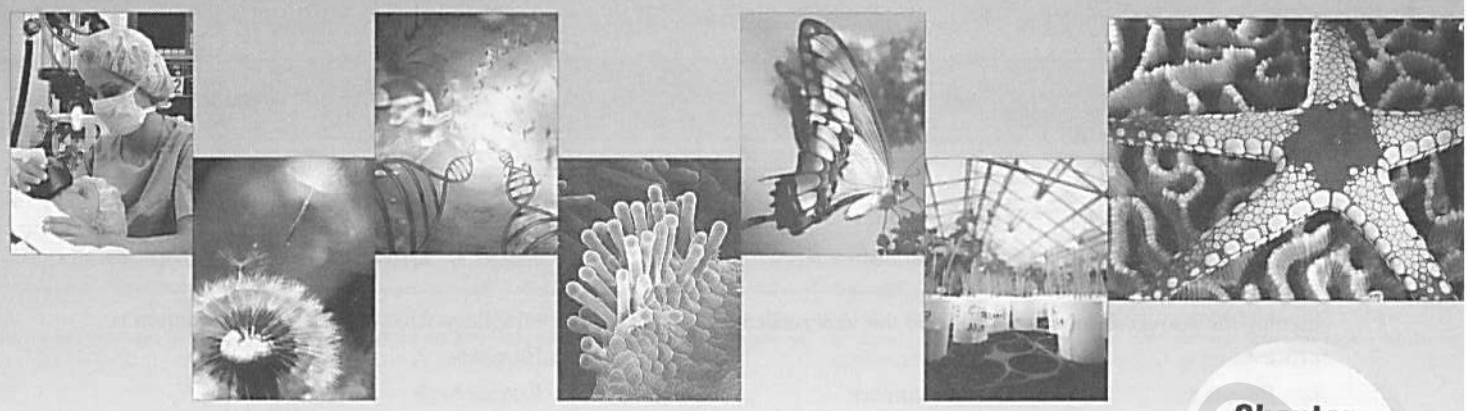

Chapter

1.6

Plant Kingdom

Characteristics of Plantae

The term plant is more commonly used for land photoautotrophs with distinct root, stem and leaves. Study of plants is called phytology.

Kingdom plantae includes green, brown and red algae, liverworts, mosses, ferns and seed plants with or without flowers. They have the following characters.

(1) Member of the kingdom are multicellular, eukaryotes. However, unicellular and colonial members of green and red algae are also included in kingdom plantae.

(2) Cells are surrounded by cell wall. It contain cellulose.

(3) Mature cells usually possess a single central vacuole.

(4) Reserve food is starch in green algae and embryophytes, floridean starch in red algae and laminarin in brown algae.

(5) They contain photosynthetic pigment in plastids.

(6) Principal mode of nutrition is photosynthesis but number of plants have become absorptive.

(7) In lower member, organization is protoplasmic or cellular. In higher forms, the organization is of tissue and organ level.

(8) Branches are present. Therefore body form is irregular.

(9) Growth occur due to presence definite growing points or cells. In higher forms, growing areas called meristems.

(10) Locomotion is absent except in some unicellular colonial forms. Multicellular members are sedentary or fixed.

(11) The cells often contain inorganic crystals of different salts.

(12) Vegetative reproduction is quite common.

(13) Asexual reproduction is found in algal group and occur by means of spores.

(14) There is a progressive evolution in sexual reproduction. The reproductive organs are multicellular.

(15) A multicellular embryo is formed during development from the zygote. Algae lack embryo stage. Life cycle consists of alternating haploid gametophyte and diploid sporophyte generation. This phenomenon is called alternation of generation.

Classification of plantae

August Wilhelm Eichler (1883) a Vinnese botanist, divided plant kingdom into two subkingdoms mainly on the basis of presence or absence of seeds.

(1) **Cryptogamae** (Gr. *Cryptos* = hidden; *gamos* = marriage) **:** Lower plants in which sex organs are hidden and seeds and flowers absent. It includes **Thallophytes, Bryophytes, Pteridophytes**.

(2) **Phanerogamae** (Gr. *Phaneros* = visible; *gamos* = marriage) **:** Higher plants in which sex organs are evident; seeds present. It includes Gymnosperms and Angiosperms.

Engler (1886) divided plants into Thallophyta (plant body thallus like and there is no embryo formation) and Embryophyta (zygote develops into multicellular embryo).

Thallophyta (Gr. *Thallos* = undifferentiated; *phyton* = plant). This term was coined by Endlicher (1836). It includes Algae, Fungi, Bacteria, Lichens. Unger (1838) placed algae, fungi and lichens under thallophyta. In modern system of clasification like Whittaker (1969), Fungi, Lichens and Bacteria are excluded from this group and are placed in separate kingdoms.

Algae

(Gk. *Phycos* = alga or sea weed)

The branch of botany dealing with the study of algae is called as **phycology** or **algology**. They are simple, thallose, autotrophic non-vascular plants having unicelled sex organs and no embryo formation. In Whittaker's classification, algae are grouped in three kingdom – Monera (blue green algae), Protista (dinoflagellates, diatoms, euglenoids) and Plantae (green algae, red algae and brown algae).

According to Fritsch **(Father of algalogy),** (1935) the designation alga must include all holophytic organisms, as well as their numerous colourless derivatives, that fail to reach the level of differentiation characteristic of archegoniatae plants.

Occurrence : The algae occur in a variety of habitats which are summarised here under :

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Fresh water forms : They occurs in rivers, ponds, pools, lakes and ditches. Those forms which remain attached to bottom soil are called as epipelic. Several forms remain attached to bottom or at the bank or to submerged objects. They are described as benthos. Many forms remain attached to rocks or stones. They are described as epilithic or lithophytic. *e.g., Batrachospermum.*

Marine forms : Most of the members of brown algae, red algae some green and blue-green algae occur in sea. While some occur as phytoplanktons and benthos, others occur as lithophytes. The giant forms like *Macrocystis* (60 *meters*) and *Nereocystis* (50 *meters*) are also marine.

Terrestrial forms : Several members of green and blue-green algae and a few others occur on damp soil. While forms like *Oscillatoria* and *Nostoc* occur on alkaline and calcareous soil, *Fritschiella* grows on acidic soil. Xanthophyceae members like *Vaucheria* and *Botrydium* growing on damp shady soil or on shady walls, are often described as Saprophytes.

Specialized habitats

Cryophytes : Plants growing on snow or ice are called as **cryophytes**. Different algal forms produce a specific colour effect while growing as cryophyte *e.g.*, yellow-green by *Chlamydomonas yellowstonensis*, red by *C. nivalis*, black by *Scotiella nivalis* and purple-brown by *Ancylonema nordenskioldii.*

Thermophytes : Plants growing in hot water are called as **thermophytes**. Some blue-green algae grow in hot water springs at about 70°C *e.g., Oscillatoria brevis.*

Epiphytes : Several algal forms grow on other plants (algae, angiosperms) as epiphytes. *e.g., Oedogonium, Cladophora, Vaucheria* etc.

Endophytes : Some blue-green algae grows as endophytes inside other plants *e.g., Anabaena* growing inside the leaf of *Azolla* (fern), *Nostoc* inside the thallus of *Anthoceros* (hornwort) and *Anabaena, Nostoc, Oscillatoria* inside the coralloid roots of *Cycas.*

Epizoic : Algae growing on the bodies of animals are described as epizoic. *e.g., Cladophora crispata* grows on snail shell, *Characium* grows on the antennae of mosquito larvae, *Cyanoderma* (red alga) and *Trichophilus* (green alga) are grows on scales of sloth.

Endozoic : Algae growing inside the body of animals. *e.g., Chlorella* grow within the tissue of *Hydra*. Some blue-green algae also grow in the respiratory tract of animals. The blue-green algae which grow endozoically inside the protozoans are called as cyanellae.

Symbiotic forms : Some algae like *Chlorella, Nostoce.* etc. growing in symbiotic relationship with members of Ascomycetes and Basidiomycetes (Fungi) constitute the lichen.

Some species of *Cladophora* live in symbiotic association in a sponge *Eplydatea.*

Parasites : The alga *Cephaleuros virescens* grows as a parasite on the tea leaves. In addition, *Rhodochytrium, Phyllosiphon* are other parasitic algal forms.

Phyllobium sphagnicolum is parasite on *Sphagnum* (moss).

Thallus organization

The algae show a considerable variation in the organization of the thallus :

(1) **Unicellular forms :** Several members of algae are unicelled. They may be motile (*Chlamydomonas*) or non-motile (diatoms). Some forms have a thick wall and become sedentary for certain duration in their life history. They are called as **coccoid** *e.g., Chlorella, Chlorococcus.*

(2) **Multicellular forms :** Multicellular forms are following :

Colonial : A colony consists of independent organisms. While the colony of *Volvox* is motile, that of *Hydrodictyon* is fixed. A colony having fixed number of cells and division of labour is called as coenobium *e.g., Volvox.*

Palmelloid : Here the vegetative cells of the alga get surrounded by a mucilagenous matrix *e.g., Tetraspora, Aphanotheca.*

Dendroid : Here the colony appears like a microscopic tree. There is secretion of mucilage from the polar end *e.g., Ecballocystis.*

Rhizopodial : Cells are united through rhizopodia *e.g., Chrysidiastrum.*

Filamentous : Most of the algal forms are filamentous. The filaments may be uniseriate or multiseriate, free floating (*Spirogyra*) or attached (*Ulothrix*), unbranched (*Ulothrix*) or branched (*Cladophora*). The branches may be monomorphic (*Cladophora*) or dimorphic (*Batrachospermum*). The branching may be lateral or dichotomous, true (*Ectocarpus*) or false (*Scytonema*). The filaments may be monosiphonous (*Batrachospermum*) or polysiphonous (*Polysiphonia*). In some filamentous forms there is distinction of a prostrate system and an erect system, thus constituting the heterotrichous habit. *e.g., Stigeoclonium.*

Siphonous : An aseptate, multinucleate (coenocytic) condition of a filament or thallus constitutes the siphonous habit *e.g., Vaucheria.*

Parenchymatous : Parenchymatous organization of the thallus has been observed in many members of brown algae (*Sargassum, Laminaria*), red algae (*Gracillaria, Porphyra*) and a few green algae (*Chara, Ulva*) etc.

Cell organization

Most of the algal groups (except blue-green and dinoflagellates) show eukaryotic cell structure. The cell wall is made up of **cellulose**. Some red algae (*Corallina*) have impregnation of $CaCO_3$. The cells possess a well organised nucleus. The minimum chromosome number in algae is $n = 2$ (*Porphyra linearis*) and the maximum number is $n = 592$ (*Netrium digitalis*). The cells possess distinct mitochondria, plastids, E.R., ribosomes and golgi body. There may be a single thylakoid in the granum of Rhodophyceae, two in Cryptophyceae, three in Phaeophyceae and Bacillariophyceae but generally many.

The motile forms also possess flagella. They show the usual 9 + 2 structure. They are of two types – **acronematic** (whiplash type) and **pleuronematic** (tinsel type).

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Reproduction

The algae reproduce vegetatively, asexually and sexually. Various method involved in reproduction are discussed in the following account.

(1) **Vegetative reproduction :** It occurs by following types.

Fragmentation : It occurs due to breakage of filament or thallus into fragments, each of which behaves as an independent organism *e.g.*, *Ulothrix*, *Spirogyra* etc.

Fission : The unicelled forms like diatoms, desmids multiply by fission *i.e.*, simple cell division.

Budding : A bud arises as a papilla on the parent cell. It enlarges and finally separates *e.g.*, *Protosiphon*.

Akinetes : Due to deposition of food material followed by thickening of the parent wall, a cell is transformed into an akinete. They may be formed in a chain. On the arrival of favourable conditions, they germinate to form a new plant *e.g.*, *Cladophora*, *Ulothrix*, *Nostoc* etc.

(2) **Asexual reproduction :** It occurs by the formation of various types of spores in sporangia. Except the zoospores, all other types of spores are non-motile.

Zoospores : These are thin walled motile spores. They are anteriorly biflagellate and the two flagella are similar in *Cladophora*. In *Vaucheria* and *Ectocarpus* they are laterally biflagellate and the two flagella are dissimilar. Multiflagellate zoospores are formed in *Oedogonium* and *Vaucheria*. In *Vaucheria* the flagella are present all over the surface in pairs and hence it is called as **synzoospore**.

Aplanospores : They are thin walled and non-motile spores commonly formed in *Chlamydomonas*, *Ulothrix* etc.

Autospores : They are also thin walled, non-motile spores which resemble the parent cell *e.g.*, *Chlorella*.

Hypnospores : These are thick walled non-motile spores formed to tide over unfavourable condition. They germinate on the arrival of favourable conditions *e.g.*, *Chlamydomonas*, *Ulothrix*.

Carpospores : In red algae, carposporangia are formed at the tip of gonimoblast filaments which produce a single haploid or diploid carpospore *e.g.*, *Batrachospermum*, *Polysiphonia*.

Tetraspores : Four non-motile tetraspores are formed inside a tetrasporangium as a result of mitosis in brown algae (*e.g.*, *Dictyota*) or by meiosis in red algae (*e.g.*, *Polysiphonia*).

