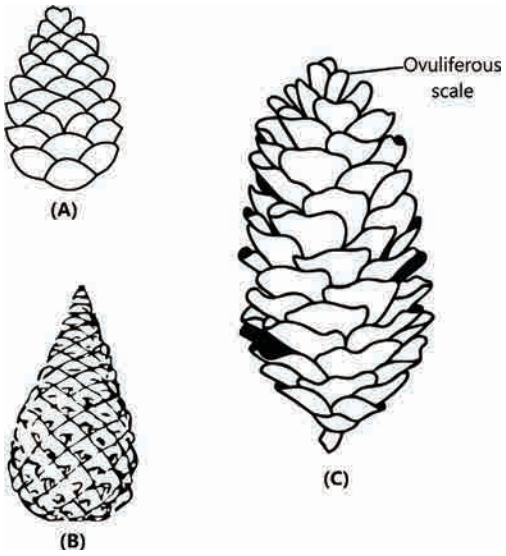


Figure 4.31: *Pinus*: **A.** First year female cone, **B.** Second year female cone, **C.** Third year female cone

(ii) Female or Seed cones

- Initially green at younger age later at maturity become woody and brown.
- They develop in groups of 2 – 6 on upper long branches of the tree.
- These are homologous with long shoot.

- A long stalk and a central axis is present in the cone where are a number of spirally arranged paired scales.
- The lower pair is called as bract scale and the upper scale is called as ovuliferous scale.
- The ovuliferous scale bears two ovules towards the basal region on the upper side.
- Each ovule shows 3-layered integument which has a terminal wide, oblique pore or micropyle and nucellus (= megasporangium).
- A megaspore mother cell differentiates and forms four haploid megaspores from meiotic division from which only one survives.
- The functional megaspore produces female gametophyte called as the endosperm.
- The female gametophyte has 1 – 8 archegonia.
- An archegonium shows a short neck and a large venter in its structure.
- It lacks neck canal cell and venter canal is ephemeral with a large egg or oosphere in it.

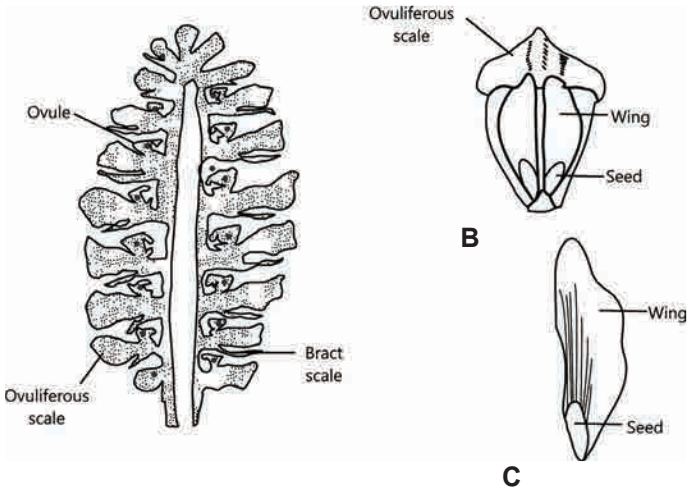


Figure 4.33: *Pinus*: **A.** L.S. female cone, **B.** A megasporophyll, **C.** A winged seed

Pollination

- Anemophilous (by air) and direct process.
- The male gamete forms after pollination.
- The pollen grains travel through the opened micropyle and stop on the tip of nucellus.
- Terminal part of nucellus oozes out mucilaginous pollination drop where pollens are caught.
- The pollen grain forms a pollen tube after germination (siphonogamy). However further growth is restricted due to arrival of winter in the first year.

- Fertilization of egg occurs after 13 months in spring of next year from the time of pollination.
- Pollen tube grows further to pierce an archegonium.
- One male gamete (male nucleus) and oospore fuse and forms diploid zygote or oospore.
- The oospore forms an embryo while the ovule matures into a seed.
- Part of the upper surface of the ovuliferous scale is peeled off along with the seed to form its wing. A female cone matures in about 26 months and then opens to release seeds with wings that get dispersed with air.
- After coming in contact with suitable soil and environment, each seed grows to a new plant.

Knowledge Builder

- Development of embryo is meroblastic in *Pinus*.
- There are 3 - 18 cotyledons in *Pinus*.
- The proembryo has 4 tiers, namely basal embryo tier, suspensor tier, rosette tier and upper tier.
- Development of polyembryony is by three methods as – simple, cleavage and adventive.

7.2 *Cycas* (Sago Palm)

- *Cycas* is called Palm-fern.
- The leaves are crown like on unbranched stem called as the caudex like palms. Also it has circinate ptyxis and ramenta like ferns.
- Roots are normal tap root and ageotropic coralloid roots which are in the form of coralline masses that have blue green algae in their cortical cells, e.g., *Anabaena*, etc as in symbiotic association to fix nitrogen.
- Leaves are scale and foliage, arising in whorls and every year one new is added. Old leaves fall with characteristic leaf scars on the stem. Foliage leaves appear like leather and pinnately compound whereas scale leaves are brown, and membranous.
- *Cycas* stem has manoxylic and polyxylic wood.
- *Rachis* have diploxylic vascular bundles that are arranged in shape of inverted omega.
- Transfusion tissue is present for lateral veins in the leaves that laterally transport food.
- Plants are dioecious with presence of male cones and no female cones (loose megasporophylls).
- Largest egg, sperm and ovule are found in *Cycas*. Ovules are orthotropous.
- *Cycas* sperms are multiflagellate (= multiciliate). Pollen tube is formed in *Cycas*, but is haustorial in nature. Thus, *Cycas* shows both siphonogamy and zooidogamy for sexual reproduction.

Economic Importance of Gymnosperms

(i) Ornamentals: Many gymnosperms are native to foreign countries, and are cultivated in Indian gardens called as ornamental plants. E.g. *Cycas revolute, Cupressus sempervirens, Cupressus funiberus, Thuja occidentalis, Araucaria species* etc.

(ii) Food Articles: Some gymnosperms have products which are used as food directly or indirectly. *Cycas circinalis* has starch in its stem and seeds, which is called as "Sago". The seeds of *Pinus gerardiana* (Chilgoza) are edible and very nutritious. Seeds of *Gnetum ulva* are also consumed. Young leaves and inflorescences of *Gnetales* are common as a vegetable. The seed kernel of *Ginkgo* is highly nutritious and is eaten as food in China and Japan.

(iii) Wood: Many gymnosperms are famous as they have valuable woods. Many species of *Abies* provide a light weight useful wood utilized in making slippers. *Cedrus deodara* yields the strongest Indian timber which is resistant to white ants and fungal attacks. The twigs of *Juniperus* are used as incense in temples. The wood of *Picea smithiana* is used in railway trains as sleepers. The wood of *Pinus roxburgii* is used as timber. The wood of *P. wallichiana* is superior to that of *P. roxburgii*. *Taxus baccata* yields a durable wood. *Cryptomeria japonica* yields a valuable light wood.

(iv) Medical Value: The resin obtained from *Cycas rumphii* cures ulcers. The wood of *Cerdus deodara* possess diuretic and carminative properties which is used in pulmonary and urinary disorders, piles and rheumatism. *Cupressus sempervirens* leaves produce an essential oil which have vermifuge properties. The resin obtained from *Pinus eoxburgii* is used internally as stomachic and as a remedy for gonorrhoea. It is used externally for buboes and abscess. The seeds of *Pinus geradiana* yield an oil which is applied in the dressing of wounds and ulcers. The species of *Ephedra* yield a drug called as Ephedrine which is effective against asthma and bronchial troubles. The seed oil of *Gnetum ulva* is used in rheumatism.

(v) Resin and Oils: The wood of *Pinus roxburgii* is tapped for turpentine which is distilled to obtain resin and turpentine oil. Resin is also obtained from *Pinus wallichinana*. *P. insularis* leaves and wood give an essential oil. Some gymnosperms yield important oils.

(vi) Other Uses: The leaves and wood of *Pinus insularis* are used as fuel. *Gnetum gnemon* is utilized for making ropes. The seeds and stems of *Cycas revoluta* are often used in the preparation of wine in Japan. Fossil gymnosperms which were common and widely distributed during carboniferous period have contributed to the coal deposits. The wood of *Juniperus verginima* (red cedar) is used for pencil making. The bark of *Tsuga canadensis* yields tannin which is used in tanning hides. *Abies balsamea* yields Canada balsam.

8. Class Angiosperms (Flowering Plants or Anthophytes)

8.1 Classification History of Angiosperms

After Linnaeus classified plants, other taxonomists also realised the necessity to gather the information on natural history of vegetative world and their affinities at various hierarchy levels. George Bentham and J.D. Hooker proposed the most important natural system of angiosperm classification with 202 families being described and that was published in three volumes of "Genera Plantarum". In this system, detailed studies and dissections described plants here. British Common wealth countries including India follow this system. The system is handy and easy thus preferred to be used by the students in their practical classes. This system covered about 97000 species of seed bearing plants.

Bentham and Hooker classification system, classifies on the basis of morphological characters such as leaf arrangement and venation pattern, number of members in floral whorls like calyx, corolla, androecium and gynoecium, number of members in floral like calyx, corolla, androecium and gynoecium, number of cotyledons in the seed and seeds with or without cover phanerogams were divided into three classes. In this classification, Class = division, series = class, cohort = order and order = family.

An outline of the Bentham and Hooker classification of phanerogamia:

Class 1: Dicotyledonae

Class 2: Gymnospermae

Class 3: Monocotyledonae

Class 1: Dicotyledonae

General characters

- Pentamerous flower,
- Reticulate venation in leaves,
- Two cotyledons in seed,
- Open vascular bundles (with cambium), and
- Secondary growth present along with wood formation.

It is divided into 3 sub-classes

Table 4.6: Sub- division of Class Dicotyledonae

Sub-class 1: Polypetalae – **Petals free.** **It includes three series.**		
Series	**Characters**	**Order**
Series 1: Thalamiflorae	Flower hypogynous, stamens and pistils many (indefinite), petals free, distinct sepals are free from ovary	6 orders, e.g., Ranales, Parietales, and Malvales etc.

Series 2: Disciflorae	Flower hypogynous, Calyx consists of free or united sepals, Petals free, a prominent cushion shaped disc is present below ovary	4 orders, e.g., Sapindales, Gerniales etc
Series 3: Calyciflorae	Flower perigynous or epigynous, calyx contains united sepals (rarely free), ovary inferior	5 orders, e.g., Rosales, Umbellates etc.
Sub-class 2: Gamopetalae – **Petals united or fused.** **It includes 3 series:**		
Series 1: Inferae	Flower epigynous, ovary inferior, stamens as many as corolla lobes or fewer	3 orders, e.g., Asterales, Campanulates etc.
Series 2: Heteromerae	Ovary usually superior, carpels more than two	3 orders, e.g., Ericales, Primulales, and Ebenales
Series 3: Bicarpellatae	Ovary usually superior, two carpels (rarely one or three).	4 orders, e.g., Lamiales, Polemoniales etc
Sub-class 3: Monochlamydeae – **Flower incomplete, no distinction between calyx and corolla, perianth present which is usually sepaloid and may be absent.** **It includes 8 series:**		
Series 1: Curvembryeae –	Embryo curved, generally one ovule.	
Series 2: Multiovulatae aquaticae	Plants are aquatic, submerged herbs, syncarpous ovary.	
Series 3: Multiovulatae terrestris	Plants are terrestrial, syncarpous ovary.	
Series 4: Microembryae	Very minute or small embryo.	
Series 5: Daphnales	Ovary with one carpel and one ovule.	
Series 6: Achlamydosporae	Ovary unilocular with 13 ovules	
Series 7: Unisexuales	Flower unisexual.	
Series 8: Ordines anomali	Families having plants with anomalous (abnormal) characters.	