Monospore : The juvenile stage of *Batrachospermum*, a red alga, multiplies by forming a single monospore formed in side a monosporangium.

Palmella stage : In dry conditions, zoospores or aplanospores get surrounded by mucilaginous sheath. The divisions continue and they take the shape of colony. This is known as palmella stage. Under favourable conditions each zoospore gives rise to a new plant. *e.g.*, *Chlamydomonas*.

(3) **Sexual reproduction :** The sexual reproduction in algae is broadly of three types as under :

Isogamy : It involves fusion of gametes which are morphologically and physiologically similar. They are called as isogametes *e.g.*, *Chlamydomonas eugametos*. In diatoms, there is simplification of isogamous reproduction.

Anisogamy : When the two gametes are morphologically dissimilar, the anisogamy is said to be **morphological** *e.g.*, *Chlamydomonas braunii*, *Ectocarpus secundus*. Here the smaller gamete may be called as male and the large one as female. When the two gametes are morphologically similar but differ in their behaviour, the anisogamy is said to be **physiological** *e.g.*, *Spirogyra*, *Ectocarpus siliculosus*.

Oogamy : In this process there is formation of unicelled sex organs. The male sex organ is called as antheridium and the female as oogonium. The antheridium forms the male gametes called antherozoids which are generally flagellate. The oogonium forms a non-motile female gamete called egg. The oogamy involves fusion of antherozoids with egg. The simplest type of oogamy is seen in *Chlamydomonas coccifera*.

Important features of some selected classes

Chlorophyceae or Green algae : Plants are fresh water or marine and forms unicelled to parenchymatous. Chief photosynthetic pigments are chlorophyll a, b; α, β, γ– carotenes, lycopene; lutein, violaxanthin. Reserve food is **starch**. Zoospore are formed and male gametes are flagellate. Flagella identical. Sexual reproduction – Isogamous, anisogamous or oogamous type. *e.g.*, *Chlamydomonas*, *Spirogyra*.

Xanthophyceae or Yellow green algae : Plants are generally fresh water and forms unicelled to siphonous. Chief photosynthetic pigments are chlorophyll a, e; β–carotene, violaxanthin, neoxanthin. Reserve food is **chrysolaminarin** and **oils**. Zoospore are formed and male gametes flagellate. Flagella non-identical (unequal). Sexual reproduction – Isogamous, anisogamous or oogamous type. *e.g.*, *Vaucheria*.

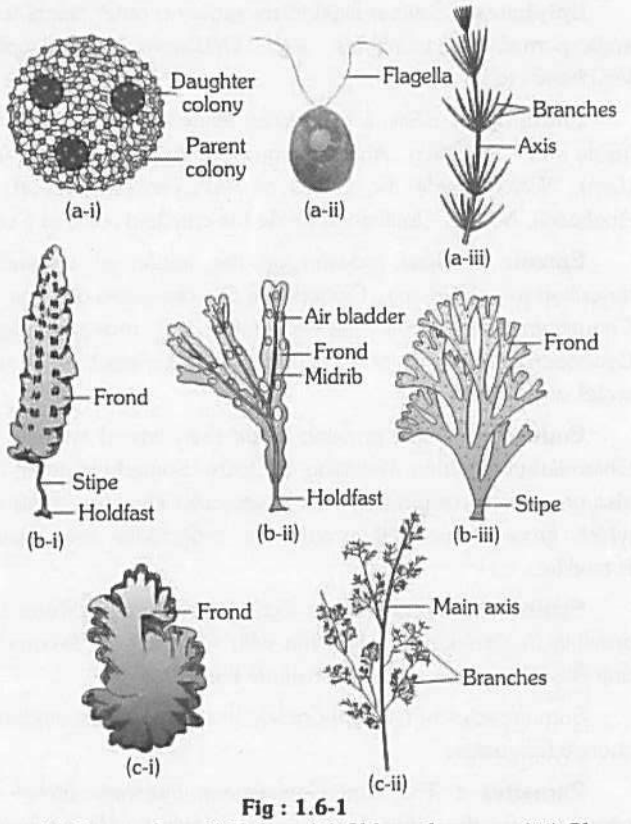

Fig : 1.6-1

Algae : (a) Green algae (i) Volvox (ii) Chlamydomonas (iii) Chara
(b) Brown algae (i) Laminaria (ii)Fucus (iii) Dictyota
(c) Red algae (i) Porphyra (ii) Polysiphonia

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Phaeophyceae or Brown algae : Plants are marine and forms unicelled to parenchymatous. Chief photosynthetic pigments are chlorophyll a, c; β–carotene, fucoxanthin (brown colour), lutein, violaxanthin, diatoxanthin. Reserve food is **laminarin, mannitol and oils**. Zoospore are formed and male gametes flagellate. Flagella unequal. Sexual reproduction – Isogamous, anisogamous or oogamous type. *e.g., Fucus, Dictyota.*

Rhodophyceae or Red algae : Plants are generally marine and forms filamentous to parenchymatous. Chief photosynthetic pigments are chlorophyll a, d is present but chlorophyll c is absent; α, β–carotene, lutein, violaxanthin, fucoxanthin, myxoxanthin, γ–phycoerythrin (red colour), γ–phycocyanin (blue pigment) and allophycocyanin. Reserve food is **floridean starch**, galactan $-SO_4$ polymers. Zoospores are not formed and male gametes are non-flagellate. Sexual reproduction by specialized type of oogamy. Life cycle haplobiontic or diplobiontic. *e.g., Polysiphonia, Porphyra.*

Myxophyceae or Cyanophyceae : Plants are generally fresh water, a few forms marine and forms unicelled to filamentous. Cells showing prokaryotic organization. Chief photosynthetic pigments are chlorophyll a; β-carotene; lutein, myxoxanthin, oscillaxanthin, c-phycocyanin, c-phycoerythrin, allophycocyanin. Reserve food is **cyanophycean starch (glycogen)** and cyanophycin (protein). Zoospore are not formed and no flagellate bodies. Sexual reproduction is absent. *e.g., Nostoc, Anabaena.*

Economic importance

Useful aspects

Nitrogen fixation : Some fifty species of blue-green algae are capable of fixing atmospheric nitrogen in the soil *e.g., Anabaena, Aulosira, Cylindrospermum, Nostoc* and *Tolypothrix* etc. Under aerobic conditions, nitrogen is fixed by heterocysts only. Under anaerobic condition the vegetative cells also show nitrogenase activity.

Algae as food : Many green algae such as *Chlorella, Ulva, Caulerpa, Enteromorpha*, etc. are used as food. *Chlorella* has about 50% protein and 20% of lipid and carbohydrates. The *Chlorella* protein contains all the amino acids essential for human nutrition. *Ulva lactuca* has formerly used in salad and soup in Scotland.

Green algae in space research : In recent years biologists have realized that unicellular green algae (*e.g., Chlorella*) could be used to provide O_2 during space flight trips.

Antibiotics : The genus *Chlorella* yields an antibiotic **chlorellin**, which is used against Gram +ve and Gram –ve bacteria, especially *Escherichia coli, Shigella dysenteriae* and *Staphylococcus aureus*. The genus *Caulerpa* also yields antibiotics.

Alginates : Alginic acid is a polymer of carbohydrate. It occurs in the cell wall and middle lamella. They are obtained from *Laminaria, Ascophyllum, Fucus, Nereocystis, Turbinaria* etc. They are used in pharmaceuticals as emulsifiers and stabilizers as well as for making pills, antibiotic capsules etc. They are also used in the preparation of soups, jellies, cosmetics, toothpastes, polishes, hair dyes, compact powders, lotions, shampoos etc.

Carrageenin : It is a polysaccharide colloid (phycocolloid) obtained from the red algae *Chondrus crispus* and *Gigartina stellata*. It is widely used in soups, sauces, milk shakes, cheese, jellies, cream and fruit juices. It is also used in painting and printing.

Agar-agar : It is a non-nitrogenous carbohydrate consisting of two polysaccharides namely agarose and agaropectin. It is obtained from several red algae *e.g., Gracilaria, Gelidium, Gigartina* and *Chondrus* etc. It is insoluble in cold water but soluble in hot. It is used as a base for a variety of culture media.

Source of minerals and elements : The members of brown algae called **'kelps'** have been the source for obtaining iodine *e.g., Laminaria, Macrocystis, Fucus*. About 25% of total iodine is extracted from kelps. Similarly red algae like *Rhodomela, Polysiphonia* and *Rhodymenia* are sources of bromine.

Sewage disposal : Green unicellular algae such as *Chlorella* and *Chlamydomonas* are used in sewage disposal ponds. They remove CO_2 and restore O_2 by the process of photosynthesis.

Medicines : Sodium lamining sulphate are used as blood anticoagulant and obtained from *Laminaria* and *Durivillea* has antiworm (vermifuge) properties.

Source of protein : The protein of *Chlorella* is superior to cereals as it contains all essential amino acids. Its nutritional value is equal to soybean and spinach.

Harmful aspects

Algal toxicity : Some dinoflagellates like *Prymnesium, Gymnodinium* are extremely poisonous to fishes. The blue-green alga *Microcystis* secretes hydroxylamine which not only kills aquatic life but also the birds and cattles who care to drink water. While *Lyngbya* and *Chlorella* may cause skin allergies in human beings.

Algal parasitism : The red alga *Cephaleuros virescens* causes red rust of tea thus destroying the tea leaves. Similar disease are caused by the species of *Cephaleuros* to coffee plant, *Piper* and *Citrus* sp.

Spoilage of drinking water : Forms like *Anabaena, Microcystis* not only spoil the taste of drinking water but also produces toxic effect. The growth of algae is controlled by using **algicides** such as dichlorophen, sodium perborate, phygon XI, exalgae, delrad etc.

Water blooms : Algae grow abundantly in water reservoirs where excess of nutrients are available to them. This algal growth floats on the water surface and look like foam or soap lather. It is called water bloom. *e.g., Microcystis, Anabaena, Oscillatoria etc.*

Some representative algae

Spirogyra

Habitat

Spirogyra was discovered by Link. It is an unbranched filamentous green alga of stagnant fresh waters which forms floating masses (supported by bubbles of oxygen) called **pond scum**. A sheath of mucilage occurs on the outside. It gives a silky touch. Hence *Spirogyra* is also called **water silk or mermaid's tresses.**

Structure

The thallus is an unbranched and uniseriate filament where cells are arranged in a single row. In some species hold fast is present (*e.g., S. fluviatilis*). The cells are elongated and cylindrical. The cell wall is two layered the outer is of pectic substance and the inner of cellulose. The outer part (pectin) dissolves in water to form a mucilaginous sheath.

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Due to this reason *Spirogyra* filament's are slippery. Transverse or septum can be plane, colligate (with H-shaped piece), replicate (ring like ingrowths) and unduliseptate (undulate). The protoplast is differentiated into plasma membrane, thin layer of cytoplasm, single nucleus, one (*e.g. S.sahni* and *S. venkataramanni*) or many (16 in *S.rectispora*) ribbon (spiral) shaped chloroplasts (wavy margin) with pyrenoids and a large central vacuole. Pyrenoid is made of protein surrounded by starch plate or starch grains and it is the centre of starch formation. Nucleus occurs inside the central vacuole where it is suspended by means of cytoplasmic strands.

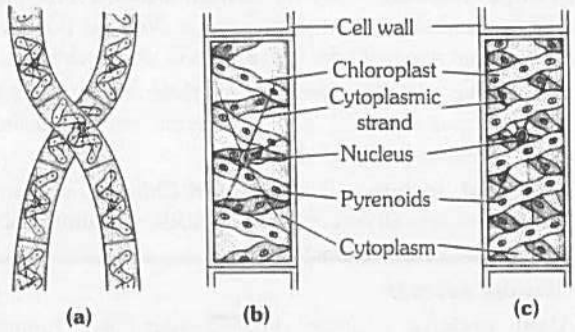

Fig : 1.6-2 *Spirogyra* (a) Two filaments (b) and (c) Detailed structure of a cell

Reproduction

Spirogyra reproduces by vegetative, asexual and sexual methods.

(1) **Vegetative reproduction :** It takes place by fragmentation of filament. Later on, each segment gives rise to new plant.

(2) **Asexual reproduction :** Normally asexual reproduction is absent in *Spirogyra*. It occurs only occasionally by the formation of akinetes, aplanospores and azygospores (Parthenospores).

Akinetes : Under unfavourable conditions, the cells of the filament develop into thick walled structures, which are known as akinetes. On the onset of favourable conditions, these give rise to new plants. Their wall is made up of cellulose and pectin *e.g., S. farlowi*.

Aplanospores : These nonmotile aplanospores are either round or oval. These later on under favourable condition give rise to the new individuals. Aplanospores are known to occur in *S. aplanospora, S. articulate* etc.

Azygospores or Parthenospores : If there is sudden change in the environment, the gametes fail to fuse and each functions as parthenospore.

(3) **Sexual reproduction :** The sexual reproduction in *Spirogyra* is called conjugation, It involves the fusion of two morphologically identical, but physiologically dissimilar gametes.

The conjugation is of two types

(1) **Scalariform conjugation :** This is the most common and advanced type of conjugation. It involves two filaments of *Spirogyra* and takes place between two recently formed cells. The cells of one filament show the formation of **papilla** towards the other filament.

It stimulates the formation of similar papilla in cells lying opposite to them. The two papillae fuse by enzymatic dissolution of the wall thus forming a **conjugation canal**.

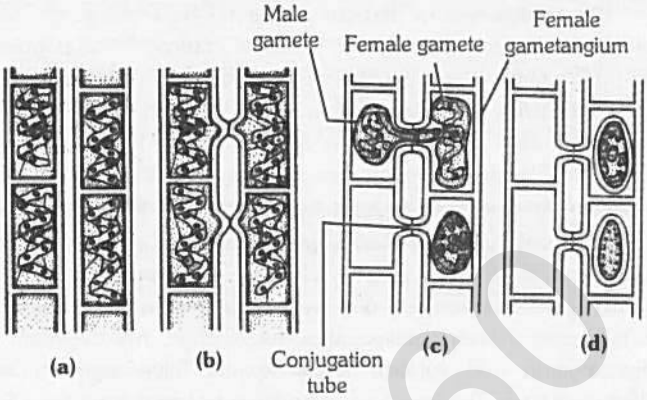

Fig : 1.6-3 (a)-(d) Sexual reproduction showing scalariform conjugation in *Spirogyra*

The conjugation tube between the two filaments looks like a ladder, through which gamete from one of the gametangia passes through to fuse with the passive gamete of another filament. The gametes are formed singly and both **active** and **passive** gametes are considered male and female gametes respectively. The fusion of both kinds of gametes with each other results into formation of zygospore.

The zygospore wall is differentiated into three layers, the outer **exospore** which is thin, the middle **mesospore** which is a thick layer of cellulose, chitinized and pale yellow to brown in colour, and inner **endospore** which is thin and cellulose in nature.

(2) **Lateral conjugation :** It takes place between two nearest cells of the same filament (homothallic). Both male and female gametes are found in same filament. It is of two types.

(i) **Indirect lateral conjugation :** Two outgrowths appear on both sides of a transverse septum of two adjacent cells which later on form a conjugation tube. Of the two cells, one behaves as male gametangium from which gamete passes through the tube into female gametangium. By fusion, zygospore is formed. Thus in each second cell of a filament zygospore is formed. It is commonly seen in *S. affinis* and *S. tenuissima*.

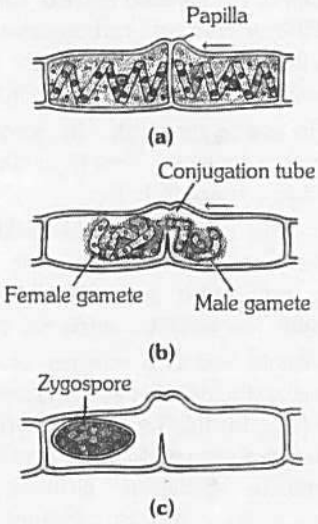

Fig : 1.6-4 Sexual reproduction showing lateral (indirect) conjugation in *Spirogyra*

(ii) **Direct lateral conjugation :** In this type of conjugation, the male gamete after passing through an aperture in the transverse septum of adjoining gametangium enters the female

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gametangium and fuses to form a **zygospore**. The two gametes, though morphologically alike but differ in their behaviour. Hence this type of sexual reproduction corresponds physiologically anisogamy. It is commonly seen in *S. jogensis*.

Germination of zygospores : The zygospores on the arrival of favourable conditions germinate. The nucleus undergoes meiosis to form four haploid nuclei (tetra nucleate). Of these three nuclei degenerate and one functions.

The exo and mesospores rupture and the endospore protudes out in the form of germling. The new cell undergoes transverse division continuously to form a new filament. Thus in the life cycle of *Spirogyra*, there is no flagellate phase.

Life cycle in *Spirogyra* is **haplontic** as dominant phase in life cycle is haploid (*n*) and diploid phase is represented by only zygospore and it undergoes R.D. or meiosis (zygotic meiosis).

Ulothrix

Habitat

It is a green filamentous algae found in slow running fresh water streams. The common species *U. zonata* occurs in cold water whereas *U. flacca* is marine. *U. implexa* occurs in estuaries (where river meets the sea) as **lithophytes**.

Structure

An unbranched filament, consisting of numerous cylindrical or rectangular cells joined end to end. The filaments remain attached to some substratum by means of rhizoidal cell, *i.e.*, showing distinction in base and apex. The basal cell is elongated and colourless known as holdfast while the uppermost cell is rounded.

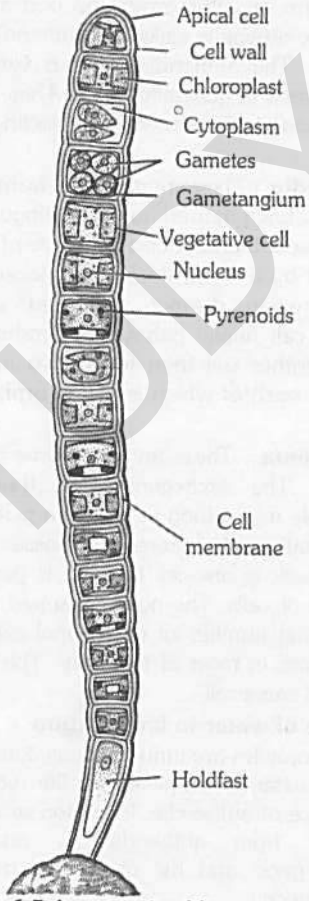

Fig : 1.6-5 A vegetative filament

Cell wall consists of two layers. Inner layer is made up of **cellulose** and outer layer is mostly made up of **protopectin** which is insoluble in water.

Due to presence of protopectin, *Ulothrix* filaments appear as **wet threads**. In the centre of the cell is a nucleus and single **girdle** or **ring** shaped (*U. zonata*) or collar shaped chloroplast. One (*U. rorida*) or more pyrenoids are present in the chloroplast. A vacuole is present, surrounding it is a thin layer of cytoplasm (primordial utricle).

Reproduction

The *Ulothrix* reproduces vegetatively, asexually as well as sexually.

(1) **Vegetative reproduction :** It takes place by fragmentation. In this process a filament divides into small parts. These smaller fragments grow and give rise to new filaments of *Ulothrix*.

(2) **Asexual reproduction :** It takes place by the production of zoospores, aplanospores, hypnospores, akinetes and palmella stage.

Zoospore formation : In favourable conditions, each cell produces zoospores except holdfast. Cytoplasm collects in the centre and divides into 2,4,8,16 or sometimes 32 segments. Each segment develops into biflagellate or quadriflagellate zoospores. Each zoospore is uninucleate, pear-shaped with thin cell membrane (zoospores not having cell wall). The zoospores are of 3 types :

Quadriflagellate macrozoospores : Usually 4 per cell.

Quadriflagellate microzoospores : Usually 8 per cell.

Biflagellate microzoospores : Usually 16-32 per cell.

The zoospores come out into a vesicle, later on the wall disintegrates (forming a pore in lateral wall) and macro and microzoospores are liberated free and float in water. Microzoospores attach to substrate by their anterior ends while macrozoospores attach by their posterior ends. After sometime zoospores give rise to new individuals.

In *Ulothrix*, aplanospores, hypnospores and akinetes are also formed under unfavourable conditions.

Palmella stage : It is produced in water deficiency or presence of toxic chemicals. A number of small green naked cells are formed in mucilage sheath. These cells can grow and divide. On the approach of favourable condition each cell now change into a quadriflagellate zoospore. Zoospore develop into new plants.

(3) **Sexual reproduction :** It occurs at the end of growing season. *Ulothrix* is heterothallic. Sexual reproduction is of isogamous type. The gametes are motile and biflagellate. Except holdfast each cell of the filament can give rise to 64 to 128 gametes.

These gametes are smaller than zoospores. On dehiscence of gametangium, the gametes come out in a bag like structure and float on water.

When two gametes of (+) and (–) strain come together, they fuse and a quadriflagellate zygospore is formed which after floating for sometime on water, rests on the bottom of the pond. At this time, its four flagella disintegrate and a wall is formed surrounding it from all sides. After taking a rest for long period it divides meiotically and gives rise to 4-16 aplanospores or zoospores. These come out of the sac and give rise to a new plant of *Ulothrix*.

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Bryophyta

(Gk. *Bryon* = moss; *phyton* = plants)

Bryophyta includes the simplest and primitive land plants. Which are characterised by the persence of independent gametophyte and parasitic sporophyte. The term bryophyta was coined by Braun (1864) but bryophytes were delimited in its present form by Schimper (1879). It occupies a position intermediate between algae and pteridophyta. Due to peculiar type of their habitats, they are regarded as **'the amphibians of the plant kingdom'**. The science connected with the study of bryophytes called bryology.

Habitats

Bryophytes usually grow in moist and shady places. The plants grow densely together and form green carpets or mats on damp soil, rock, walls, barks of trees and on decaying logs in forests, especially during the rainy season.

Specialized habitats : Some bryophytes grow in diverse habitats such as – **aquatic** (*e.g., Riccia fluitans, Ricciocarpus natans, Riella*), **epiphytes** (*e.g., Dendroceros, Radula protensa* and many mosses), **saprophytes** (*e.g., Buxbaumia aphylla, Cryptothallus mirabilis*), and in **dry habitats** such as dry heaths (*e.g., Polytrichum juniperinum*), deserts (*e.g., Tortula desertorum*) and dry rocks (*e.g., Porella platyphylla*).

Gametophytic plant body

(1) The life cycle of bryophytes consists of two distinct phases – the gametophytic phase and the sporophytic phase. The haploid gametophyte is dominant, long lived, green and independent whereas the diploid sporophyte is short lived and dependent upon the gametophyte. The two phases are morphologically distinct.

(2) The plants are small, range from few millimetres (*e.g., Zoopsis*) to 30–40 centimetres. The tallest species may reach upto 70 *cm* in length (*e.g., Dawsonia*).

(3) The gametophytes are either thalloid (*i.e.*, not differentiated into true roots, true stem and true leaves) or leafy shoot having stem-like central axis and leaf-like appendages.

(4) The roots are completely absent and they are replaced by unicellular or multicellular thread like rhizoids. In some higher forms the multicellular rhizoids form cords.

(5) The vascular tissue (*i.e.*, xylem and phloem) are completely absent.

Reproduction

(1) **Vegetative reproduction :** The bryophytes reproduce vegetatively by following methods :

Death and Decay : Most of these plants reproduce vegetatively by gradual death and decay of the older part of the plant body.

Adventitious branches : Many plants like *Riccia fluitans, Reboulia, Asterella, Pellia* etc. reproduce by adventitious branches. They separate and produce new plants.

Tubers : Several species of *Riccia, Anthoceros, Sewardiella, Asterella* etc. produce tubers which give rise to new plants on the arrival of favourable conditions.

Gemmae : Several members, reproduce vegetatively by forming multicelled gemmae. In *Marchantia, Lunularia,* the gemmae are produced in **gemma cups**. Gemmae are also produced on the thallus of *Anthoceros*. Several mosses also produce gemmae on the 'leaves' (*Bryum*), or axis or rhizoids or on the protonema (*Funaria*).

Primary protonema : The mosses generally reproduce vegetatively by breaking of the primary protonema. New gametophores now arise from the buds differentiated on it.

Secondary protonema : In several mossess a secondary protonema may arise from the rhizoids or primary protonema or even from the injured sporophyte. It may produce buds which give rise to new gametophores.

Rhizoids : Mosses may also reproduce vegetatively from the rhizoids *e.g., Leucobryum*.

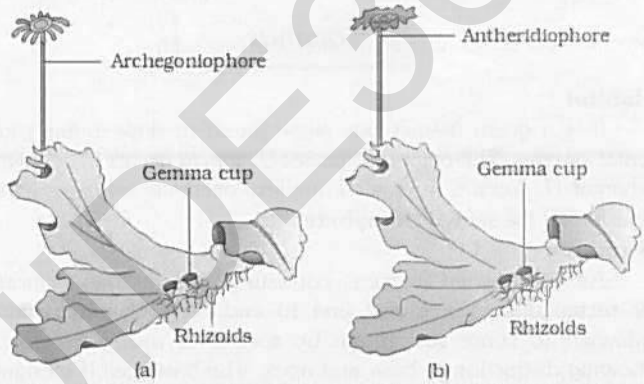

Fig : 1.6-6 Bryophytes (a) Female Thallus (b) Male Thallus

(2) **Sexual reproduction :** It is oogamous, between a flagellate sperm or antherozoid and non motile egg or oosphere. The male sex organs is called as antheridium and the female as archegonium. The antheridial stalk is very distinct whereas the archegonial stalk is generally short. They may be of embedded type *e.g., Riccia, Anthoceros* or of projecting type *e.g., Marchantia,* mosses.

Antheridia : They are generally borne on the dorsal surface of the thallus. Each antheridium is distinguishable into a stalk and the body. The antheridial body consists of a mass of androgonial cells covered by a 1-cell thick sterile jacket. The terminal cell of the jacket, when distinct, is called as **operculum**. Each androgonial cell finally behaves as androcyte mother cell. The androcyte mother cell then forms two androcytes (antherozoid mother cell), each of which is metamorphosed into a biflagellate antherozoid.