Class 2: Gymnospermae

Sex organs are male and female cones, perianth is absent, ovule and seeds are naked (not found inside ovary), haploid endosperm.

It has three families – Gnetaceae, Coniferae and Cycadaceae.

Class 3: Monocotyledonae

Parallel venation in leaves, embryo with one cotyledon, flower usually trimerous, wood absent, no secondary growth.

It includes 7 series

Table 4.7: Sub- division of Class Monocotyledonae

Series	Features
Series 1: Microspermae	Ovary inferior, seed minute.
Series 2: Epigynae	Ovary inferior, seeds larger.
Series 3: Coronarieae	Ovary superior, perianth coloured.
Series 4: Calycineae	Ovary superior, perianth green.
Series 5: Nudiflorae	Perianth absent, ovary superior.
Series 6: Apocarpae	Carpels free (apocarpous).
Series 7: Glumaceae	Flowers arranged in spikelets with bracts, perianth reduced, bracts large and scaly.

Merits of this System

- Useful in practical uses.
- Ranales were given most primitive position in the dicots
- Giumaceae was believed to be most advanced species in monocots.

Demerits of Bentham and Hooker's System

- Gymnosperms had a place between dicots and monocots.
- Many important floral characters were not considered.
- It believes in fixity of species and not a phylogenetic system.
- Some closely related families were separately placed in different cohorts (order) and unrelated families were placed in same cohorts.
- Advanced family like Orchidaceae (Microspermae) was considered to be primitive.

Angiosperms as per Whittaker

Angiosperms are the plants that have ovules and seeds covered inside the fruits and the sporophylls are present in the flowers. These plants grow and thus seen in all the possible habitats. *Tillandsia* (Spanish moss) is an epiphytic angiosperm.

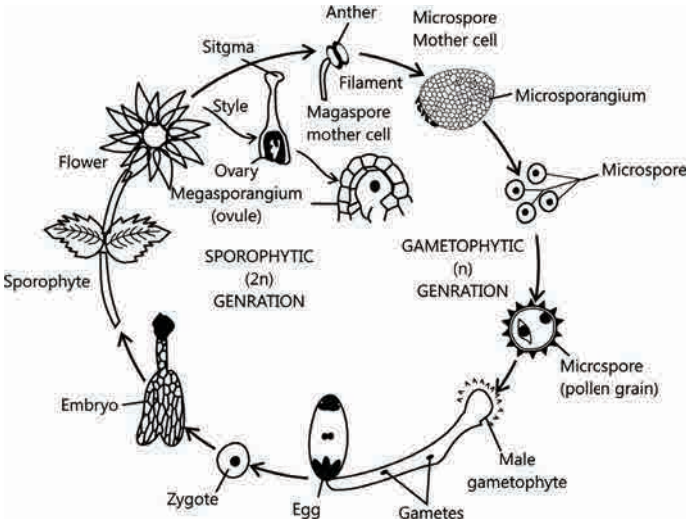


Figure 4.33: Reproduction and alteration of generations in Angiosperms

General Characters of Angiosperms

- The most recent thus highly evolved plants.
- Sporophylls are aggregated in flowers, the most specific feature of angiosperms. Thus, angiosperms are also called as flowering plants.
- Stamen (male sex organ) is made up of a filament and an anther. Carpel (female sex organ) is rolled, partly sterilised so that it forms a stigma, style and ovary, which is made of ovules.
- Pollination is indirect through several agencies, most common is through animals, especially insects.
- Pollen grains or microspores travel to reach the stigmatic surface at the tip of carpel or megasporophyll.
- Female gametophyte or embryo sac is highly shortened, multiplies upto 8-nucleate stage before fertilisation.
- Archegonia are replaced by one egg surrounded by two specialised synergid cells to attract the pollen tube in fertilisation. The synergid cells attract two naked non-flagellate male gametes.
- Double fertilisation takes place: One male gamete with one egg produces zygote that is embryo. The other male gamete with synergid cell and forms primary endosperm cell.
- Endosperm is formed through triple fusion (male gamete and two synergid cells) thus it is triploid.
- Ovules then fertilize into embryo which ripen into seeds. The seeds have a cover of ovary wall. A fruit is thus a ripened ovary. Fruits protect the seeds, help in their dispersal and nourish it till the dispersion.
- Xylem contains vessels.
- Phloem has sieve tubes and companion cells.
- Angiosperms have two sub-groups on the basis of number of embryonic leaves or cotyledons: dicotyledons and monocotyledons. The two are commonly termed as dicots and monocots respectively.

Table 4.8: Difference between Dicotyledonae and Monocotyledonae

Dicots	Monocots
Seeds have two cotyledons.	Seeds have one cotyledon.
Flowers are pentamerous or tetramerous (floral parts in sets of 5 and 4 or their multiples)	Flowers are trimerous (floral parts in sets of three or its multiples).
Leaves are net-veined with reticulate venation with a few exceptions.	The leaves possess parallel venation with a few exceptions.
Primary root is long lived, forming tap root system and adventitious roots are uncommon.	Primary root is short-lived and thus adventitious roots are common.
Vascular bundles of the stem are arranged in a ring.	Vascular bundles are found scattered.
Vascular bundles of the stem possess cambium (vascular bundles open), and hence secondary growth is possible.	Cambium is absent (vascular bundle closed), thus no secondary growth.

Table 4.9: Difference Between Various Plant Groups Having Embryo

Features	Bryophyta	Pteriodophyta	Gymnosperms	Angiospersms
Dominant phase	Gametophyte	Sporophyte	Sporophyte	Sporophyte
Ploidy of main plant body	Haploid	Diploid	Diploid	Diploid
Differentiation of body	Thallus or foliose structures and rhizoids	Roots, stem and leaves	Roots, stem and leaves	Roots, stem and leaves
Vascular bundles	Absent	Present	Present	Present
Nature of spores	Homospores	Homospores and Heterospores	Heterospores	Heterospores
Seed and its covering	Seed absent	Seed absent	Seed naked (without covering)	Seed with covering
Flower and fruit	Absent	Absent	Absent	Present

9. Plant Life Cycles and Alternation of Generations

Life cycle of a plant shows spore formation and seed formation which is called alternation of generations.

- In plants, both haploid and diploid cells can divide by mitosis.

  This ability leads produces different plant bodies: halpoid gamete producing plant (gametophyte) and diploid spore producing plant (sporophyte).

- The haploid plant body produces gametes with mitosis.

  Following fertilization, the zygote may divide mitotically to produce sporophyte or may divide meiotically to produce haploid spores.

- Haploid spores divide mitotically and produce gametophyte.

  Thus, in the life cycle of a sexually reproducing plant, an alternation of generations occur between the haploid and diploid phases of the plant.

  Syngamy and meiosis seems to be instrumental for this event.

  There are three phases in the life cycle. They are fundamentally different in the duration of the haploid and diploid phases.

9.1 Haplontic

Haplophase is the most dominant phase. The plant body is gamete producer and independent. The sporophyte phase is dependent on gametophyte phase, and thus does not exist as a free living body. The major part of life is dominated by gametophyte, e.g., majority of green algae viz. *Chlamydomonas, Ulothrix, Spirogyra* etc.

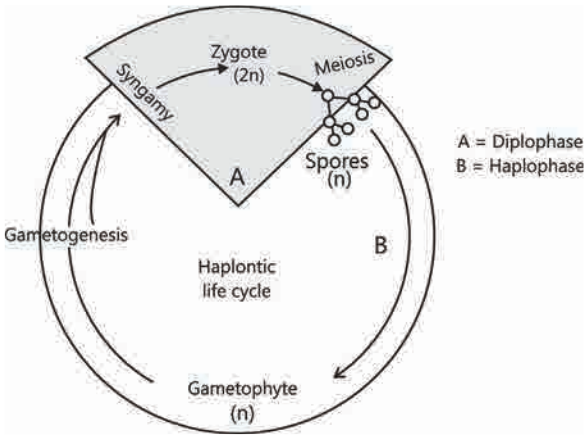


Figure 4.34: Haplontic life cycle in *Ulothrix*

9.2 Diplo-Haplontic or Haplo Diplontic

There exists both sporophyte as well as gametophyte. Both perform photosynthesis and are multicellular bodies, free living with almost two equal phases: the diplophase and haplophase. When morphologically different sporophytes and gametophytes occur, then the cycle is called as Diplo-Haplontic-heteromorphic, e.g., all pteridophytes; all bryophytes, some brown algae viz., *Laminaria* and other Kelps. When the two phases are morphologically identical, then the life cycle is called as Diplo-Haplontic-isomorphic, e.g., green algae viz., *Ulva* and *Cladophora*; brown algae, such as *Ectocarpus*.

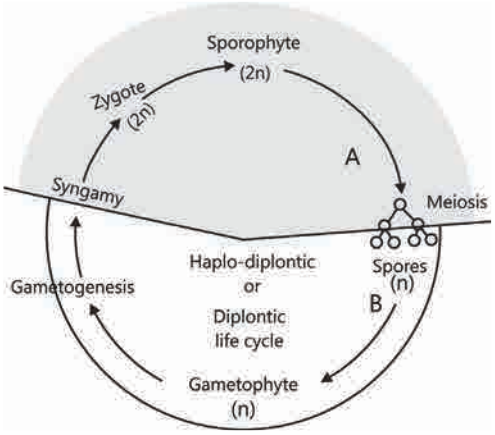


Figure 4.35: Haplo Diplontic life cycle in *Ulva*

9.3 Diplontic

The dominant phase is diplophase. The plant body is sporophyte which is independent and free living. The gametophytes are extremely reduced, dependent physically and nutritionally on the sporophyte. The major part in life cycleis the sporophyte, e.g., all gymnosperms and angiosperms; *Diatoms*; some brown algae, viz., *Fucus* and *Sargassum*.

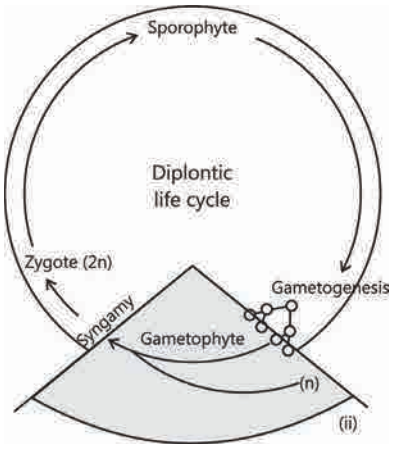


Figure 4.36: Diplontic life cycle in *Fucus*

Try It Yourself

1. *Fucus* and *Sargassum* show _____ life cycle pattern.
2. Both pollen grains and seeds are winged in *Cycas* (True/False).
3. Polyxylic and manoxylic wood is present in *Cycas* (True/False).
4. Endosperm is triploid, nutritive tissue in _____.