Archegonia : These are also borne on the dorsal surface of the thallus. The archegonia are **flask shaped** structures distinguishable into a long neck and a globular, swollen venter. A multicelled stalk is also present in mosses but in others it is very short. The neck is one-cell thick. It is generally made up of six vertical rows of cells. The neck is capped by four cover cells and contain varying number of neck canal cells inside. The venter is also 1-cell thick in most of the plant. The venter contains an egg and a ventral canal cell.

Importance of water in fertilization

The bryophytes are fundamentally terrestrial plants but require presence of water to complete their life cycle. The water is needed for dehiscence of antheridia, liberation of antherozoids, transfer of antherozoids from antheridia to archegonia, opening of archegonial neck, and the movement of antherozoids into the archegonial neck.

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Before fertilization the walls of androgonial cells disorganise to form a mucilagenous mass. The opercular cell is removed and the antherozoids are liberated. The neck canal cells and the ventral canal cell also disorganise. The cover cells split apart giving a free passage to incoming antherozoids. The antherozoids are attracted towards the egg by chemotactic stimulus, which in bryophytes, is provided in the form of sugars. Antherozoids enter into archegonia and fertilized the egg.

Sporophyte

(1) The diploid fertilized egg (zygote) is the first cell of sporophytic generation. It divides and develops into a sporophytic plant body called sporogonium.

(2) The wall of venter forms calyptra, which provides a protective covering to the developing sporogonium.

(3) The sporogonium, in most of the cases, is differentiated into foot, seta and capsule.

(4) The sporogonium is completely dependent on the gametophyte for water and mineral supply and, in most of the cases, partly or wholly for organic nutrition. The sporogonium remains attached to the gametophytic plant body throughout its life.

(5) The sporogonium is mainly concerned with the production of asexually formed haploid spores (or meiospores). The spores are produced inside the capsule of sporogonia as a result of meiosis in the spore mother cells.

(6) The spores are the first cells of gametophytic generation. They germinate to produce the gametophytic plant body either directly or through a juvenile filamentous stage, called protonema.

Important features of classes

Campbell (1940), Smith (1955), Takhtajan (1953) divided bryophyta into three classes namely **Hepaticae, Anthocerotae** and **Musci**. Proskauer (1957) changed the names of these classes in accordance with the recommendations of the code, into Hepaticopsida, Anthocerotopsida and Bryopsida.

Hepaticopsida : The latin word Hepatica means liver. Thus the members of hepaticopsida are popularly known as **liverworts**.

The gametophytic plant body is small, dorsiventral, thallose or leaf axis (foliose). Chlorophyllous cells contain many chloroplasts, one to several oil bodies, pyrenoids are absent. Rhizoids are unicellular. Sex organs develop from single superficial cells.

Anthocerotopsida : Gametophyte is thalloid. Thalli are lobed, dorsiventral, internally homogenous without any differentiation of tissues. Air chambers and air pores are absent but mucilage cavities may be present. Rhizoids are only smooth walled and scales are absent. Each cell possesses single (some times more) large chloroplast with central pyrenoid and oil bodies are absent. Antheridia are endogenous in origin, borne singly or in groups inside the closed cavities.

Bryopsida : The members of bryopsida are commonly known as **mosses**. Gametophyte is differentiated into two stages – prostrate protonema and erect radial leafy shoot. Leaf-like appendages are spirally arranged on stem like axis. Rhizoids are multicellular with oblique septa. Sex organs develop from superficial cells.

Economic importance

(1) **Soil conservation :** Mosses grow in dense mats over the soil surface. They bind the soil particles and prevent soil erosion by running water.

(2) **Formation of soil :** Mosses along with lichens play a very important role in the formation of soil over the bare rocky surface. They grow on rocks and add organic matter to the substratum after their death. It makes the rock surface suitable for the growth of higher plants.

(3) **Use in nursery :** The *Sphagnum* plants have magnificent property of retaining water. They can with hold water two hundred times more than their own weight. Hence they are widely used by gardeners to keep cut plant parts moist during transportation and propagation.

(4) **Peat :** *Sphagnum* plants grow as semiaquatic or submerged in acidic marshes. The older portions of plants die but do not decay due to peculiar germicidal properties. Constantly increasing mass of dead remains accumulate year after year. These dead remains are slowly compressed and become hardened due to weight and forms a compact dark coloured peat rich in carbon.

(5) **Other uses :** Certain bryophytes are used to obtain a number of **antibiotic** substances. Some bryophytes have important medicinal uses. For example – The tea prepared from *Polytrichum commune* is used to dissolve kidney and gall bladder stones.

Some representative bryophytes

Funaria (Moss)

Habitat

Funaria is known as **common moss** or **green moss** or **cord moss**. There are 117 species of *Funaria* which are worldwide or cosmopolitan in distribution. 25 species have been reported from India. Most common species are *Funaria hygrometrica, F.obtusa, F. attentua* and *F. fasicularis*.

Funaria grows well in recently burnt grounds rich in plant ashes (alkaline condition). Common places for its growth are moist rocks, moist walls and moist grounds.

External structure (Gametophytic phase) : The main plant body of *Funaria* is gametophyte and is of two forms.

(1) Juvenile form (creeping protonema).

(2) Adult form (leafy gametophore).

Protonema is the branched filamentous portion which is produced by germination of spores. It is ephemeral or short lived.

Leaves : These are small, sessile, ovate with acute apex and broad base. Leaves are arranged spirally in 1/3 phyllotaxy in upper region and 3/8 in lower region. A distinct midrib is present.

On the lower portion of the leafy gametophore, there are presence of branched, multicellular rhizoids with oblique septa.

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Initially the rhizoids are colourless and hyaline but at maturity they become dark in colour due to dark cell walls. If rhizoids are exposed to light they become green.

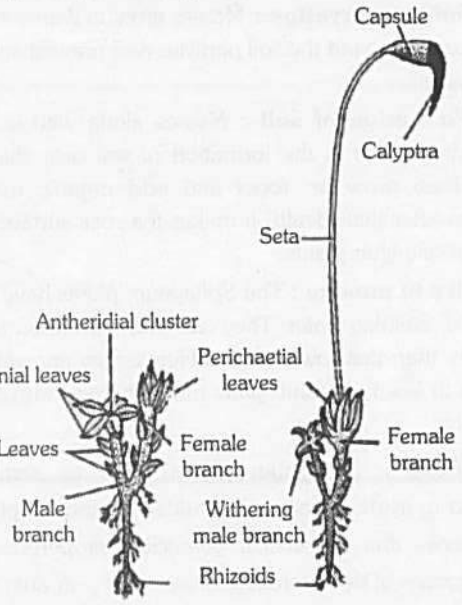

Fig : 1.6-7 *Funaria* plant showing male and female branches

Reproduction

Funaria reproduces both by vegetative and sexual methods.

(1) **Vegetative reproduction :** Vegetative reproduction takes place by fragmentation, primary protonema, secondary protonema, bulbils, gemma and apospory.

In apospory some cells from any part of sporophyte separate from the parent, fall on the soil and form a protonema. Buds of leafy gametophore are produced on the protonema and give rise to a gametophyte- like plant but the cells have diploid set of chromosome (2*n*). In this way a gametophyte like plant is produced from diploid sporophyte without reduction division.

(2) **Sexual reproduction :** The *Funaria* plants are monoecious and autoecious, *i.e.*, male (antheridia, club shaped) and female (archegonia, flask shaped) reproductive organs are produced on the same plant but on different branches. Male organs mature first and hence *Funaria* plants are **Protandrous**.

Antheridium : Each male sex organ is reddish brown/orange stalked multicellular club shaped called antheridium. Main branch is male branch which is called antheridiophore. The antheridia are borne at the tip of antheridiophore. The antheridial cluster remains surrounded by a rosette of leaves called Perigonium. In between antheridia are present club shaped green multicelled sterile hair called paraphyses. An antheridium is distinguishable into stalk and the body. It has a 1-cell thick jacket. Jacket is green in the young antheridium but colour changes in mature antheridium. A number of biflagellate sperms are produced by antheridium.

Archegonium : Female receptacle appear bud like. It contains a number of archegonia intermixed with pointed 4-5 celled green paraphyses. The whole complex is surrounded by upwardly bending or convergent perichaetial leaves.

The archegonium of moss is distinguishable into a stalk, venter and a neck. The venter is double layered and contains an egg and a ventral canal cell inside. The neck is several cells high and is made up of six vertical rows of cells. It contains six or more neck canal cells. It is capped by four cover cells or lid cells. At maturity the venter canal cell and neck canal cells degenerate to form mucilaginous mass. It absorbs water and swells up and opens the lid to create a passage upto oosphere. Oosphere secretes sucrose for attracting sperms.

Fertilization : The neck canal cells and the ventral canal cell also degenerate and the cover cells split apart giving a free passage to incoming antherozoid. The fertilization is affected by water medium. Out of many antherozoids, only one of them is able to fuse with the single egg to produce zygote (2*n*). The zygote without any resting period enlarges and divides to form sporophyte or sporogonium. The first division in zygote is transverse. The epibasal (upper) portion forms capsule and upper half of seta while hypobasal (lower) portion forms foot and lower half of seta.

Sporophytic phase : Fully developed sporophyte or sporogonium is made of three regions, *i.e.*, **basal foot, seta and capsule**. Sporophyte is semiparasite on moss plant taking water, minerals and some growth factors.

(1) **Basal foot :** Basal foot is embedded in the apex of female branch and is conical in shape. Its function is to absorb nutrients and to provide support for sporophyte.

(2) **Seta :** It is a long, slender, reddish brown stalk like structure which bears capsule at the top. Internally it is differentiated into a central cylinder and epidermis. The central cylinder helps in the conduction of water and the thick walled cells of the cortex provide mechanical strength to the slender seta.

(3) **Capsule :** Capsule is the terminal pear shaped portion. Initially it is surrounded by calyptra but later on this calyptra breaks up. Stomata are present on the lower part of capsule. The capsule consists of three portions, *i.e.*, basal apophysis, central theca and terminal operculum.

Apophysis : Apophysis is green, photosynthetic basal sterile portion of capsule in continuation with seta. In capsule of Funaria primitive types of stomata are present only in apophysis.

Theca : Theca is the fertile middle zone of capsule, situated between apophysis and operculum. The outer layer of theca is epidermis, inner to which is 2 layered hypodermis. Central sterile portion of theca is called columella, outer to which is spore sac containing spores. Spore sac develops from endothecium. It enclose spore mother cells which undergo meiosis to form haploid spores.

Outer to spore sac there are present air spaces transversed by many portions of assimilatory cells called **trabeculae**.

Operculum : The upper region of capsule is slightly oblique having upper cap-like portion called operculum. Which covers the peristome. The opercular region is separated from the theca region by two rings. The lower ring is the rim or diaphragm and the upper is annulus. The peristome is distinguishable into two whorls of radially arranged **peristomial teeth**. In each whorl, there are sixteen teeth. Each tooth is a triangular structure. Outer ring of these teeth called exostome (hygroscopic in nature) and inner ring is called endostome (non-hygroscopic in nature).

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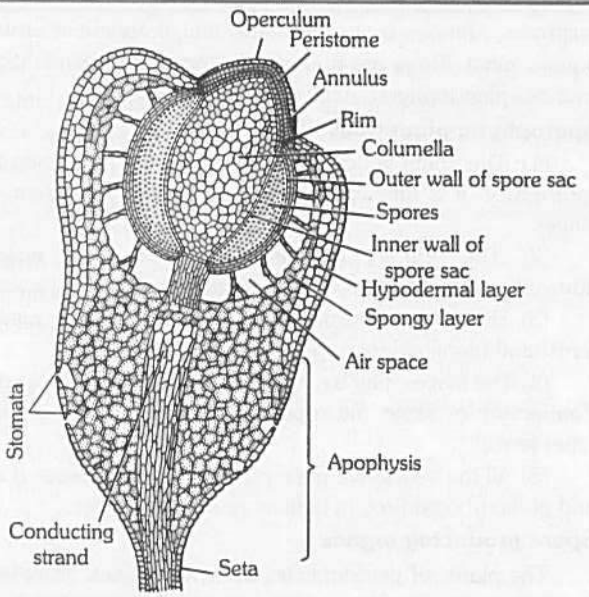

Fig : 1.6-8 L.S. of capsule

Dehiscence of capsule : The capsule swings in air due to twisting movements of long seta. As the capsule matures the thin walled cells including columella dry up. The thin walled cells of operculum break away. The operculum is thus separated along the annulus exposing the peristome. The hygroscopic action of the peristomial teeth also help in the removal of operculum. The capsule becomes inverted due to epinasty. It also shows hygroscopic action. The lengthening and shortening of peristomial teeth help in the dispersal of spores. The inner peristome acts as a sieve allowing only a few spores to escape at a time. Spores have a long viability, *i.e.*, 8-15 years.

Germination of spores : The spore is the first cell of gametophytic generation. Each spore is spherical with two walls, outer one is smooth and coloured called exosporium and inner colourless smooth endosporium. Inside the spore is a single haploid nucleus, numerous chloroplasts and oil globules.

On approach of favourable conditions the spore absorbs water, outer thick exine ruptures and intine comes out in the form of a germ tube which is cut off by means of a septum (oblique). Then it divides and enlarges to form a branched alga like, filamentous, primary protonema.