Summary

- Plant kingdom is divided into algae, bryophytes, pteridophytes, gymnosperms and angiosperms.
- Algae are chlorophyll-bearing simple, thalloid, autotrophic and largely aquatic organisms.
- Depending on the type of pigment possessed and the type of stored food, algae are classified into three classes, namely Chlorophyceae, Phaeophyceae and Rhodophyceae.
- Algae usually reproduce vegetatively by fragmentation, asexually by formation of different types of spores and sexually by formation of gametes which may show isogamy, anisogamy or oogamy.
- Bryophytes are plants which can live in soil but are dependent on water for sexual reproduction. Their plant body is more differentiated than that of algae. It is thallus-like and prostrate or erect and attached to the substratum by rhizoids. They possess root-like, leaf like and stem-like structures.
- The bryophytes are divided into liverworts, hornworts and mosses.
- The plant body of liverworts is thalloid and dorsiventral whereas mosses have upright, slender axis bearing spirally arranged leaves.
- The main plant body of a bryophyte is gamete-producing and is called gametophyte. It bears the male sex organs called antheridia and female sex organs called archegonia. The male and female gametes fuse to form zygote which produces a multicellular body called sporophyte. It produces haploid spores. The spores germinate to form gametophytes.
- In pteridophytes the main plant is a sporophyte which is differentiated into true root, stem and leaves. These organs possess well-differentiated vascular tissues.
- The sporophytes in pteridophytes bear sporangia which produce spores. The spores germinate to form gametophyte which require cool, damp places to grow.
- The gametophyte in pteridophytes bear male and female sex organs called antheridia and archegonia, respectively.
- Water is required for transfer of male gametes to archegonium in both bryophytes and pteridophytes where zygote is formed after fertilisation. The zygote produces a sporophyte by dividing mitotically.
- The gymnosperms are the plants in which ovules are not enclosed by any ovary wall. After fertilization the seeds remain exposed and therefore these plants are called naked-seeded plants.
- The gymnosperms produce microspores and megaspores which are produced in microsporangia and megasporangia borne on the sporophylls.
- The sporophylls-microsporophylls and megasporophylls are arranged spirally on axis to form male and female cones, respectively.
- The pollen grain germinates and pollen tube releases the male gamete into the ovule, where it fuses with the egg cell in archegonia. Following fertilisation, the zygote develops into embryo and the ovules into seeds.

- In angiosperms, the male sex organs (stamen) and female sex organs (pistil) are born in a flower. Each stamen consists of a filament and an anther. The anther produces pollen grains (male gametophyte) after meiosis. The pistil consists of an ovary enclosing one to many ovules.
- Within the ovule is the female gametophyte or embryo sac which contains the egg cell. The pollen tube enters the embryo-sac where two male gametes are discharged. One male gamete fuses with egg cell (syngamy) and other fuses with diploid secondary nucleus (triple fusion). This phenomenon of two fusion is called double fertilisation and is unique to angiosperms.
- The angiosperms are divided into two classes-the dicotyledons and the monocotyledons.
- During the life cycle of any sexually reproducing plant, there is alternation of generations between gamete producing haploid gametophyte and spore producing diploid sporophyte. However, different plant groups as well as individuals may show different patterns of life cycles-haplontic or intermediate, i.e., haplodiplontic or diplohaplontic.

EXERCISE

Objective Questions

Q.1 Which of the following are parasitic algae?

(A) *Cephaleuros* (B) *Harveyella*

(C) Both (A) and (B) (D) None of the above

Q.2 Red algae is red due to the presence of

(A) R-Phycocyanin (B) R-Phycoerythrin

(C) C-Phycocyanin (D) C-Phycoerythrin

Q.3 Sea Lettuce is the name given to

(A) *Laminaria* (B) *Fucus* (C) *Sargassum* (D) *Ulva*

Q.4 Sea weeds belong to

(A) Red algae (B) Brown algae

(C) Green algae (D) Blue green algae

Q.5 Chlorophyll '*a*' and chlorophyll '*d*' are found in

(A) Rhodophyta (B) Phaeophyta

(C) Xanthophyta (D) Myxophyta

Q.6 Which pigment is found in phaeophyceae

(A) Chl. '*a*' and '*c*' (B) Chl. '*a*' and '*d*'

(C) Chl. '*a*' and '*e*' (D) None of these

Q.7 Reserve food in Rhodophyta is

(A) Floridean starch (B) Mannitol

(C) Leucosin (D) All of the above

Q.8 Photosynthetic pigments common with all algae are

(A) Chlorophyll '*b*' and carotene (B) Chlorophyll '*a*' and '*b*'

(C) Chlorophyll '*a*' and carotene (D) Chlorophyll and xanthophyll

Q.9 *Acetabularia*, belongs to

(A) Chlorophyta (B) Rhodophyta
(C) Pyroophyta (D) Phaeophyta

Q.10 Deepest algae in sea is

(A) Red algae (B) Brown Algae
(C) Green Algae (D) Golden Algae

Q.11 Which of the following plant groups have similar pigment composition

(A) Rhodophyta and Phaeophyta (B) Chlorophyta and Phaeophyta
(C) Rhodophyta and Cyanophyta (D) Xanthophyta and Euglenophyta

Q.12 Harveyella belong to which group

(A) Brown algae (B) Red algae
(C) Dinoflagellates (D) Diatoms

Q.13 Which of the following are colour less parasitic red algae?

(A) *Cephaleuros* (B) *Harveyella*
(C) *Polysiphonia* (D) *Ectocarpus*

Q.14 Green algae are considered as the ancestors of higher plants due to their resemblance with higher plants in

(A) Pigments (B) Cell wall
(C) Stored food (D) All the above

Q.15 The name ‘‘Thallophyta’’ was coined by

(A) Endlicher (B) Linnaeus
(C) Christenson (D) Haeckel

Q.16 Unique character of Thallophyta is

(A) Thalloid body (B) Absence of vascular tissue
(C) Zygotic meiosis (D) All the above

Q.17 The characters of thallophyta is / are

(A) Plant body thallus (B) Non vascular plant
(C) Sex organ are unicellular (D) All the above

Q.18 Most advanced group of algae is

(A) Myxophyta
(B) Chlorophyta
(C) Xanthophyta
(D) Phaeophyta

Q.19 ''Agar-agar'' is obtained from

(A) Green Algae
(B) Red Algae
(C) Brown Algae
(D) Yellow green Algae

Q.20 Cephaleuros, which causes ''Red rust of tea'' is a

(A) Red Algae
(B) Brown Algae
(C) Dinoflagellate
(D) Green Algae

Q.21 Classification of algae is mainly based upon

(A) Reproductive organs
(B) Structure of spores
(C) Pigments
(D) Stored food

Q.22 ''Carageenin'' is obtained from

(A) *Chondrus*
(B) *Laminaria*
(C) *Gelidium*
(D) *Macrocystis*

Q.23 Female sex organ of algae is called

(A) Carpel
(B) Oogonium
(C) Archegonia
(D) Oospore

Q.24 Reserve food of algae and fungi are

(A) Starch and soluble floridoside
(B) Oil droplet and fats
(C) Starch and glycogen
(D) Starch and Glycerol

Q.25 Chlorophyll '*c*', '*d*' and '*e*' are characteristic pigments of respectively

(A) Red algae, brown algae and yellow green algae
(B) Brown algae, Red algae and yellow green algae
(C) Diatoms, Dinoflagellates, Euglena
(D) Higher plants, Red algae, Diatoms

Q.26 Vascular cryptogams or seed less vascular plants belong to

(A) Bryophyta (B) Pteridophyta
(C) Thallophyta (D) Spermatophyta

Q.27 Most conspicuous alternation of generation occurs in

(A) Thallophyta (B) Bryophyta
(C) Pteriodophyta (D) Spermatophyta

Q.28 Which of the following is called resurrection pteridophyte

(A) *Lycopodium* (B) *Selaginella*
(C) *Pteridium* (D) *Dryopteris*

Q.29 Pteridophytes which produce cones, can be classified in

(A) Psilopsida and Lycopsida (B) Lycopsida and Filicinae
(C) Sphenopsida and Filicinae (D) Sphenopsida and Filicinae

Q.30 Which of the following is called ‘‘Tree Fern’’?

(A) *Cyathea* (B) *Marsilea*
(C) Sphenopsida and Lycopsida (D) Sphenopsida and Filicinae

Q.31 The main plant body of Pteridophytes is

(A) Sporophyte (B) Gametophyte
(C) Haploid (D) None of the above

Q.32 Which one of the following is called as ‘‘Walking fern”?

(A) *Adiantum* (B) Selaginella (C) *Pteridium* (D) *Marsilea*

Q.33 Among the folowing fern, which is an excellent biofertilizer?

(A) *Salvinia* (B) *Azolla* (C) *Pteridium* (D) *Marsilea*

Q.34 Which of the following is an aquatic fern?

(A) *Azolla* (B) *Selaginella* (C) *Isoetes* (D) *Equisetum*

Q.35 The botanical name of ‘’Sanjeevani’’ is

(A) *Selaginella utricularia* (B) *Selaginella bryopteris*
(C) *Selaginella crotalaria* (D) *Selaginella botardia*

Q.36 The aquatic fern which support the growth of the blue green algae, *Anabaena*, and is used to increase the yield of paddy crop is

(A) *Salvinia* (B) *Marsilea* (C) *Isoetes* (D) *Azolla*

Q.37 In ferns, the permanent roots are

(A) Tap root (B) Adventitious roots
(C) Tuberious roots (D) Rhizome

Q.38 Stem is distinctly differentiated into node and inter node in

(A) Psilopsida (B) Lycopsida
(C) Sphenopsida (D) None

Q.39 Cone is absent in

(A) Sphenopsida (B) Filicinae
(C) Lycopsida (D) Both (B) and (C)

Q.40 In pteridophytes the spores germinate to form

(A) Ptotonema (B) Prothallus
(C) Sporophyte (D) Archegonium

Q.41 In heterosporous pteridophyta, the gametophytes are

(A) Monoecious (B) Dioecious
(C) Sterile (D) Inter sex

Q.42 The charasterstic feature of pteridophytes is

(A) Seeds are naked (B) Seeds are covered with fruit
(C) No seed formation (D) Vessels are present

Q.43 Green leaves are totally absent in

(A) Psilopsida (B) Lycopsida
(C) Sphenopsida (D) Ferns

Q.44 Seedless vascular plants are

(A) Ferns (B) Lower gymnosperm
(C) Dicots (D) Ferns and lower gymnosperm

Q.45 Pteridophytes plants are more successful to terrestrial life as compared to bryophytes in having

(A) Roots and nonmotile gamets
(B) Roots and independend gametophyte
(C) Leaves
(D) Roots and vascular tissue

Q.46 Ressurection plant is

(A) *Selaginella*
(B) *Azolla*
(C) *Marsilea*
(D) *Isoetes*

Q.47 In pteridophyta, reproductive leaves are called:

(A) Cataphylls
(B) Trophophylls
(C) Gametangia
(D) Sporophylls

Q.48 Most advanced Gymnosperm belongs to –

(A) Cycadales
(B) Coniferales
(C) Gnetales
(D) Cycadofilicales

Q.49 Which of the following is called father of forest –

(A) *Pinus*
(B) *Banyan*
(C) *Sequoia*
(D) *Cedrus*

Q.50 All Gymnosperms are-

(A) Heterosporus
(B) Vascular
(C) Seed plants
(D) All the above

Q.51 Gymnosperm plants lack –

(A) Vessels
(B) Fruits
(C) Companion cells
(D) All the above

Q.52 Resin turpentine is obtained from

(A) *Pinus*
(B) *Adiantum*
(C) Club mosses
(D) *Sequoia*

Q.53 Which group is largest in gymnosperms

(A) Cycadales
(B) Gnetales
(C) Coniferales
(D) Cordaitales

Q.54 Gnetum belongs to

(A) Pteridophyta
(B) Bryophyta
(C) Angiosperms
(D) Gymnosperm

Q.55 Living fossils

(A) *Cycas*
(B) *Ginkgo*
(C) *Psilotum*
(D) All the above

Q.56 Which of the following order of gymnosperae is totally extinct –

(A) Cycadales (B) Ginkgoales (C) Gnetales (D) Cycadofilicales

Q.57 Which of the following is commonly known as ''Yew tree''

(A) *Pinus roxburghli* (B) *P. strobus* (C) *Taxus* (D) *P. sylvestris*

Q.58 Gymnosperms differ from pteridophytes in having

(A) Presence of vessels (B) Presence of embryo
(C) Presence of seed (D) Companion cell

Q.59 Fossils of *Williamsonia* were first discovered by

(A) Williamson (B) Seward (C) Birbal Sahani (D) Kashyap

Q.60 Professor Birbal sahani discovered a fossil plant from 100 million years old fossil forest at Rajmahal Hills, Bihar. This plant is –

(A) *Rhynia* (B) *Homeophyton* (C) *Williamsonia* (D) Red algae

Q.61 The characteristic feature of gymnosperm is –

(A) Seeds are naked (B) Fruits are absent
(C) Heterosporus (D) All

Q.62 In nature the largest ovules are found in –

(A) *Sequoia* (B) *Ginkgo* (C) *Pinus* (D) *Cycas*

Q.63 The plants of gymnosperms are –

(A) Homo and heterosporous (B) Homosporous
(C) Heterosporous (D) Monoecious

Q.64 *Taxus* belongs to –

(A) Ephedrales (B) Cycadales (C) Coniferales (D) Gnetales

Q.65 Vessels are found in –

(A) Coniferales (B) Gnetales (C) Cycadales (D) Ginkgoales

Q.66 In heterosporous plants like some ferns, gymnosperms and angiosperms, the gametophytes are

(A) Monoecious (B) Dioecicus (C) Heteroecious (D) Autoecious

Q.67 If pollen tube bursts in mid way, the male gametes will not be anle to fertilize the egg in.

(A) Lower gymnosperms (B) High gymnosperms
(C) Angiosperm (D) (B) and (C) both

Q.68 Cedar wood oil is obtained from

(A) *Cedrus* (B) *Ables balsemia* (C) *Pinus* (D) *Junipenus virginiana*

Q.69 The megasporophyll of gymnosperms is equivalent to

(A) Stem (B) Carpels (C) Female cone (D) stamens

Q.70 Which in the most logical sequence with reference to the life cycle of angiosperm

(A) Germination, endosperm formation, seed dispessal, double fertilization
(B) Endosperm formation, seed formation, fertilization, seed germination
(C) Pollination, fertilization, seed formation, seed germination
(D) Fertilization, seed dispersal, edosperm formation, seed germination

Q.71 Only angiosperms have –

(A) Seed (B) Vascular tissue
(B) Fruit (D) Endosperm

Q.72 Most reduced size gametophyte is of –

(A) Bryophytes (B) Pteridophytes (C) Gymnosperm (D) Angiosperm

Q.73 Microsporophyll of angiosperms is known is –

(A) Androecium (B) Anther (C) Filament (D) Stamen

Q.74 Which one is female gametophyte –

(A) Embryo (B) Embryosac (C) Endosperm (D) Pistil

Q.75 Ovule of an angiosperm is technically equivalent to –

(A) A megasporangium (B) A microsporangium
(C) A micro spore (D) A megaspore

Q.76 In angiosperm megasporophyll is equal to –

(A) Gynoecium (B) Carpel (C) Ovary (D) Stigma

Q.77 Which of the following nuclei participate in double fertilization –

(A) The egg (B) The secondary nucleus

(C) The two male nuclei (D) All of the above

Q.78 After fertilization which structure produces seed –

(A) Ovule (B) Ovary (C) Embryo (D) Endosperm

Q.79 Normal embryo is developed by the activity of

(A) Two polar nuclei of embryosac

(B) Secondary nucleus and male gamete

(C) Egg cell and male gamete

(D) Synergids

Q.80 The fusion product of polar nuclei and male gametes is

(A) Nucellus

(B) Zygote

(C) Primary endosperm nucleus

(D) Secondary nucleus

Q.81 Haploid diploid and triploid conditions can be traced respectively in –

(A) Egg, Nucellus, Endosperm

(B) Antipodal, Egg, Endosperm

(C) Nucellus, Endosperm, Synergids

(D) Antipodal, Synergids, Endosperm

Q.82 The number of nucleus taking part in double fertilization are

(A) Two (B) Three (C) Four (D) Five

Q.83 Endosperm of maximum angiosperm is

(A) 2n (B) 3n (C) n (D) n + 1

Q.84 Embryosac is

(A) 7 celled 7 nucleated (B) 8 celled 8 nucleated

(C) 7 Celled 8 nucleated (D) 8 celled 7 nucleated

Q.85 Subkingdom Cryptogamia in classification system given by Linnaeus includes

(A) Thallophyta, Bryophyta and Gymnosperms
(B) Thallophyta, Bryophyta and Pteridophyta
(C) Pteridophyta, Gymnosperms and Angiosperms
(D) Gymnosperms and Angiosperms

Q.86 Find odd one out w.r.t. natural classification systems

(A) Bentham and Hooker's system
(B) De Candolle system
(C) John Ray's system
(D) Eichler's system

Q.87 1. Number and codes are assigned to few of the selected characters in numerical taxonomy

2. Phylogenetic classification system are based on evolutionary relationships between the various organisms

3. Cytotaxonomy is based on cytological information like chromosome number, structure & behaviour

(A) 1 and 2 are incorrect
(B) Only 3 is correct
(C) Only 1 is incorrect
(D) 2 and 3 are incorrect

Q.88 Each character is given equal important and at the same time hundreds of characters can be considered in

(A) Cladistics
(B) Phenetics
(C) Chemotaxonomy
(D) Cytotaxonomy

Q.89 Which of the following type of taxonomy deals with the collection and identification of organism on the basis of gross morphology?

(A) Alpha taxonomy
(B) Beta taxonomy
(C) Omega taxonomy
(D) Karyotaxonomy

Q.90 Coenobium is the name given to the colony of

(A) *Chlamydomonas*
(B) *Fritshiella*
(C) *Volvox*
(D) *Voucheria*

Q.91 All given algal members possess unicelled sex organs, except

(A) *Chara*
(B) *Ulothrix*
(C) *Spirogyra*
(D) *Chlamydomonas*

Q.92 Anteriorly placed, equal, 2-8, flagella are characteristic to

(A) Blue green algae
(B) Green algae
(C) Brown algae
(D) Red algae

Q.93 Which set of characters is specific to red algae?

(A) Phycobilins, Chlorophyll *a* and *c*
(B) Chlorophyll *a* and *d*, Floridean starch
(C) Flagella absent, Mannitol
(D) Fucoxanthin, Floridean starch

Q.94 Find odd one w.r.t. fresh water algae

(A) *Batrachlospermum*
(B) *Spirogyra*
(C) *Volvox*
(D) *Chondrus*

Q.95 Select an incorrect match

(A) *Porphyra* – Edible red algae
(B) *Gracilaria* – Agar
(C) *Alaria* – Surumen
(D) *Cephaleuros* – Iodine

Q.96 Plant body is differentiated in hold fast, stipe and frond in

(A) *Ulva*
(B) *Laminaria*
(C) *Oedogonium*
(D) *Acetabularia*

Q.97 Chloroplast is star shaped in

(A) *Oedogonium*
(B) *Zygnema*
(C) *Chlorella*
(D) *Ulothrix*

Q.98 *Chlorella pyrenoidosa* is commonly called as

(A) Irish moss
(B) Laver
(C) Space alga
(D) Frog spawn alga

Q.99 Thin walled, non-motile, asexual, endogenous spores in some algal members are called

(A) Zoospores
(B) Aplanospores
(C) Hyponspores
(D) Cyst

Q.100 Select incorrect statement w.r.t. *Chlamydomonas*

(A) Cell is pyriform
(B) Presence of contractile vacuoles
(C) Cell wall having polysulphate esters
(D) Cup shaped chloroplast

Q.101 Flagella in a *Chlamydomonas* cell are

(A) 2; both tinsel type
(B) 2; one tinsel and other whiplash
(C) Cell wall having polysulphate esters
(D) Cup shaped chloroplast

Q.102 Red snow is associated with _____ of *Chlamydomonas*.

(A) Zoospore (B) Hypnospore (C) Aplanospore (D) Tetraspore

Q.103 The cell of *Ulothrix* attached to substratum

(A) Is non dividing and photosynthetic
(B) Is green and dome shaped
(C) Is non green and non dividing
(D) Has an eye spot

Q.104 Quadriflagellated zoospores are characteristically found in

(A) *Spirogyra*
(B) *Chlamydomonas*
(C) *Ulothrix*
(D) *Volvox*

Q.105 All given statements are correct for *Ulothrix*, except

(A) Unbranched filamentous algae
(B) Parenchymatous sheet like body
(C) Occurrence of palmella stage
(D) Girdle shaped chloroplast

Q.106 Number of new filaments produced by means of sexual reproduction in *Spirogyra* is equivalent to

(A) Number of zygospores
(B) Number of melosis
(C) Number of gametes
(D) More than one option is correct

Q.107 Mark the correct option (w.r.t. *Spirogyra*)

(A) Chloroplast is spiral
(B) Many pyrenoids are present in chloroplast
(C) Cytoplasmic strands hold the nucleus
(D) All of these

Q.108 Select a correct match

(A) *Cryptothallus* – Epiphytic bryophyte
(B) *Buxbaumia* – Parastic bryophyte
(C) *Bryophyta* – First archegoniate
(D) *Riccia fluitans* – Saprophytic bryophyte

Q.109 Ecologically the most important moss is

(A) *Sphagnum* (B) *Funaria* (C) *Polytrichum* (D) *Pogonatum*

Q.110 Thallus of which bryophyte resembles algae in structure?

(A) *Porella* (B) *Riccia* (C) *Anthoceros* (D) *Marchantia*

Q.111 All given members are monoecious, except

(A) *Marchantia* (B) *Funaria* (C) *Anthoceros* (D) *Sphagnum*

Q.112 Hygroscopic structure present in *Marchantia* for spore dispersal is called

(A) Elater (B) Pseudoeiater (C) Nurse cell (D) Annulus

Q.113 Select incorrect statement w.r.t. characters of true moss

(A) Multicelled branched rhizoids (B) Multicelled asexual buds
(C) Diploid sporophytic structures (D) Haploid sexual structures

Q.114 *Gemmae* are

(A) Unicelled structures (B) Multicelled asexual buds
(C) Diploid sporophytic structures (D) Haploid sexual structures

Q.115 Number of neck canel cells in true mosses is

(A) 4 (B) 4 – 6 (C) 1 (D) 6 – 10

Q.116 Find odd one out w.r.t. ploidy level in bryophytes

(A) NCC (B) VCC (C) spore (D) Theca

Q.117 Sporophyte is a partial parasite on gametophyte in

(A) *Marchantia* (B) *Porella* (C) *Pogonatum* (D) *Riccia*

Q.118 Photosynthetic tissue is present in _____ region of *Funaria* capsule.

(A) Apophysis (B) Theca
(C) Operculum (D) More than one option is correct

Q.119 Central sterile tissue of capsule in sporophyte of *Funaria* is called as

(A) Apophysis (B) Annulus (C) Columella (D) Operculum

Q.120 Pteridophytes are also called

(A) Vascular amphibians of plant kingdom (B) First tracheophytes
(C) Botanical snakes (D) All of these

Q.121 Find the correct option w.r.t. Filicophyta

(A) *Seleginella* (B) *Equisetum* (C) *Dryopteris* (D) *Lycopodium*

Q.122 Select a set of heterosporous genera

(A) *Marsilea, Azolla* (B) *Salvinia, Pteridium*
(C) *Adiantum, Azolla* (D) *Pteris, Lycopodium*

Q.123 True ferns are associated with all, except

(A) *Circinate ptyxis* (B) Presence of rementa

(C) Presence of frond (D) Biflagellated male gametes

Q.124 Select the correct match

(A) Psilopsida – *Dryopteris* (B) Lycopsida – *Selaginella*

(C) Sphenopsida – *Pteris* (D) Pteropsida – *Equisetum*

Q.125 Ectophloic siphonostele is found in

(A) *Equisetum* (B) *Adiantum* (C) *Marsilea* (D) *Rhynia*

Q.126 In life Cycle of *Dryopteris*

(A) Main plant body is gametophyte (B) True indusium covers the sorus

(C) Sucrose attracts the male gametes (D) Two NCC are found in archegonium

Q.127 (i) Companion cells and sieve tubes are absent in pteridophytes

(ii) Eusporangiate development is characteristic of true ferns

(iii) Cordate prothallus is found in *Dryopteris*

(A) Only (iii) is incorrect (B) Only (i) is incorrect

(C) (i) and (ii) are correct (D) Only (ii) is incorrect

Q.128 Stele with large number of overlapping leaf gaps is called as

(A) Protostele (B) Actinostele (C) Dictyostele (D) Plectostele

Q.129 Antheridium of *Dryopteris* has _____ called jacket and about _____ sperm mother cells.

(A) 3, 16 (B) 2, 32 (C) 2, 16 (D) 3, 32

Q.130 ''Organ sui generis'' is also called

(A) Rhizoid (B) Rhizomorph (C) Rhizophore (D) Rhizine

Q.131 Consider the given features

(i) Resurrection habit, (ii) Meroblastic embryo development

(iii) Endosporic and diploid female gametophyte, (iv) Precocious germination of spores

Find correct w.r.t. *Selaginella*

(A) (i), (ii), (iii) (B) (i), (iii), (iv) (C) (i), (iii) (D) (i), (ii), (iv)

Q.132 Endosperm in gymnosperms is

(A) n (B) 2n (C) 3n (D) 4n

Q.133 Select a correct match

(A) Chilgoza – *Pinus gerardiana* (B) Canada balsum – *Ephedra*

(C) Cedar wood oil – *Cedrus* (D) Taxol – *Ginkgo*

Q.134 (i) Siphonogamy is found in *Pinus*, (ii) Stem branches are monomorphic in *Pinus*
(iii) Wood is monoxylic and manoxylic in *Pinus*

(A) (i) and (iii) are incorrect (B) Only (i) is correct

(C) Only (iii) is correct (D) (i) and (ii) are correct

Q.135 How many ovules are present on each megasporophyll of *Pinus*?

(A) One (B) Two (C) Four (D) Eight or more

Q.136 Mark the odd one (w.r.t. *Ginkgo biloba*)

(A) Presence of naked seeds (B) Absence of flowers

(C) Presence of heterospory (D) Absence of long shoot

Q.137 Transfusion tissue is found in the leaves of

(A) Gymnosperms (B) Ferns (C) Monocols (D) Dicots

Q.138 Match the column I with column II

	Column I		Column II
(P)	Largest gymnosperm	(i)	*Zamia*
(Q)	Pagoda tree	(ii)	*Ephedra*
(R)	Smallest gymnosperm	(iii)	*Ginkgo biloba*
(S)	Ephedrine	(iv)	*Sequoia*

(A) P(i), Q(iv), R(iii), S(ii) (B) P(iv), Q(iii), R(i), S(ii)

(C) P(iv), Q(iii), R(ii), S(i) (D) P(ii), Q(iii), R(iv), S(i)

Q.139 Mark the incorrect option (w.r.t. Gnetales)

(A) *Ephedra* (B) *Ginkgo* (C) *Welwitschia* (D) *Gnetum*

Q.140 Features like coralloid root and circinate ptyxis are present in

(A) *Pinus* (B) *Cycas* (C) *Ginkgo* (D) *Cedrus*

Q.141 Independent free living, photosyntheric gametophyte is not found in

(A) *Funaria* (B) *Marchantia* (C) *Cycas* (D) *Riccia*

Q.142 Female gametophyte in angiosperms is called

(A) Endosperm (B) Carpel (C) Ovule (D) Embryo sac

Q.143 Find odd one out w.r.t. haplontic life cycle

(A) *Ectocarpus* (B) *Ulothrix* (C) *Spirogyra* (D) *Chlamydomonas*

Q.144 Select correct w.r.t. diplohaplontic life cycle

(A) Found in *Polysiphonia* and *Gnetum*

(B) Both gametophyte and sporophyte phases are present

(C) Common in green algae

(D) Gametic meiosis occurs

Q.145 Details of sexual system of classification were published in

(A) Historia Plantarum (B) Historia Naturalis

(C) Historia Generalis Plantarum (D) Genera Plantarum

Q.146 Basis of dendrogram is

(A) Phenetics (B) Taximetrics (C) Numerical taxonomy (D) All of these

Q.147 Huxley is considered to be the founder of

(A) Classical systematics (B) New systematics

(C) Phylogenetic system of classification (D) Artificial system of classification

Q.148 The classification of plants and animals on the basis of chromosome number if called

(A) Cytotaxonomy (B) Biochemical systematics

(C) Taxonomy (D) Numerical taxonomy

Q.149 The sequencing in DNA and chemical nature of proteins have been used as the basis of classification by

(A) Cytotaxonomist (B) Karyotaxonomist

(C) Chemotaxonomist (D) Natutal taxonomist

Q.150 Term Alpha-taxonomy was introduced by

(A) John Ray (B) Hutchinson (C) Bassey (D) Turril

Q.151 Sexual system of classification is

(A) Artificial system (B) Based on stamens characters

(C) Based on corolla and carpels characters (D) Both (A) and (B)

Q.152 The Linnaeus system of classification contains

(A) 4 classes of plants (B) 8 classes of plants

(C) 16 Classes of plants (D) 24 classes of plants

Q.153 Classification based on several characters is

(A) Natural (B) Artificial (C) Classical (D) Phylogenetic

Q.154 The natural system of classification was proposed by

(A) Engler and Prantl (B) Bentham and Hooker

(C) Carolus Linnaeus (D) Julian Huxley

Q.155 The Bentham and Hooker's classification is

(A) Classification of taxa based on actual examination

(B) Artificial system of classification

(C) Phylogenetic system of classification

(D) Based on evolution

Q.156 In Bentham and Hooker's system the term cohort have been used. It is same as which rank in today's classification?

(A) Class (B) Family (C) Order (D) Sub-Family

Q.157 Which one of the following classification is best suited for identification of seed plants?

(A) Bentham and Hooker's classification (B) Engler and Prantl's classification

(C) Hutchinson's classification (D) Takhtajan's classification

Q.158 Which is most advanced among the following?

(A) Cycadaceae (B) Gnetaceae (C) Coniferae (D) Cryptogamae

Q.159 Which is not true about the series Heteromerae in Bentham and Hooker's system?

(A) Always bicarpellary condition (B) Ovary usually superior

(C) Stamens are as many as corolla lobe (D) It includes 3 cohorts

Q.160 Who is not associated with the artificial system of classification?

(A) Pliny (B) Theophrastus (C) Hutchinson (D) Engler and prantl

Q.161 Evolutionary history of an organism is known as

(A) Candolle (B) Ontogeny (C) Phycology (D) Mycology

Q.162 Angiosperms (Dicotyledons) were distinguished into archichlamydeae and metachlamydeae by

(A) Candolle (B) Cronquist (C) Hutchinson (D) Engler and Prantl

Q.163 ''Taxonomy without phylogeny may be like a body without flesh'' is a statement supported by

(A) Oswald (B) Bentham and Hooker

(C) Takhtajan (D) John Hutchinson

Q.164 Select the cladistics system of classification in which dicots are primitive than monocots

(A) Horizontal system (B) Hutchinson system

(C) Bentham and Hooker's system (D) Engler and Prantl's system

Q.165 Seedless tracheophytes are

(A) Bryophyta (B) Pteridophyta (C) Gymnosperms (D) Angiosperms

Q.166 Algae were grouped into _____ kingdoms according to Whittaker.

(A) Two (B) Three (C) One (D) Four

Q.167 Heterotrichous nature of thallus is found in

(A) *Funaria* (B) *Fritschiella* and *Ectocarpus*

(C) *Stigeoclonium* and *Coleochaete* (D) All of these

Q.168 Thick walled perennation sexual spore is

(A) Zygote (B) Zoospore (C) Hyponspore (D) Zygospore

Q.169 Gulf weed belongs to the class

(A) Chlorophyceae (B) Dinophyceae (C) Phaeophyceae (D) Rhodophyceae

Q.170 The thallus organisation of *Volvox* is

(A) Multicellular and coccoid (B) Colonial and nonflagellate
(C) Unicellular (D) Colonial and motile

Q.171 Hydroxyproline nature of cell wall is found in

(A) *Chlamydomonas* (B) *Ulothrix* (C) *Spirogyra* (D) *Chlorella*

Q.172 Gametophytic plant body is nonvascular in

(A) Algae and liverworts (B) Mosses and ferns
(C) Gymnosperms and angiosperms (D) All of these

Q.173 Brown algae are quit common in

(A) Fresh water habitats (B) Mosses and ferns
(C) Temperate sea water (D) Both (B) and (C)

Q.174 Chloroplast with many pyrenoids is the feature of

(A) Chlamydomonas (B) Sargassum
(C) Batrachospermum (D) Spirogyra

Q.175 Algae with floridean starch as reserve food material is also characterised by

(A) Presence of chlorophyll *b* (B) Stacked thylakoids
(C) Nonsulphated phycocolloids (D) Nonflagellate nature

Q.176 Number of species of marine algae used as food is

(A) 20 (B) 70 (C) 50 (D) 120

Q.177 Red snow is caused by

(A) Zoospores of *Chlamydomonas* nivalis (B) Hypnospores of *C. braunii*
(C) Aplanospores of *C. media* (D) Hypnospores of *C. nivalis*

Q.178 Thallus is flattened, leaf like and anchors to the rocks with the help of holdfast in

(A) Laminaria (B) *Polysiphonia* (C) *Batrachosperum* (D) *Ectocarpus*

Q.179 100 zygospores, alternate with empty cells in spirogyra are under _____ Conjugation and the total number of daughter filaments formed will be _____

(A) Scalariform, 400
(B) Lateral, 100
(C) Lateral, 400
(D) Scalariform, 100

Q.180 Algin is a phycocolloid, obtained from the cell wall of

(A) *Macrocystis* and *Porphyridium*
(B) *Mastigocladus* and *Laminaria*
(C) *Microcystis* and *Nereocystis*
(D) *Macrocystis* and *Fucus*

Q.181 Which of the given is a parasitic algae?