There are two generations in life cycle of *Funaria*, *i.e.*, gametophytic generation (n) which is independent and complex and sporophytic generation ($2n$) which is partially dependent upon gametophytic generation. These two generations follow each other in regular sequence. This is called heteromorphic or heterologous alternation of generations.

Riccia

Habitat

It is a cosmopolitan genus. The plants occur on moist soil or rocks. Most of the species are terrestrial (on damp soils) except *Riccia fluitans*, which is aquatic in nature.

External structure (Gametophytic phase) : The main plant body of *Riccia* is gametophytic (n). It is small, green, flat and fleshy. The thallus is dorsiventral and dichotomously branched. The thalli are present in the form of patches called **rosettes**. Scales are found on the margins, while rhizoids are present in the mid-rib region of thallus. Rhizoids are unicellular and unbranched and are of two types – smooth and tuberculate. Rhizoids help in fixation. In submerged species, (*e.g.*, *R. fluitans*) scales and rhizoids are not present.

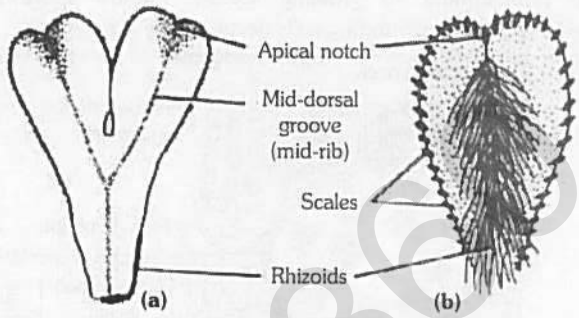

Fig : 1.6-9 Rosette habit (a) Dorsal view of thallus (b) Ventral view of thallus

Internal structure : The thallus is internally differentiated into :

An upper or dorsal photosynthetic region : It consists of vertical rows of chlorenchymatous cells. In between these vertical rows are present very narrow air canals or air chambers. The canals communicate with the outside through air pores. The uppermost cell of each row is enlarged and non-green. These non green cells of vertical rows form a discontinuous and poorly-defined upper epidermis.

A lower or ventral storage region : The lower portion consists of closely packed parenchymatous cells without intercellular spaces. The cells do not contain chloroplasts. They store water and food. The lowermost row of cells form the lower epidermis. Rhizoids and scales develop from the lower epidermis.

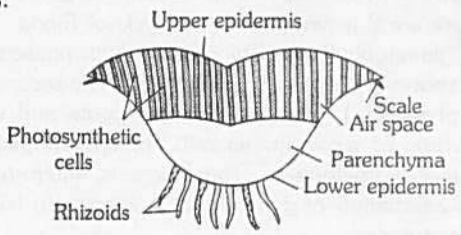

Fig : 1.6-10 A V.T.S of *Riccia* thallus

Reproduction

Riccia reproduces by both vegetative and sexual method.

(1) **Vegetative reproduction :** *Riccia* reproduces vegetatively by progressive death and decay, persistent apices (*R. discolor*), adventitious branches (*R. fluitans*), tubers (*R. billardieri*, *R. discolor*, *R. perennis*) and by rhizoid (*R. glauca*).

(2) **Sexual reproduction** : Sexual reproduction is oogamous type in *Riccia*. Antheridia and archegonia are the male and female sex organs respectively. Sex organs are embedded in the thallus.

Antheridia produce biflagellated elongated curved sperms, both flagella are alike (whiplash type). Archegonia are flask shaped with neck and venter. Neck enclose 4-6 neck canal cells. Venter wall is single layered and encloses one venter canal cell and one egg cell (oosphere). It attracts sperm by secreting protein and K^+ salts (chemotaxis).

Fertilization : The fertilization is affected by water medium (zooidogamous). Many antherozoids may enter into the archegonium, but only one of them is able to fuse with single egg to form zygote ($2n$), which is beginning of sporophytic phase.

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Sporophytic phase : Sporophyte or sporogonium is also embedded. It is covered by two layered calyptra. Sporogonium is undifferentiated and function like a spore sac on capsule. Nurse cell wall of sporophyte and inner layer of calyptra degenerate to provide nourishment to growing spores. Mature spores are liberated when the surrounding cells decay or dry up.

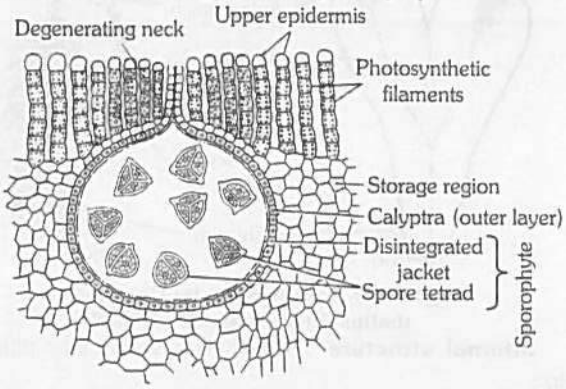

Fig : 1.6-11 V.T.S. of *Riccia* thallus showing mature sporophyte

Germination of spores : Spores are the first cells of the next gametophytic generation. Spores are dispersed by the decay of the surrounding thallus tissue. The wall of the spore is thick and sculptured, and is differentiated into three layers- the outer exosporium, the middle mesosporium and the inner endosporium which is made of pectose and callose. The surface is having clear triradiate mark. In the mass of cytoplasm, stored food is present in the form of oil – globules. After liberation, the spores germinate in about 6-10 days in presence of light, low temperature and sufficient moisture contents. After absorbing water, the spore swells up. The endosporium grows out in the form of a germ tube which, after further divisions, develops into a new thallus (gametophyte).

Thus there are 2 generations in life cycle of *Riccia*. The main plant body is gametophytic (*n*). The gametophytic phase starts with formation of spores and ends with fertilization. The second phase is sporophytic phase (2*n*), which starts with zygote and ends with reduction division of spore mother cell. The sporophytic phase is dependent upon gametophyte. Thus there is heteromorphic or heterologous alternation of generations in *Riccia*. So life cycle in *Riccia* is diplohaplontic.

Pteridophyta

(Gk. *Pteron* = father/fern; *phyton* = plants)

The term pteridophyta was first introduced by Haeckel in (1866). The pteridophytes are flowerless, seedless, spore producing vascular plant which have successfully invaded the land. Pteridophytes represent an intermediate position between bryophytes and spermatophytes (Gymnosperm and Angiosperm). They are also called vascular cryptogams. (The term cryptogams was coined by Linnaeus (1737) which means plants without seeds). The group has a long fossil history. Pteridophytes flourished well during devonian, missipian and pensylvanian periods of late paleozoic age. This period can be well recognised as "**age of pteridophyta**".

Habitat

The plants of pteridophytes are mostly terrestrial. They prefer shady habitats. Some species of *Selaginella* and *Adiantum* are xerophytes. A fern, *Acrostichum aureum is a halophyte.* Some species *e.g., Selaginella oregana, Psilotum flacidum, Lycopodium squarrosum* and ferns like *Asplenium nidus, Pleopeltis* sp. are epiphytes. *Marsilea* occurs as a terrestrial, amphibious as well as an aquatic plant. There are true aquatic ferns like *Salvinia* (Salvinia is root less pteridophyte), *Azolla* and *Ceratopteris*.

Sporophytic plant body

(1) The main independent plant body of pteridophytes is sporophyte. It is differentiated into true roots, true stem and true leaves.

(2) The primary root is short lived. It is replaced by adventitious roots. The root has a permanent growing apex.

(3) The stems are usually herbaceous (except in some woody ferns) and branched monopodially or dichotomously.

(4) The leaves may be small microphyllous (*e.g., Lycopodium, Equisetum*) or large macrophyllous (*e.g., Pteridium, Pteris* and other ferns).

(5) All the vegetative parts possess vascular tissues (*i.e.*, xylem and phloem) organized in definite groups or steles.

Spore producing organs

The plants of pteridophytes are sporophytes. They reproduce asexually by forming spores in sporangia. They are **homosporous** but a few plants are **heterosporous** also *e.g., Isoetes, Selaginella, Marsilea, Regnellidium, Pilularia, Azolla* and *Salvinia*. In *Selaginella* the sporangia are borne in relation to sporophylls which constitute a strobilus. In *Equisetum* they are borne on sporangiophores which constitute a cone. In ferns the sporangia are borne in **sori** on the sporophylls. The sori are of three types :

(1) **Simple sorus :** Here all the sporangia mature at the same time.

(2) **Gradate sorus :** Here the oldest sporangium lies in the centre and the sporangia on either side show successively younger stages.

(3) **Mixed sorus :** It shows mixed arrangement of younger and older sporangia.

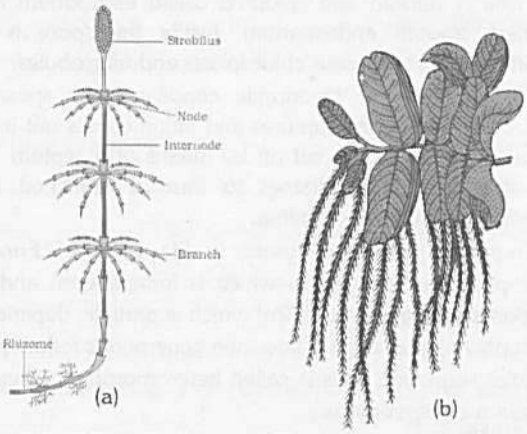

Fig : 1.6-12 Pteridophytes (a) Equisetum (b) Salvinia

Sporangium

The sporangia are generally stalked structures. Each sporangium is distinguishable into a jacket enclosing a mass of sporogenous tissue. The sporangial jacket may be 2-4 layered. The innermost wall layer is the tapetum. No tapetum is formed in *Psilotum* and *Tmesipteris*. It is a nutritive layer which degenerates at maturity of the sporangium. The sporangial jacket in some ferns shows distinctions of annulus and stomium. On the basis of development, the sporangia have been classified by Goebel, 1881 into two categories as under :

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(1) **Eusporangiate type :** Such a sporangium develops from a group of superficial initials. They divide periclinally into outer and inner components. The outer cells form the wall whereas the inner cells give rise to sporogenous tissue. *e.g., Selaginella, Equisetum, Lycopodium.*

(2) **Leptosporangiate type :** Such a sporangium arises from a single superficial initial. It divides periclinally into outer and inner components. While the inner cell forms the stalk, the outer gives rise to sporagnium proper. In *Marattia alata*, the sporangia in a sorus may fuse to form a synangium. *e.g., Salvinia, Azolla.*

Spore

The plants may be homosporous, *i.e.*, produce only one type of spores (*e.g., Lycopodium, Pteridium*) or heterosporous *i.e.*, produce two different types of spores, smaller microspores and larger – megaspores (*e.g., Selaginella, Marsilea* etc.). The spore germination is homosporous pteridophytes may be bipolar (*e.g., Lycopodium, Equisetum*) or tripolar (*e.g., Hymenophyllum*) or amorphous (*e.g., Angiopteris*).

Sex organs and Fertilization

The archegonia and antheridia are generally of embedded type. The archegonium consists of neck which usually projects from the surface of the prothallus. It contains 1-2 neck canal cells. There is no venter. The egg and the venter canal cell remain surrounded by the cells of prothallus. The antheridia are generally sessile. They have a 1-cell thick jacket enclosing a mass of androgonial cells. They form the androcytes which are metamorphosed into biflagellate (*Lycopodium, Selaginella*) or multiflagellate (*Equisetum, ferns*) antherozoids.

Fertilization is affected by water medium (**zooidogamous**). The antherozoids are attracted towards the egg by a chemotactic stimulus provided by the degeneration of neck canal cell and venter canal cell, in the form of malic acid.

Embryogeny

As a result of fertilization the zygote is formed. It divides into an upper or anterior **epibasal cell** and a lower or posterior **hypobasal cell**.

In *Selaginella, Lycopodium* the epibasal cell forms the suspensor and the hypobasal gives rise to embryo proper. By further segmentation a quadrant and then an octant is formed. Usually the epibasal quadrant forms the stem and root and the hypobasal gives rise to foot and root.

The young sporophyte of pteridophytes is dependent upon the gametophyte for food which is drawn with the help of its foot. Like bryophytes, the pteridophytes also show heteromorphic alternation of generations.

Stelar system

The **stelar theory** was proposed by Van Tiegham and Douliot (1886). Some important types of steles found in pteridophytes are :

(1) **Protostele :** Solid core of xylem surrounded by phloem, pericycle and endodermis. The types of protosteles are :

Haplostele : A protostele having a central smooth core of xylem surrounded by phloem, pericycle and endodermis *e.g., Selaginella* sp., *Lygodium*, etc.

Actinostele : A protostele having star-shaped xylem core with radiating ribs *e.g., Psilotum, Lycopodium serratum*, etc.

Plectostele : A protostele having xylem broken into parallel plates alternating with parallel phloem plates *e.g., Lycopodium clavatum.*

Mixed protostele : A protostele having several xylem groups scattered and embedded in phloem *e.g., Lycopodium cernuum.*

(2) **Siphonostele :** A stele having central pith. It is formed by medullation (or appearance of pith) in the protostele. The types of siphonosteles are :

Ectophloic siphonostele : The central pith is surrounded by xylem, phloem, pericycle and endodermis. The phloem occurs only outside the xylem *e.g., Osmunda.*

Amphiphloic siphonostele : The ring of xylem is surrounded on both outer and inner sides by phloem, pericycle and endodermis *e.g., Marsilea rhizome, Adiantum pedatum* rhizome.