(A) *Porphyra*
(B) *Sargassum*
(C) *Laminaria*
(D) *Cephaleuros*

Q.182 An edible red algae is

(A) *Fucus*
(B) *Sargassum*
(C) *Acetabularia*
(D) *Porphyra*

Q.183 A floating brown algae that covers thousands of hectares of sea in atlantic ocean is

(A) *Fucus*
(B) *Nereocystis*
(C) *Sargassum*
(D) *Dicyota*

Q.184 Motile, flagellated asexual spore is

(A) Zygote
(B) Zygospore
(C) Aplanospore
(D) Zoospore

Q.185 Laminarin starch is a reserve product and is a characteristic of

(A) Green algae
(B) Blue green algae
(C) Red algae
(D) Brown algae

Q.186 Which of the following is a red alga that is not red?

(A) *Nemalion*
(B) *Polysiphonia*
(C) *Gelidium*
(D) *Batrachospermum*

Q.187 The colour of brown algae is due to

(A) Carotene
(B) Fucoxanthin
(C) Phycoerythrin
(D) Phycocyanin

Q.188 The alga *Chara* is called ‘Stonewort’ because its plant body is encrusted with

(A) Calcium bicarbonate
(B) Calcium carbonate
(C) Calcium chloride
(D) Calcium oxalate

Q.189 In chlorophyceae, the flagella are

(A) Tinsel type (B) Whiplash type

(C) Whiplash and tinsel type (D) Basal tinsel, apical whiplash type

Q.190 Irish moss belongs to

(A) Mosses (B) Bryophytes (C) Red algae (D) Lichens

Q.191 Which of the following are useful for curing goitre?

(A) Sea kelps (B) Diatoms (C) Red algae (D) Porphyra

Q.192 Of all algae, the property of nitrogen fixation is restricted to the members of

(A) Cyanophyta (B) Chlorophyta (C) Rhodophyta (D) Phaeophyta

Q.193 Find the site of meiosis in green algae

(A) Gametangia (B) Zygote (C) Sporangia (D) Zygospore

Q.194 Non-motile gametes are characteristically found in

(A) Cyanophyta (B) Rhodophyta (C) Phaeophyta (D) Chlorophyta

Q.195 Flagella are of equal length and smooth in Chlamydomonas. This condition can be referred to as

(A) Isokont and pleuronematic (B) Heterokont and acronematic

(C) Isokont and acronematic (D) Heterokont and pleuronematic

Q.196 The female sex organ in red aglae is flask shaped and is known as

(A) Trichogyne (B) Carpogonium (C) Spermatium (D) Archegonium

Q.197 Non-vascular archegoniates are

(A) Thallophyta (B) Pteridophyta (C) Bryophyta (D) Gymnosperms

Q.198 Protonema represents photosynthetic, filamentous, juvenile gametophyte of

(A) Irish moss (B) Club moss (C) Cord moss (D) Spanish moss

Q.199 What is the chromosomes number in calyptra, perichaetial cells, columella and protonema if endothecium cell contains 20 chromosomes?

(A) 10, 10, 20 and 10 respectively (B) 10, 20, 20 and 10 respectively

(C) 20, 10, 20 and 10 respectively (D) 10, 10, 20 and 0 respectively

Q.200 Which one of the following is homosporous with exoscopic embryogeny?

(A) All pteridophytes
(B) Bryophytes and gymnosperms
(C) Angiosperms
(D) All bryophytes

Q.201 Algae, bryophytes and pteridophytes resemble with each other in which one of the following feature?

(A) Gametophytic plant body
(B) Dependence on water for fertilisation
(C) Heteromorphic alteration of generation
(D) Presence of embryo

Q.202 Find the correct match

	Column I		Column II
P	Cord moss	(i)	Rhizophore
Q	Spike moss	(ii)	Agar
R	Irish moss	(iii)	Peristome
S	Ceylon moss	(iv)	Carrageenin

(A) P(i), Q(ii), R(iii), S(iv)
(B) P(iii), Q(ii), R(iv), R(i)
(C) P(iii), Q(i), R(ii), R(iv)
(D) P(iii), Q(i), R(iv), S(ii)

Q.203 Bryophytes are not characterised by

(A) Sporophyte parasitic over gametophyte
(B) Independent gametophyte
(C) Absence of vascular tissues
(D) Independent sporophyte

Q.204 One of the following is a heterotrophic bryophyte

(A) *Cryptothallus*
(B) *Riccia*
(C) *Dawsonia*
(D) *Sphaerocarpus*

Q.205 In *Funaria*, the number of peristome teeth in exostome is

(A) 32
(B) 64
(C) 16
(D) 8

Q.206 Rhizoids of mosses are

(A) Unicellular and pigmented
(B) Multicellular and nonpigmented
(C) Unicellular and nonpigmented
(D) Multicellular and nonpigmented

Q.207 In *Funaria*, calyptra is derived from

(A) Antheridium
(B) Columella
(C) Capsule
(D) Archegonium

Q.208 Which of the following is not connected with spore dispersal in *Funaria*?

(A) Seta
(B) Perisome
(C) Annulus
(D) Foot

Q.209 Chloroplasts are present in the spores of

(A) *Rhizopus* (B) *Funaria* (C) *Yeast* (D) *Dryopteris*

Q.210 Stomata having pores bounded by a single ring shaped guard cell are found in

(A) Capsule of *Funaria* (B) Leaf of fern
(C) Pinnule of *Cycas* (D) All of these

Q.211 Conducting tissue is not found in

(A) Mosses (B) Liverworts (C) *Cycas* (D) Ferns

Q.212 Stems and leaves of bryophytes are

(A) Analogous to vascular plants (B) Homologous to vascular plants
(C) Analogous to algae thallus (D) None of these

Q.213 Non-vascular embryophyte with leaves is

(A) *Riccia* (B) *Porella* (C) *Selaginella* (D) Macrocystis

Q.214 The hygroscopic structures in moss capsule is/are

(A) Stomium cells (B) Annulus (C) Operculum (D) Peristome teeth

Q.215 Mitospores are totally absent in life cycle of

(A) Chlorophyceae (B) Phaeophyceae
(C) Fungi (D) Bryophytes

Q.216 Which is a member of bryopsida?

(A) maiden hair moss (B) Irish moss
(C) Reindeer moss (D) All of these

Q.217 Which group of plantae represents gametrophytic plant body with dependent sporophyte?

(A) Algae and bryophytes (B) Bryophytes and pteridophytes
(C) Liverworts and mosses (D) Ferns and cycades

Q.218 Life cycle of cord moss is

(A) Haplontic (B) Haplodiplontic (C) Diplontic (D) Haplohaplontic

Q.219 Heterosporous pteridophyte with eusporangiate type of sporangium is

(A) *Pteris* and *Adiantum*
(B) *Isoetes* and *Selaginella*
(C) *Dryopteris* and *Azolla*
(D) *Marsilea* and *Pteris*

Q.220 In little club moss, embryo develops from the part of zygote and rest is used to form suspensor. This mode of development is called

(A) Exoscopic
(B) Endoscopic
(C) Meroblastic
(D) Holoblastic

Q.221 Shedding of male gametophyte in *Selaginella* occurs at 13-celled stage which consists of

(A) 8 jacket cells, 1 generative cell and 4 androgonial cells
(B) 9 jacket cells and 4 androgonial cells
(C) 12 jacket cells and 1 male gamete
(D) 8 jacket cells, 1 prothalial cell and 4 androgonial cells

Q.222 Find correct statement for the prothallus of fern

(A) Monoecious, protandrous with multicellular rhizoides
(B) Monocious, protandrous with unicellular rhizoides
(C) Dioecious, with unicellular rhizoides
(D) Monoecious, protandrous with apical antheridia and basal archegonia on ventral surface

Q.223 Pteridophytes are divided into _____ classes.

(A) Two
(B) Three
(C) Four
(D) Six

Q.224 Rootless pteridophytes with rhizoides are included into

(A) *Sphenopsida*
(B) *Psilopsida*
(C) *Pteropsida*
(D) *Lycopsida*

Q.225 The dominant photosynthetic phase in the life cycle of pteridophyta is equivalent to the

(A) Gametophytic phase of bryophyte
(B) Sporophytic phase of bryophyte
(C) Gametophytic phase of pteridophytes
(D) Gametophytic phase of gymnosperm

Q.226 In Pteridophytes, reduction division occurs when

(A) Prothallus is formed
(B) Sex organs are formed
(C) Spores are formed
(D) Gametes are formed

Q.227 Fern sperms (antherozoids) are

(A) Multiflagellated (B) Uniflagellated

(C) Biflagellated (D) Non flagellated

Q.228 The evolutionary advanced features of *Selaginella* are

(1) Heterospory

(2) Endosporic development of gametophyte

(3) Reduced gametophyte

(4) Localization of sporangium bearing appendages in strobili

(5) Unisexual gametophytes

(6) Fertilization with the help of water

(A) All are correct (B) All except (6) is correct

(C) All except (5) and (6) are correct (D) All except (3) is correct

Q.229 When the gametophyte development occurs within spore it is known as

(A) Exosporic (B) Endosporic (C) Episporic (D) None of these

Q.230 In *Selaginella* life cycle, generative tissue of female gametophyte makes

(A) Androgonial cells (B) Endosporic

(C) Episporic (D) None of these

Q.231 In the fern rhizome, the meristele is

(A) Amphicribal (B) Collateral (C) Conjoint (D) Radial

Q.232 Venation in fern leaves is

(A) Unicostate (B) Reticulate (C) Furcate (D) Parallel

Q.233 If the number of chromosome in the foot of an embyo is 8, what should be the number in its spore?

(A) 4 (B) 8 (C) 16 (D) 23

Q.234 Select the type of stele without pith

(A) Solenostele (B) Siphonostele (C) Protostele (D) Dictyostele

Q.235 The sporangia of eusporangiate ferns

(A) Possess a single layer of wall cells (B) Produce very few spores
(C) Originate from a group of initial cells (D) Dehisce at the region of a well defined stomium.