Modification of siphonostele

(1) **Cladosiphonic siphonostele :** A siphonostele not perforated by leaf gaps *e.g.*, a few species of *Selaginella.*

(2) **Phyllosiphonic siphonostele :** A siphonostele perforated by leaf gaps *e.g., Nephrolepis.*

(3) **Solenostele :** A siphonostele perforated by leaf gaps which are scattered but not overlapping *e.g.*, Ferns.

(4) **Dictyostele :** A siphonostele perforated by several overlapping leaf gaps. Each separate strand is called meristele. *e.g., Dryopteris, Pteridium, Pteris*, etc.

(5) **Polycyclic dictyostele :** A dictyostele consisting of two or more concentric rings of meristeles *e.g., Pteridium aquilinum.*

(6) **Eustele :** Much dissected siphonostele having vascular strands separated apart by parenchyma *e.g., Equisetum.*

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Heterospory

The sporophytes reproduce asexually producing spores in sporangia. When all the spores are alike *i.e.*, almost of the same size, the phenomenon is called homospory. However, in some pteridophytes, two types of spores are formed which differ significantly in their size as also in function. This phenomenon is called as heterospory. It is seen in pteridophytes like *Selaginella, Isoetes, Stylites, Marsilea, Regnellidium, Pilularia, Azolla, Salvinia* and *Platyzoma*.

Apogamy, Apospory and Parthenogenesis

The terms **apogamy** was coined by de Bary (1878). It is defined as formation of sporophyte from a gametophytic cell other than egg without fertilization. It was first observed by Farlow (1874) in *Pteris cretica*. Thereafter it was observed in several other plants *e.g., Lycopodium, Selaginella, Nephrodium, Lastrea, Marsilea* etc. The apogamy is of two types, **obligate** and **facultative**.

The formation of gametophyte from a sporophytic cell without meiosis is called as **apospory**. This phenomenon was first observed by Druery (1884) in *Athyrium filix-femina*. Thereafter it has been established in several pteridophytes. *e.g., Pteridium aquilinum, Asplenium, Trichomanes* etc. Induced apospory was seen in *Pteris* species.

Formation of sporophyte from egg without fertilization is called as parthenogenesis. Farmer and Digby (1907) observed that in homosporous, leptosporangiate ferns, apospory was always followed by parthenogenesis. This phenomenon has been observed in several species of *Selaginella* and *Marsilea*.

Economic importance

(1) **Ornamental value :** Many ferns are grown as ornamental plants in gardens for their large and graceful foliage. *e.g.*, species of *Lycopodium, Nephrolepis, Selaginella, Lygodium, Anemia, Cyathea* etc.

(2) **Medicines :** An anthelmintic drug is obtained from the rhizomes and petioles of the fern *Dryopteris*. *Lycopodium clavatum* is used in skin diseases. *Equisetum arvense* has diuretic properties.

(3) **Food :** The sporocarps of *Marsilea* are rich source of starch and used by tribals for their nutritive value.

(4) **Soil conservation :** Plants like *Selaginella* are useful in soil conservation.

Some representative pteridophytes

Selaginella

Habitat

Selaginella is commonly called the little club moss or spike moss. *Selaginella* is mainly found in damp shaded places. A few species are xerophytic and can withstand the dry conditions for months together. In dry conditions, the plant rolls up into a compact ball and root system is disorganized. During the rainy conditions the ball on absorbing moisture, becomes green again. Such plants are called **resurrection plants** or **bird's nest moss**, *e.g.*, *S.lepidophylla* and *S. pilifera* are xerophytes and sold in the market as novelties, *S.bryopteris* (Sanjeevani) and *S.rupestris* (ornamental).

The common epiphytic species are *S. chrysocaulos, S. kraussiana, S. oregana, S. chrysorrhizos*.

Structure

External structure : The plant body is sporophytic (2*n*), which is an evergreen and delicate herb having adventitious roots. The plants show great variation in their morphology. Some species are prostrate growing upon the surface (*e.g.*, *S.kraussiana)*, some are suberect (*e.g.*, *S.trachyphylla*) and others are climbers (*e.g.*, *S.allegans)*. The stem is covered with four rows of small leaves, out of these two rows are of smaller leaves and two of large leaves species with dimorphic leaves such as *S.kraussiana, S.helvetica, S.lepidophylla, S.chrysocaulos* etc.

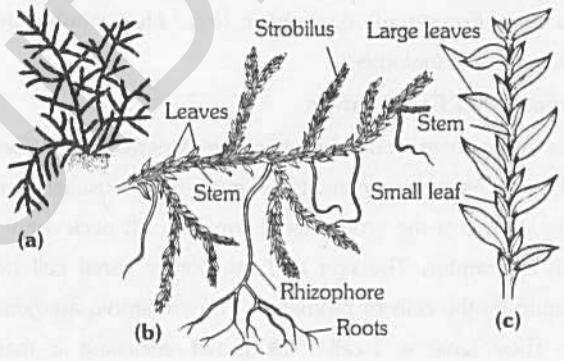

Fig : 1.6-13 *Selaginella kraussiana* : (a) General habit (b) A part of the plant (c) Small portion of plant showing arrangement of leaves

Leaves are sessile, ovate or lanceolate with acute apex. Unbranched midrib is present in the centre of each leaf. The leaves are ligulate, *i.e.*, a flap-like outgrowth is present at the base on adaxial side called ligule. It may be fan-shaped or tongue-shaped or lobed or fringed. At the base of ligule, there is present a sheath of elongated cells called glossopodium (secretory).

The leaves possess a midrib but there is **no venation**. At the place of bifurcation of stem, a leafless, colourless, positively geotropic, elongated, cylindrical structure grows downwards. This is called the rhizophore and is quite different from the root in that it has no root cap.

Internal structure

Root : In root the stele is a protostele. It has a central core of xylem surrounded by phloem which is **horse shoe shaped**. It has a single protoxylem element (monarch). The xylem is exarch.

Stem : The stem is internally distinguishable into a single layered epidermis having no stomata. This is followed by cortex. The stele is suspended by unicelled (rarely multicelled) trabaculae (modified endodermal cell).

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This layer, due to presence of casparian strips is regarded as endodermis. The stele is a protostele (haplostele) surrounded by a pericycle with a central core of xylem enclosed by phloem. Protostele is **diarch** and **exarch**. Stem of *Selaginella kraussiana* shows distelic condition. More than one steles are present in the stem of some pteridophytes (*i.e.*, polystelic condition) *e.g.*, steles are present in *S. laevigata*.

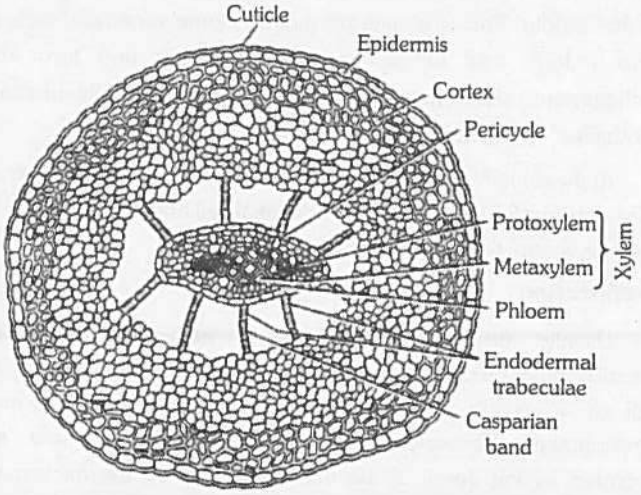

Fig. 1.6-14 T.S. stem of *Selaginella*

Leaf : The leaf displays a simple structure. The mesophyll is uniform, being composed of elongated chlorenchymatous cells with large intercellular spaces. Each measophyll cells has one (*S.martensii*), two (*S.kraussiana*) or eight (*S.willdenovii*) chloroplasts. Each chloroplast has several pyrenoid-like bodies similar to Anthocerotales. The single midrib bundle is concentric, amphicribal (ectophloic) with annular or spiral tracheids surrounded by a few sieve elements.

Rhizophore : Its anatomy is similar to root. The stele is a protostele. The xylem is exarch and monarch with several protoxylem groups. In *S.kraussiana*, centroxylic condition (having protoxylem in the centre surrounded by metaxylem elements) has been recorded.

Reproduction

Reproduction takes place by vegetative and sexual (by spores) method.

(1) **Vegetative reproduction :** It is of rare occurrence and may takes place by following methods :

Fragmentation : It occurs during very humid conditions. Some branches act as adventitious branches, which get separated from the plant and give rise to new *Selaginella* plants, *e.g.*, in *S.rupestris*.

By resting buds : In some cases, terminal leaves get overlapped and become fleshy and form resting buds, which are means of vegetative reproduction, *e.g.*, in *S.chrysocaulos*.

By tubers : In *S.chrysorrhizos*, some branches penetrate into substratum and at terminal ends swell to form tubers, which give rise to new plants.

By apogamy : In some cases, development of sporophyte occurs directly from gametophyte without intervention of sex organs, it is called apogamy and such plants are genetically **haploid**.

(2) **Sexual reproduction :** The reproductive structure in *Selaginella* is strobilus or spike. It is a sessile structure and develops at the terminal ends of the branches and its length varies from 1/4th of an inch to 2–3 inches in different species.

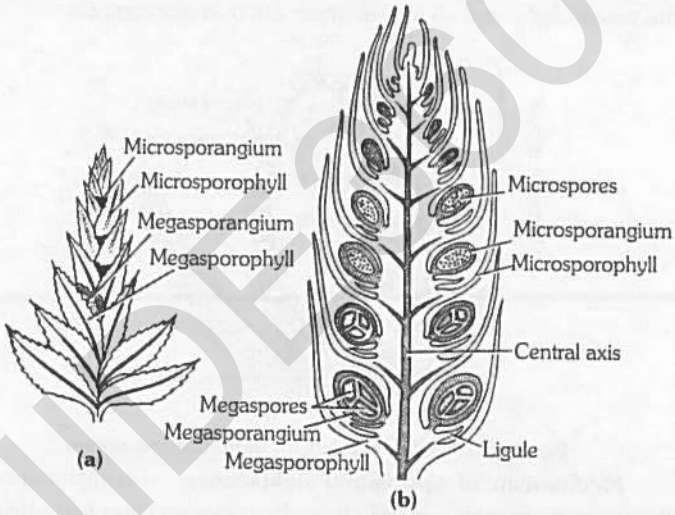

Fig : 1.6-15 *Selaginella* : (a) A strobilus showing compactly arranged sporophylls (b) L.S. through strobilus

A strobilus is having many ligulate sporophylls arranged in cluster, each bearing a small, short, stalked sporangium on its upper surface. The sporangia are of two types :

(i) **Megasporangia :** Borne on megasporophylls. Megasporangium is pale greenish and contains chalky white, yellow or orange **megaspores**.

The megasporangium **is four-lobed** structure with a 2-layered jacket, one layer of tapetum and a large number of microspore mother cell. However, only one megaspore mother cell is functional. After meiosis it produces 4 megaspores out of which 1–3 may degenerate. In *S.rupestris*, there is only a single megaspore.

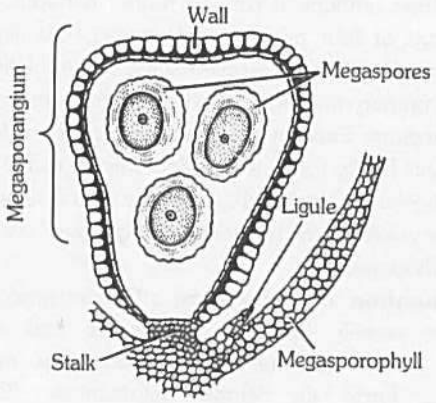

Fig : 1.6-16 *Selaginella* : V.S. of megasporangium

(ii) **Microsporangia :** Borne on microsporophylls having a large number of small spores. Thus *Selaginella* is heterosporous. Microsporangium is pale yellow, oval or spherical body, with 2-

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layered jacket, one layered tapetum and a number of microspore mother cells which undergo meiosis and form haploid microspores. The main body consists of a wall having two layers, inside which are present numerous small microspores (400–2000). Development of sporangium is of eusporangiate type.

In most of the cases, the strobilus or spike bears two types of sporophylls; the lower are megasporophylls and the upper ones are microsporophylls. In *S.kraussiana* there is single megasporophyll at the base of spike and the rest of upper are microsporophylls.

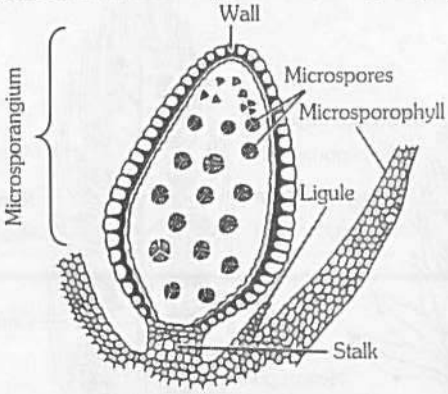

Fig : 1.6-17 *Selaginella* : V.S. of microsporangium

Mechanism of sporangial dehiscence : On maturation, the sporangium splits vertically from the upper end into two valves (vertical apical splitting). The lower cup-shaped portion shrinks and the spores come out through apical slits. This is brought about by cohesion owing to hygroscopic changes in the apical and lateral part of the sporangial wall. This liberation of spores takes place at intervals in small masses.