Q.236 Spore having their wall modified to elater is characteristic of

(A) *Lycopodium* (B) *Equisetum* (C) *Adiantum* (D) *Marchantia*

Q.237 In the archegonium of *Dryopteris*, the number of neck canal cells is/are

(A) 4 (B) 2 (C) 1 (D) 6-10

Q.238 Vascular cryptogames are

(A) Bryophyta (B) Pteridophyta (C) Gymnosperm (D) Angiosperm

Q.239 Maiden hair fern is

(A) *Adiantum* (B) *Dryopteris* (C) *Cyathea* (D) *Alsophila*

Q.240 Endosperm of gymnosperm is ontogenetically similar to angiospermic

(A) Endosperm (B) Embryo sac (C) Archegonium (D) Megasporangia

Q.241 Which group of plantae represents smallest group with perennial plants only?

(A) Pteridophyta (B) Angiosperms (C) Bryophyta (D) Gymnosperms

Q.242 Living fossils of gymnosperms are

(A) *Araucaria embricata* (B) *Cycas revoluta*
(C) *Pinus longifolia* (D) *Gnetum gnemone*

Q.243 Identify the oldest gymnosperm

(A) *Cycas* (B) *Metasequoia* (C) *Ginkgo biloba* (D) All of these

Q.244 Member of plantae having endospermic, perispermic, polycotyledonous and winged seeds is also related to

(A) Sulphur shower (B) Largest ovule
(C) Double fertilization (D) Placentation

Q.245 The ovuliferous scale of *Pinus* bears _____ ovules

(A) One (B) Three (C) Two (D) Four

Q.246 Pollination occurs in *Pinus* at

(A) 2 celled stages (B) 3 celled stages
(C) 4 celled stages (D) 5 celled stages

Q.247 Polyxylic and manoxylic wood is present in

(A) *Pinus* (B) *Cycas* (C) *Ginkgo* (D) *Gnetum*

Q.248 Which one of the following group acts as connecting link between gymnosperms and angiosperms?

(A) Ginkgoales (B) Cycadales (D) Coniferales (D) Gnetales

Q.249 Phanerogams without womb are

(A) Angiosperms (B) Bryophytes (C) Ferms (D) Gymnosperms

Q.250 Fruits are not produced in gymnosperms because they are

(A) Without pollination (B) Without fertilization
(C) Seedless plants (D) Without any ovary

Q.251 Which one constitutes the dominant vegetation in colder regions?

(A) Monocots (B) Dicots (C) Legumes (D) Gymnosperms

Q.252 In gymnosperms, pollination takes place through

(A) Insects (B) Wind (C) Bats (D) Birds

Q.253 Of the following, the false character with respect to *Pinus* is

(A) Resin canals in needles (B) Tracheids with bordered pits
(C) Bracts and ovuliferous scales (D) Embryo with two cotyledons

Q.254 Maiden hair tree is

(A) *Ginkgo biloba* (B) *Gnetum*
(C) *Ephedra* (D) *Welwitschia*

Q.255 Edible seeds are obtained from

(A) *Mangifera indica* (B) *Pinus gerardiana*
(C) *P.roxburghii* (D) *Dalbergia sisso*

Q.256 Diploxylic vascular bundles are found in

(A) *Pteris* (B) *Selaginella* (C) *Funaria* (D) *Cycas*

Q.257 Circinate ptyxis is found in

(A) *Pteris* (B) *Dryopteris* (C) *Cycas* (D) All of these

Q.258 Transfusion tissue replaces the veins in

(A) *Cycas* (B) *Ferns* (C) *Pinus* (D) *Pinus* and *Cycas*

Q.259 Find the correct match

	Column I		Column II
a	Cedar wood oil	(i)	*Juniperus virginiana*
b	Canada Balsam	(ii)	*Pinus girardiana*
c	Chilgoza seeds	(iii)	*Cycas revolute*
d	Sago grains	(iv)	*Cedrus deodara*
		(v)	*Abies species*

(A) a(i), b(v), c(ii), d(iii) (B) a(i), b(v), c(iii), d(ii)

(C) a(iii), b(v), c(i), d(ii) (D) a(i), b(v), c(ii), d(iv)

Q.260 Carpels are equivalent to the

(A) Microsporophylls (B) Megasporophylls

(C) Megasporangia (D) Embryo sac

Q.261 Vessels are present in the xylem of which group of tracheophytes?

(A) Angiosperms (B) Gymnosperms

(C) Pteridophytes (D) Both (A) and (B)

Q.262 A marine angiosperm is

(A) *Hydrilla* (B) *Utricularia* (C) *Potamogeton* (D) *Zostera*

Q.263 Biennials are characterised by

(A) Bearing flowers for two seasons

(B) Forming aerial stem and flowering in second year

(C) Flowering in first year and forming fruits in second year

(D) Forming storage organs in the first year and reproductive organ or flowers in the second year.

Q.264 Flowering plants are more successful than other members of the plant world because

(A) They are large and have a good vascular tissue system

(B) They carry out variety of pollination mechanism

(C) The protected plant embryo can servive in the period of unfavourable conditions

(D) All of these

Q.265 Some characters of algae are given below

(1) Floridean starch

(2) Sulphated phycocolloids in cell wall

(3) Alginic acid

(4) Trumpet hypha

(5) Haplodiplontic life cycle

(6) Isomorphic alternation of generation

(7) Fucoxanthin

(8) Phycoerythrin

(9) Zygotic meiosis

(10) Two anterior flagella.

Which of the given set of characters belongs to *Laminaria*?

(A) (1), (2), (5), (6), (8)

(B) (3), (4), (5), (7)

(C) (2), (3), (4), (5), (6), (7) (8)

(D) (3), (4), (5), (6), (7), (8)

Q.266 Anthoceros resembles green algae in all, except

(A) Agal filament like gametophyte that develops after spore germination

(B) Single pyrenoid per cell

(C) Single chloroplast per cell

(D) Presence of starch storing bodies

Q.267 (1) Leptosporangiate development of sporangium is found in all members of Pteropsida.

(2) *Selaginella* is advance among pteridophytes as it produces seeds

(3) *Pinus* leaves are monomorphic, pinnate compound and have sunken stomata as adaptation against transpiration

(4) Sporic meiosis is characteristic of life cycle in many organisms like *Volvox, Chlamydomonas* and *Ulothrix*.

(A) All are incorrect

(B) Both 1, 2 and 3 are correct

(C) Only 2 is correct

(D) Only 4 is incorrect.

Q.268 Wood of *Pinus* is

(A) Soft, nonporous, homoxylous, manoxylic, polyxylic

(B) Hard, nonporous, heteroxylous, polyxylic, monoxylic

(C) Soft, porous, homoxylous, pycnoxylic, monoxylic.

(D) Soft, nonporous, homoxylous, pyconxylic, monoxylic.

Q.269 How many structures listed below are diploid for typical fern member?

(1) Indusium cell (2) Stomium cell (3) NCC

(4) Root stock cell (5) Sporophyll cell (6) Prothallus cell

(7) SMC (8) Spore (9) Antherozoid mother cell

(A) Nine (B) Six (C) Five (D) Seven

Q.270 (i) Ranales is considered most advanced among the dicots by Bentham and Hooker.

(ii) Engler and Prnatl system is transition between natural and artificial systems

(iii) Numerical taxonomy uses all observable characters and employs computers for establishing correlation between the plants

(iv) Chemical constituents of the plants can be used to resolve taxonomic problems

(A) All are correct (B) All are incorrect

(C) C and D are correct (D) A, C and D are correct

Q.271 Identify the labels A, B, C and D in the figure given below

(A) A – Sporophyte; B - Meiosis
C – Gametogenesis; D – Endosperm

(B) A – Sporophyte; B – Mitosis
C – Gametogenesis; D – Zygote

(C) A – Gametophyte; B – Meiosis
C – Gametogenesis; D – Zygote

(D) A – Sporophyte; B – Meiosis
C – Gametogenesis; D – Zygote

Q.272 Find set of features related to *Funaria*

(1) Protonema (2) Prothallus (3) Gametophore (4) Thallus body(5) 4 NCC
(6) Haplodiplontic (7) True plant organs in sporophyte (8) Fragmentation

(A) (2), (4), (5), (7) (B) (1), (4), (6), (7)
(C) (1), (3), (6), (7), (8) (D) (1), (3), (6), (8)

Q.273 Mark the correct statement for the organism given below in figure.

(A) The structure labelled A is male cone (B) It is member of sphenopsida
(C) Nodes are hollow while internodes are solid (D) This is commonly called as stonewort

Q.274 Which of the given sets are matched correctly?

(1) *Chondrus* - Algin
(2) *Gracilaria* - Agar
(3) *Cycas* - Coralloid root
(4) *Pinus* - Canada balsum
(5) *Adiantum* - Maiden hair fern
(6) *Lycopodium* - Little club moss
(7) *Cedrus* - Independent gametophyte
(8) *Sequoia* - Tallest gymnosperm

(A) (2), (3), (5), (8) (B) (1), (2), (3), (5), (6)
(C) (2), (3), (5), (7), (8) (D) (2), (3), (4), (5), (7), (8)

Previous Years' Questions

Q.1 Young leaves of *Cycas* show ***(Chandigarh CET 2009)***

(A) Simple venation (B) Circinate venation
(C) Alternate arrangement (D) Opposite arrangement

Q.2 The seed of *Pinus* is ***(Chandigarh CET 2009)***

(A) Covered and non-endospermic (B) Naked and non –endospermic
(C) Abaxially placed and covered (D) Adaxially placed naked and endospermic

Q.3 Male and female gametophytes are independent and free-living in ***(CBSE PMT prelims 2010)***

(A) Cellulose, hemicellulose and pectins (B) Cellulose, galactans and mannans

(C) Hemicellulose, pectins and proteins (D) Pectins, cellulose and proteins

Q.4 Algae have cell wall made up of ***(CBSE PMT Prelims 2010)***

(A) Cellulose, hemicellulose and pectins (B) Cellulose, galactans and mannans

(C) Hemicellulose, pectins and proteins (D) Pectins, cellulose and proteins.

Q.5 The chief water conducting elements of xylem in gymnosperms are ***(CBSE PMT Prelims 2010)***

(A) Tracheids (B) Vessels (C) Fibres (D) Transfusion tissue

Q.6 Which among the following group of plants is known as vascular cryptogams? ***(Chandigarh CET 2010)***

(A) Mosses (B) Liverworts (C) Ferns (D) Conifers

Q.7 Which of the following algal groups has no motile stage ? ***(Chandigarh CET 2010)***

(A) Brown (B) Yellow (C) Red (D) Green

Q.8 Sphagnum is an example of ***(HP PMT 2010)***

(A) Moss (B) Pteridophyte (C) Algae (D) Gymnosperm

Q.9 Consider the following four statements whether they are correct or wrong ***(CBSE Main PMT 2011)***

(1) The sporophyte in liverworts is more elaborate than that in mosses

(2) *Salvinia* is heterosporous

(3) The life-cycle in all seed-bearing plants is diplontic

(4) In *Pinus* male and female cones are borne on different trees

The two wrong statements together are

(A) Statements (1) and (3) (B) Statements (1) and (4)

(C) Statements (2) and (3) (D) Statements (1) and (2)

Q.10 *Selaginella* and *Salvinia* are considered to represent a significant step toward evolution of seed habit because ***(CBSE Main PMT 2011)***

(A) Female gametophyte is free and gets dispersed like seeds

(B) Female gametophyte lacks archegonia

(C) Megaspores possess endosperm and embryo surrounded by seed coat

(D) Embryo develops in female gametophyte which is retained on parent sporophyte

Q.11 Archegoniophore is present in ***(CBSE PMT Prelims 2011)***

(A) *Marchantia* (B) *Chara* (C) *Adiantum* (D) *Funaria*

Q.12 Compared with gametophytes of the bryophytes, the gametophytes of vascular plants tend to be ***(CBSE PMT Prelims 2011)***

(A) Smaller but to have larger sex organs (B) Larger but to have smaller sex organs

(C) Larger and to have larger sex organs (D) Smaller and to have smaller sex organs

Q.13 The gametophyte is not an independent, free-living generation in ***(CBSE PMT Prelims 2011)***

(A) *Polytrichum* (B) *Adiantum* (C) *Marchantia* (D) *Pinus*

Q.14 Asexual reproduction in *Liverworts* takes place by the formation of specialized structures called ***(HP PMT 2011)***

(A) Gemmae (B) Zoospores (C) Sporangia (D) Microspores

Q.15 *Pinus* belongs to the class ***(Karnataka CET 2011)***

(A) Gnetopsida (B) Cycadopsida (C) Coniferopsida (D) Sphenopsida

Q.16 Read the following five statements (1 – 5) and answer as asked next to them ***(CBSE Main PMT 2012)***

(1) In *Equisetum* the female gametophyte is retained on the parent sporophyte.

(2) In *Ginkgo* male gametophyte is not independent.

(3) The sporophyte in *Riccia* is more developed than that in polytrichum

(4) Sexual reproduction in – *Volvox* is isogamous.

(5) The spores of slime moulds lack cell walls

How many of the above statements are correct ?

(A) Four (B) One (C) Two (D) Three

Q.17 Which one of the following pairs is wrongly matched ? ***(CBSE Main PMT 2012)***

(A) Viroids – RNA (B) Mustard – Synergids

(C) *Ginkgo* – Archegonia (D) *Salvinia* – Prothallus

Q.18 How many organisms in the list given below are autotrophs ? ***(CBSE Main PMT 2012)***

Lactobacillus, Nostoc, Chara, Nitrosomonas, Nitrobacter, Streptomyces, Sacharomyces, Trypanosoma, Porphyra, Wolfia

(A) Six (B) Three (C) Four (D) Five

Q.19 *Cycas* and *Adiantum* resemble each other in having ***(CBSE PMT Prelims 2012)***

(A) Motile sperms (B) Cambium (C) Vessels (D) Seeds

Q.20 Which one of the following is common to multicellular fungi, filamentous algae and protonema of mosses ? ***(CBSE PMT Pre 2012)***

(A) Members of kingdom plantae (B) Mode of Nutrition

(C) Multiplication by Fragmentation (D) Diplontic life cycle

Q.21 Which one of the following is a correct statement ? ***(CBSE PMT Pre 2012)***

(A) In gymnosperms female gametophyte is free-living

(B) Antheridiophores and archegoniophores are present in pteridophytes

(C) Origin of seed habit can be traced in pteridophytes

(D) Pteridiophyte gametophyte has a protonemal and leafy stage

Q.22 Fucoxanthin is a characteristic pigment of ***(Chandigarh CET 2012)***

(A) Phaeophyta (B) Chlorophyta (C) Rhodophyta (D) Cyanophyta

Q.23 First amphibian plants of the plant kingdom are ***(HP PMT 2012)***

(A) Thallophytes (B) Bryophytes (C) Pteridophytes (D) Gymnosperms

Q.24 The leaves of fern plants are called ***(HP PMT 2013)***

(A) Macrophylls (B) Microphylls (C) Sporophylls (D) Megasporophylls

Q.25 The tallest tree species of the gymnosperms is ***(HP PMT 2012)***

(A) *Cycas* (B) *Pinus* (C) *Sequola* (D) *Cedrus*

Q.26 Select the wrong statement ***(NEET 2013)***

(A) In Oomycetes female gamete is smaller and motile, while male gamete is larger and non-motile

(B) *Chlamydomona* exhibits both isogamy and anisogamy and focus shows oogamy

(C) Isogametes are similar in structure, function and behaviour

(D) Anisogametes differ either in structure, function or behaviour

Q.27 Which of the following represent maximum number of species among global biodiversity? ***(NEET 2013)***

(A) Fungi (B) Mosses and Ferns (C) Algae (D) Lichens

Q.28 Male gametophyte with least number of cells is present in ***(AIPMT 2014)***

(A) *Pinus* (B) *Pteris* (C) *Funaria* (D) *Lillum*

Q.29 Which one of the following shows isogamy with non-flagellated gamets ? ***(AIPMT 2014)***

(A) *Spirogyra* (B) *Sargassum* (C) *Ectocarpus* (D) *Ulothrix*

Q.30 An alga which can be employed as food for human being is ***(AIPMT 2014)***

(A) *Polysiphonia* (B) *Ulothrix* (C) *Chlorella* (D) *Spirogyra*

Q.31 Which of the following is responsible for peat formation ? ***(AIPMT 2014)***

(A) *Sphagnum* (B) *Marchantia* (C) *Riccia* (D) *Funaria*

ANSWER KEY

Objective Questions

Q.1 C	**Q.2** B	**Q.3** D	**Q.4** B	**Q.5** A	**Q.6** A
Q.7 A	**Q.8** C	**Q.9** A	**Q.10** A	**Q.11** C	**Q.12** B
Q.13 B	**Q.14** D	**Q.15** A	**Q.16** C	**Q.17** D	**Q.18** B
Q.19 B	**Q.20** D	**Q.21** C	**Q.22** A	**Q.23** B	**Q.24** C
Q.25 B	**Q.26** B	**Q.27** C	**Q.28** B	**Q.29** C	**Q.30** C
Q.31 A	**Q.32** A	**Q.33** B	**Q.34** A	**Q.35** B	**Q.36** D
Q.37 B	**Q.38** C	**Q.39** B	**Q.40** B	**Q.41** B	**Q.42** C
Q.43 A	**Q.44** A	**Q.45** D	**Q.46** A	**Q.47** D	**Q.48** C
Q.49 C	**Q.50** D	**Q.51** D	**Q.52** A	**Q.53** C	**Q.54** D
Q.55 D	**Q.56** D	**Q.57** C	**Q.58** C	**Q.59** C	**Q.60** C
Q.61 D	**Q.62** D	**Q.63** C	**Q.64** C	**Q.65** B	**Q.66** B
Q.67 D	**Q.68** D	**Q.69** B	**Q.70** C	**Q.71** C	**Q.72** D
Q.73 D	**Q.74** B	**Q.75** A	**Q.76** B	**Q.77** D	**Q.78** A
Q.79 C	**Q.80** C	**Q.81** A	**Q.82** D	**Q.83** B	**Q.84** C
Q.85 B	**Q.86** D	**Q.87** C	**Q.88** B	**Q.89** A	**Q.90** C
Q.91 A	**Q.92** B	**Q.93** B	**Q.94** D	**Q.95** D	**Q.96** B
Q.97 B	**Q.98** C	**Q.99** B	**Q.100** C	**Q.101** C	**Q.102** B
Q.103 C	**Q.104** C	**Q.105** B	**Q.106** D	**Q.107** D	**Q.108** C
Q.109 A	**Q.110** C	**Q.111** A	**Q.112** A	**Q.113** B	**Q.114** B
Q.115 D	**Q.116** D	**Q.117** C	**Q.118** D	**Q.119** C	**Q.120** D
Q.121 C	**Q.122** A	**Q.123** D	**Q.124** B	**Q.125** A	**Q.126** B

Q.127 D	**Q.128** C	**Q.129** D	**Q.130** C	**Q.131** D	**Q.132** A
Q.133 A	**Q.134** B	**Q.135** B	**Q.136** D	**Q.137** A	**Q.138** B
Q.139 B	**Q.140** B	**Q.141** C	**Q.142** D	**Q.143** A	**Q.144** B
Q.145 D	**Q.146** D	**Q.147** B	**Q.148** A	**Q.149** C	**Q.150** D
Q.151 D	**Q.152** D	**Q.153** A	**Q.154** B	**Q.155** A	**Q.156** C
Q.157 A	**Q.158** B	**Q.159** A	**Q.160** C	**Q.161** A	**Q.162** D
Q.163 C	**Q.164** B	**Q.165** B	**Q.166** B	**Q.167** D	**Q.168** D
Q.169 C	**Q.170** D	**Q.171** A	**Q.172** D	**Q.173** C	**Q.174** D
Q.175 D	**Q.176** B	**Q.177** D	**Q.178** A	**Q.179** B	**Q.180** D
Q.181 D	**Q.182** D	**Q.183** C	**Q.184** D	**Q.185** D	**Q.186** D
Q.187 B	**Q.188** B	**Q.189** B	**Q.190** C	**Q.191** A	**Q.192** A
Q.193 D	**Q.194** B	**Q.195** C	**Q.196** B	**Q.197** C	**Q.198** C
Q.199 A	**Q.200** D	**Q.201** B	**Q.202** D	**Q.203** D	**Q.204** A
Q.205 C	**Q.206** D	**Q.207** D	**Q.208** D	**Q.209** B	**Q.210** A
Q.211 B	**Q.212** A	**Q.213** B	**Q.214** D	**Q.215** D	**Q.216** A
Q.217 C	**Q.218** B	**Q.219** B	**Q.220** C	**Q.221** D	**Q.222** B
Q.223 C	**Q.224** B	**Q.225** A	**Q.226** C	**Q.227** A	**Q.228** B
Q.229 B	**Q.230** D	**Q.231** A	**Q.232** C	**Q.233** A	**Q.234** C
Q.235 C	**Q.236** B	**Q.237** C	**Q.238** B	**Q.239** A	**Q.240** B
Q.241 D	**Q.242** A	**Q.243** D	**Q.244** A	**Q.245** C	**Q.246** C
Q.247 B	**Q.248** D	**Q.249** D	**Q.250** D	**Q.251** D	**Q.252** B
Q.253 D	**Q.254** A	**Q.255** B	**Q.256** D	**Q.257** D	**Q.258** D
Q.259 A	**Q.260** B	**Q.261** A	**Q.262** D	**Q.263** D	**Q.264** D
Q.265 B	**Q.266** A	**Q.267** A	**Q.268** D	**Q.269** C	**Q.270** C
Q.271 D	**Q.272** D	**Q.273** B	**Q.274** A		

Previous Years' Quetions

Q.1 B	**Q.2** D	**Q.3** A	**Q.4** B	**Q.5** A	**Q.6** C
Q.7 C	**Q.8** A	**Q.9** B	**Q.10** D	**Q.11** A	**Q.12** D
Q.13 D	**Q.14** A	**Q.15** C	**Q.16** B	**Q.17** D	**Q.18** A
Q.19 A	**Q.20** C	**Q.21** C	**Q.22** A	**Q.23** B	**Q.24** A
Q.25 C	**Q.26** A	**Q.27** A	**Q.28** D	**Q.29** A	**Q.30** C
Q.31 A					