Germination of microspore : The microspore is a double layered structure and contains oil droplets. The outer wall exospore is much thicker (spiny) than inner endospore. It measures 15–50μ in diameter. The microspore on germination forms the male gametophyte. The structure and development of male gametophyte was first described by Slagg (1932). The first division leads to formation of a small prothallial cell and a large antheridial cell.

The larger antheridial cell, by further divisions, gives rise to central group of four primary androgonial cells, surrounded by eight jacket cells. At this 13-celled stage (1 prothallial + 8 jacket cells and 4 primary androgonial cells), the microspore is shed from microsporangium. Each of the central groups of cells divides and redivides and finally forms about 256 spirally coiled antherozoids with two flagella (biflagellated); the jacket cells disintegrate. It takes about three weeks for germination of microspore and formation of antherozoids or sperms.

Germination of megaspore : The megaspore has three wall layers namely exospore, mesospore and endospore. It measures 1.5 – 5.0 *mm* in diameter. The megaspore on germination forms the female gametophyte. Generally the megaspore germinates inside the megasporangium (*i.e.*, in *situ*). In some sps., megaspores are shed after the development of first archegonium, *i.e.*, in *S.kraussiana*, while in *S.apoda* and *S.rupestris*, megaspores are not liberated till a well developed embryo is formed.

During the development of female gametophyte, the protoplasm after contraction forms a small sac-like structure. The outer wall bursts into two layers, the exospore and mesospore. At this stage, megaspore contains a haploid nucleus which by division produces many nuclei. Wall formation takes place in the upper beak-like portion and a small-celled cellular tissue is formed. This is one celled thick at the sides and three celled thick in the middle. This is female prothallus. Some superficial cells at apex enlarge and act as archegonial initials and form the archegonia. The megaspore bursts exposing the female prothallus. Vestigial rhizoids develop.

Archegonium are sessile and embedded type and consists of very short neck having a single neck canal cell and a venter, having a single ventral canal cell and an egg.

Fertilization

Usually the male gametophytes are shed from the microsporangium on the ground at 13-celled stage (one prothallial cell +8 jacket cells +4 androgonial cell). Here they complete their development ultimately producing spermatozoids. These are liberated by the decay of the microspore wall. If the microspore falls near the mature female gametophyte, the sperms swim from the male gametophyte to reach archegonia and one sperm fuses with egg to form zygote. Water is necessary for fertilization and sperms are attracted due to **malic acid**.

Development of embryo or Sporophyte

The oosphere after fertilization gets surrounded by wall and become oospore. The oospore (zygote) divides transversely into two cells, the upper epibasal cell which forms suspensor cell and the hypobasal cell which develops into embryo.

The embryo differentiates into foot, root, primary stem with two rudimentary leaves and rhizophore. By growth of stem and the root, the young sporophyte becomes independent of the gametophyte tissue and falls on the ground where the primary rhizophore forms roots that grow into the soil and the plant starts independent life.

In some species of *Selaginella*, the archegonial initial develop apogamously into embryo. In *S.intermedia*, no microspores are formed. Here the embryo develops parthenogenetically from the egg. In *S.helvetica*, the archegonia fails to open and here also parthenogenetic development of embryo is seen.

There is distinct **heteromorphic** alternation of generations in *Selaginella*.

Pteris, Dryopteris and Pteridium (Fern)

Habitat

Ferns live in moist, cool and shady places. They are perennial and evergreen. *Fern Dryopteris filix-mas* is commonly known as **Beech fern** or Male shield fern or **Hay scented fern**. There are about 150 sps. and 25 sps. have been reported in India. It is found in sub-tropical regions as well as warm temperate regions.

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Structure

Fern plant is sporophytic (2*n*) with an underground rhizomatous stem, large aerial leaves or fronds and adventitious roots. Rhizome is sparingly branched in *Dryopteris*, moderately branched in *Pteris* and *Adiantum* (*Adiantum* is commonly called "Maiden hair fern" or walking fern because it propagates vegetatively by its leaf tips) and profusely branched in *Pteridium*. The younger leaf is called like a spring from apex downwards are called circinate venation. The venation (arrangement of viens) in leaf is open furcate type.

Younger parts of leaves and rhizome are surrounded by brown hairy structures called **scales** or ramenta. Leaf bases are persistent.

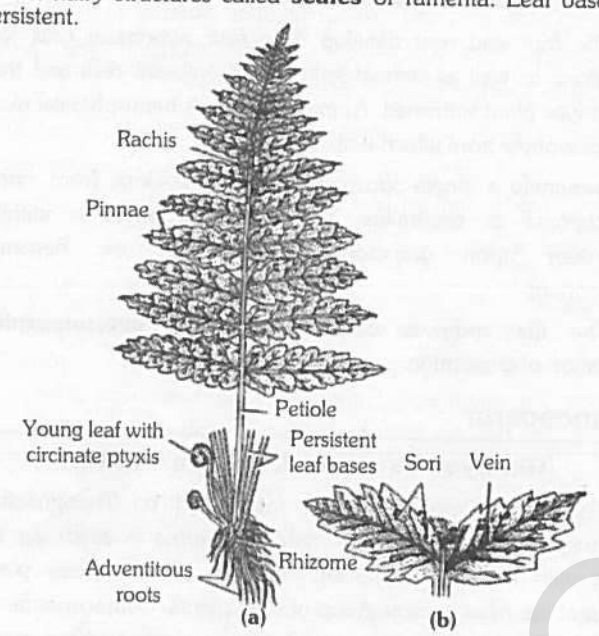

Fig : 1.6-18 *Dryopteris* (a) Plant showing habit (b) Fertile pinnule

Root : In root the xylem is diarch and exarch with two phloem groups alternating the protoxylem.

Rhizome : Meristeles are found in fern rhizomes. Each meristele has its own endodermis followed by thin walled pericycle. It is amphicribal with mesarch xylem. The phloem lacks companion cells. In *Dryopteris filix-mas* the vasculature comprises a dictyostele consisting of a ring of meristele. In *Pteris*, however, the vasculature ranges from solenostele to polycyclic dictyostele.

Rachis : In the rachis of *Dryopteris filix-mas* there are 6–8 meristeles arragned in a horse-shoe like manner and single arched with hooked xylem in *Pteris*. The structure of the meristele is similar to that of rhizome.

Leaf lamina : Transverse section of lamina exhibits cuticularised upper and lower epidermis having chloroplast. The vascular strands lie embedded in mesophyll. Each strand is generally amphicribal but sometimes they are bicollateral also. The bundles in minor veins are collateral.

Reproduction

Vegetative reproduction : Vegetative reproduction can occur through fragmentation or rhizome and adventitious buds and these on separation gives rise to new fern plant.

Sexual reproduction : Sexual reproduction takes place through spores. Spores are born in sporangia. The spores are of one kind only (homosporous). When leaves are mature they bear groups of sori on the under surface of fertile *pinnae*. Such fronds are called sporophylls.

Sori are linear and submarginal in *Pteris* and *Pteridium* and median abaxial in *Dryopteris*. Each sorus is surrounded by a kidney-shaped covering called indusium. In *Dryopteris*, true indusium is present because this arises from placenta or placental tissue, from which sporangia arise. (In *Pteris* false indusium is there because it is formed by leaf margins).

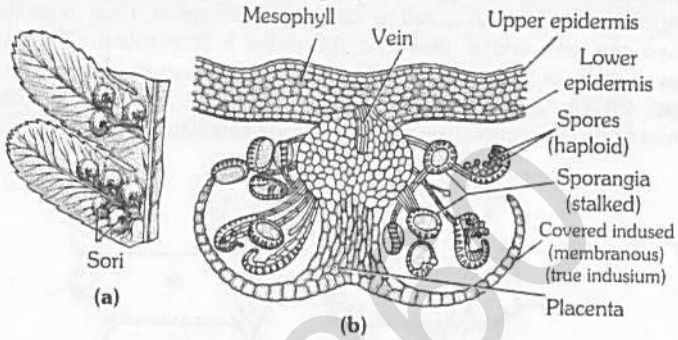

Fig : 1.6-19 *Dryopteris* (a) Part of sporophyll with sori (b) T.S. of sorus

In sorus of Pteridium is covered by two flap like appendages that protect the sporangia. The upper flap is called false indusium and lower is called the true indusium. In the centre of sorus, the vein ends into placental tissue from where arise a number of sporangia. The sorus is mixed in *Dryopteris* (*i.e.*, no definite arrangement of sporangia).

Sporangium : The sporangial development is leptosporangiate *i.e.*, it develops from a single superficial initial. (In eusporangiate type the sporangium arises from a group of initials). A sporangium is distinguishable into a stalk and a capsule. The stalk is multicelled and biseriate.

The capsule is oval or elliptical and biconvex in shape. It consists of a single layered wall followed by double layered tapetum that encloses the archesporium. The archesporial cells divide and redivide to form a mass of sporogenous tissue. Most of the sporogenous cells behave as spore mother cells. They undergo meiosis to form tetrahedral tetrads of (haploid) spores. As a result 32–64 spores are formed in each capsule. The tapetal layer is nutritive. It degenerates at maturity of the sporangium.

Gametophytic generation

Spores : It is the first cell of gametophytic generation. Spores are double layered. The outer wall **exospore** is much thicker than inner **endospore**. On approach of favourable condition spore germinates to form a filamentous gametophyte which develops into green, dorsiventral and heart shaped prothallus.

Prothallus : Fern prothallus is monoecious but protandrous (antheridia mature first). Antheridia are present in between the rhizoids while archegonia are present near the apical notch.

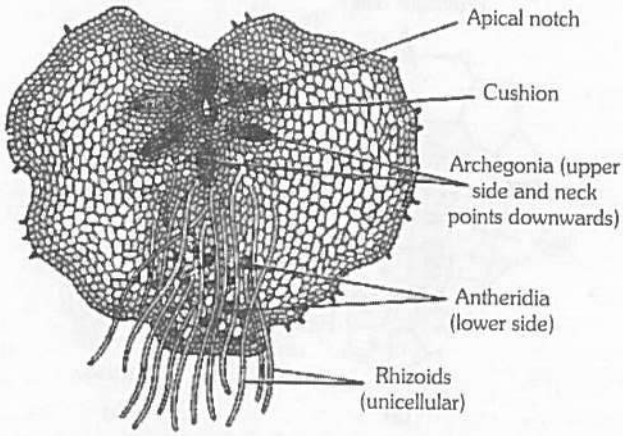

Fig : 1.6-20 Mature prothallus of *Dryopteris*

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Antheridium : It consists of a three celled jacket enclosing a mass of androgonial cells. The two lower jacket cells are ring like (first and second ring cells), and the terminal cell is called as opercular cell or cover cell or cap cell. Sometimes, there may be two cap cells and in that case the jacket is four celled. The last generation of androgonial cells forms the androcytes. There may be 20–25 androcytes in an antheridium, each of which metamorphose into a spirally coiled, multiflagellate antherozoid.

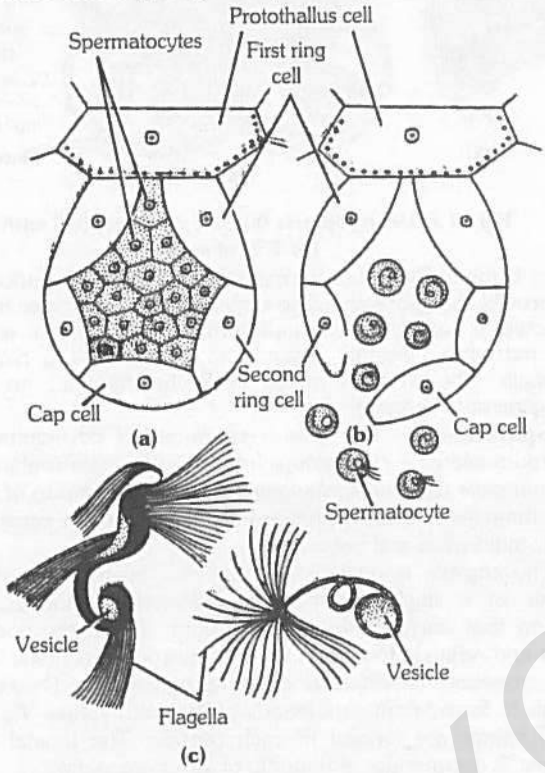

Fig : 1.6-21 *Dryopteris* (a) L.S. antheridium (b) dehisced antheridium (c) Multiflagellate spermatozoids

Archegonium : It is a flask-shaped structure having venter and neck. Neck is projected out of the prothallus and is curved posteriorly.

Venter is having basal large egg cell and upper small venter canal cell. The neck is having single neck canal cell but is binucleate. Venter is not having any covering or jacket but neck is surrounded by jacket of 4 vertical rows of cells.

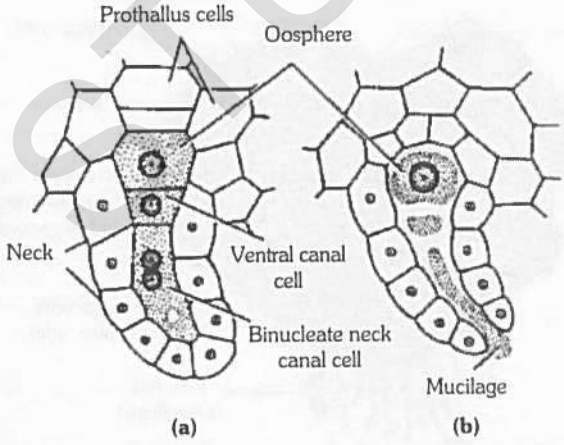

Fig : 1.6-22 *Dryopteris* (a) Mature archegonium (b) Before fertilization

Fertilization and development of sporophyte : Fertilization takes place in the presence of water. The antherozoids are attracted towards archegonium due to the presence of malic acid in the mucilage oozing out from archegonia.

A single antherozoid is able to fuse with egg to form zygote ($2n$), which is beginning of sporophytic generation.

Zygote divides first by vertical division, followed by another vertical division and quadrate stage is formed. Then octant stage is formed by transverse division.

The foot and root develop from four hypobasal cells and cotyledons as well as stem develop from epibasal cells and thus sporophytic plant is formed. At maturity foot is hemispherical mass of gametophyte from which it absorbs food.

Generally a single sporophytic plant develops from single gametophyte or prothallus. The fern sporophyte is initially dependent upon gametophyte but later on becomes independent.

The life cycle is diplohaplontic with **heteromorphic** alternation of generation.

Gymnosperm

(Gk. *Gymnos* = naked; *sperma* = seed)

The term gymnosperm was introduced by Theophrastus. Gymnosperm (Gk. *Gymnos* = naked ; *sperma* = seed) are the plants with exposed or naked seeds or ovules. These plants represent the most ancient group of seed plants. Gymnosperms are called fruitless phanerogames or flowering plants without ovary. Robert Brown (1827) separated them from angiosperms and placed under a distinct group due to presence of unprotected ovules in them. The gymnosperms originated much earlier then angiosperms. However, most of the members of this group have now become extinct and only few living forms are known today.

Distribution

Plants of gymnosperms occur throughout the world. The group is presently represented by only 900 living species. Of these, about 500 species belong to 'Conifers' or cone bearing plants. Several species of conifer occur in north-west America and eastern and central China. In India several members are found in Himalayas, *Podocarpus* and *Cupressus* in the central and *Larix*, *Tsuga*, *Cephalotaxus* in the eastern.

Habit

Living gymnosperms are mostly perennials, xerophytic, evergreen, arboreal and woody plants. They grow as woody trees, bushy shrubs or rarely as climbers (*e.g.*, Gnetales). None of them are herbs or annuals.

External features

(1) The plant body is sporophyte and differentiated into root, stem and leaves.

(2) The plant possess well developed tap root system. In some cases the roots are symbiotically associated with algae (*e.g.*, Coralloid roots of *Cycas*) or with fungi (*e.g.*, Mycorrhizal roots of *Pinus*).

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(3) The stem is erect, aerial, solid, woody and branched (unbranched in Cycadales) but almost tuberous in *Zamia*.

(4) The leaves may be microphyllous or megaphyllous.

(5) In gymnosperm xylem is generally made up of tracheids but vessels have been observed in *Gnetum*, *Ephedra* and *Welwitschia*.

(6) The primitive haplochelic type of stomata are found in *Cycas*, *Pinus*, *Ginkgo*, *Ephedra* etc.

(7) Development of oospore is meroblastic.

Gymnospermous wood

Monoxylic wood : The wood formed may be in one ring due to persistent cambium. Such a wood is called as monoxylic *e.g.*, *Pinus*.

Cambial activity is short lived, cortex and pith are broad, parenchymatous rays are broad, wood is soft and commercially useless. *e.g.*, *Cycas*.

Pycnoxylic wood : The wood is formed in more than one ring due to ephimeral nature of cambium. Such a wood is called as polyxylic.

Cambial activity is long lived, cortex and pith are reduced, parenchymatous rays are few, wood is hard and compact, wood is commercially most important and used as good quality timber. *e.g.*, *Pinus*.

Reproduction

Gymnosperms are heterosporous, *i.e.*, produce two different kinds of spores – the male microspores and the female megaspores. The spores are borne inside the sporangia. The two types of sporangia are borne on special leaf-like structures, called sporophylls. The microsporangia (pollen sacs) are borne on microsporophylls (= stamens) and the megasporangia (ovules) are borne on megasporophylls (= carpels).

The sporophylls are usually aggregated in the form of compact structures called cones or strobili. The cones are generally unisexual, *i.e.*, the male cones are microsporangiate (pollen cones) and the female cones are megasporangiate (seed cones). The male cones are short lived whereas the female cones are long lived. The female cones remain attached on the plants for several years till the maturity or ripening of the seeds.

Pollination

The microsporangium (Pollen sac) produces numerous light pollen grains. Pollination is anemophilous (wind pollination). The ovules are orthotropous and remain exposed on the megasporophyll. Each ovule is surrounded by integuments. It encloses the nucellus and a female gametophyte formed from the haploid megaspore. The female gametophyte contains archegonia. The pollen grains are captured by the pollination drop secreted by the micropyle of the ovule. When it dries, the grains are sucked in the pollen chamber. The pollen grains now germinate. A pollen tube is formed due to elongation of the tube cell. In *Cycas* and *Ginkgo* the pollen tube is haustorial in nature. The lower end of the tube bursts and releases the male gametes which fuse with the egg to form the zygote.

Fertilization

Fertilization occurs by siphonogamy, *i.e.*, the male gametes are carried to the archegonia through pollen tube (except in *Cycas* where pollen tube functions as haustorium and fertilization occurs by zoodiogamy). Fertilization thus takes place in the absence of external water.

Embryogeny

The zygote undergoes free-nuclear divisions in *Cycas* followed by wall formation. There are no free-nuclear divisions in *Sequoia* and *Gnetum*. The embryo is soon differentiated into an upper haustorial, middle suspensor and lower embryonal regions. In *Pinus*, on the other hand, the zygote gets differentiated into four tiers of four cells each, designated as open tier, rosette tier, suspensor tier and embryonal tier. Cleavage polyembryony is seen in *Pinus*. The embryonal part shows differentiation of radicle, hypocotyl, cotyledons and plumule.

Seed

As a result of fertilization the ovule develops into a seed. The integument forms the seed coat. The middle stony layer of the integument forms the **testa** whereas the inner fleshy layer gives rise to tegmen. The nucellus persists as a cap like **perisperm**. In *Taxus* a fleshy **aril** is also present at the base as a cup like structure. The seeds of gymnosperms comprise tissue of three generations namely **parent sporophytic** (integument and nucellus), **gametophytic** (endosperm) and **second sporophytic** (embryo).

Living fossils

When a group of plants is represented by a single genus or species while rest of the other representatives of the group have become extinct and fossilized the long surviving individual is called a living fossil *e.g.*, *Ginkgo biloba*. However, *Cycas* is also regarded as a living fossil because most of the cycad species are confined to tropical and subtropical regions and the group is becoming endangered. Therefore, cycads have been referred as reptiles of plant kingdom or panda of vegetable kingdom.

Economic importance

(1) **Ornamentals :** Some of the gymnosperms are grown in the gardens in different parts of the world *e.g.*, *Cycas revoluta*, *Ginkgo biloba*, *Araucaria cookii*, *A. bidwilli*, *Biota orientalis*, *Cupressus* sp., *Juniperus* sp., *Thuja* sp., *Taxus baccata*, *Cryptomeria japonica* etc.

(2) **Wood :** Several plants of this group yield useful timber. The wood of *Cedrus deodara* is used for making railway sleepers. It is also used as a structural timber and making bridges. The wood of *Callitris verrucosa*, *Pinus roxburghii*, *P. wallichiana*, *P. pinaster*, *P. lambertiana* etc. is used for making furniture. *Juniperus virginiana* wood is used for making pencils. The gymnosperm *Agathis australis* is perhaps the largest timber producing tree of the world. Soft wood of many gymnosperms is used for making toys.

(3) **Resins :** Several conifers yield resin which is obtained by tapping. By distilling the oleoresin is obtained from pines.

The resins are of three types namely hard resins, oleoresins and gum-resins. Several hard resins are obtained from living and fossil conifers which are as under :

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Copals : Kauri copal is obtained from *Agathis australis* and manila copal from *Agathis alba*.

Amber : It is obtained from the fossil conifer *Pinites succinifera*.

Canada balsam : It is obtained from *Abies balsamea*.

Spruce gum : It is obtained from *Picea rubens*.

Bordeaux turpentine : It is obtained from *Pinus pinaster*.

Venetian turpentine : It is obtained from *Larix decidua*.

(4) **Essential oils :** They are obtained from several plants. These oils are used mainly in perfumery, soap industry etc. The important oil yielding plants are *Tsuga canadensis, Picea glauca, Abies siberica* and *Cedrus deodara*.

(5) **Paper industry :** The wood of several gymnosperms, particularly those of conifers is used in paper industry *e.g., Abies pindrow, Picea smithiana, Cryptomeria japonica, Pinus roxburghii, Tsuga canadensis* etc.

(6) **Edible :** The seeds of *Pinus gerardiana* (*chilgoza*) and *P. roxburghii* are edible. Sago is obtained from *Cycas revoluta* and *Cycas circinalis*. The seeds of *Cycas* sp. are used in the preparation of many edible products.

(7) **Medicinal use :** Species of *Ephedra* yield an alkaloid called ephedrine. It is used in the preparation of medicines for the treatment of cough, asthma and bronchitis.

Some representative gymnosperms

Pinus

Habitat

It is commonly known as pine with about 90 species among which six species are found in India. (N. East and N. West Himalayas) occurring in wild state. These are *Pinus gerardiana* (Chilgoza pine), *P. Wallichiana* (Blue pine or Kail), *P.roxburghii* (Chir pine), *P.merkusii* (Teenasserim pine), *P.insularis (Khasi pine), and P.armandi* (Armand's pine). In addition to these, 4 sps. of exotic pines, *i.e., P.montana, P.laricia and P.sylvestris* (Scotch pine) and *P.strobus* (white pine) have been introduced in India. *P.excelsa* are found at maximum height *i.e.*, grow upto 3500 m above sea level.

Structure

External structure : *Pinus* is an evergreen, perennial plant of xerophytic nature. Mostly the species are tall and straight. The whorled branching gives a typical conical or excurrent appearance to the plant (due to apical dominance). The plant body is sporophyte and the plants are monoecious. The plant body is differentiated into roots, stem and leaves.

Root : A prominent tap root is present which does not penetrate deep into the soil. Lateral roots which develops later, grow extensively and help in anchoring the plant in the soil. Root hairs are scanty. Ectotrophic mycorrhiza *i.e.*, symbiotic association of some fungal hyphae with the ultimate branches of roots, is of common occurrence.

Stem : The stem is erect, thick, cylindrical and branched. The branching is **monopodial** type. The main stem is covered by scaly bark. Branches are developed from the buds present in the axil of scale leaves and appear to be in whorls. These branches develop every year and help in calculating the age of the plant.

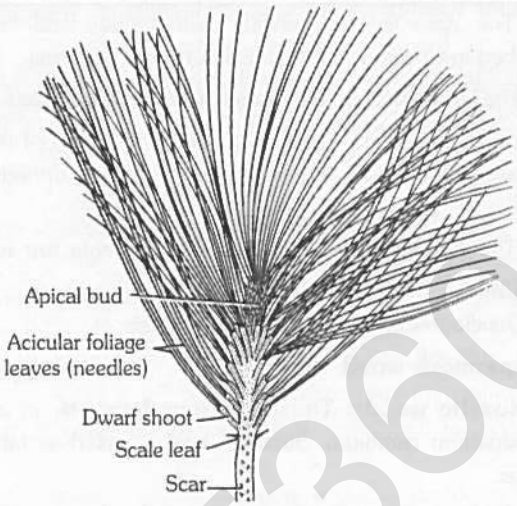

Fig : 1.6-23 A long shoot with dwarf shoots (spurs) of *Pinus roxburghii*

Branches are of two types :

(1) **Long shoots or Branches of unlimited growth :** These have apical buds, grow indefinitely in whorls each year from the buds in the axil of scale leaves. These shoots spread out horizontally and bear scale leaves on them.

(2) **Dwarf shoots or Branches of limited growth :** These branches lack apical buds and grow for a definite or short period. They arise in the axil of scale leaves on long shoots. The scale leaves on dwarf shoots are called the cataphylla possess a distinct midrib.

Leaves : The leaves are of two types *i.e.*, **dimorphic** – scale leaves and foliage leaves.

Scale leaves : The scale leaves are small membranous and brown. They are present on both types of branches (*i.e.*, long and dwarf shoots). Scale leaves are non-photosynthetic. These protect the young buds.

Foliage leaves : The foliage leaves are green, needle like and are born at the tips of the dwarf shoots only. Their size and number is different in different species. The dwarf shoot with needles is called a **spur**. On the basis of number of needles, spur is of different types as :

Monofoliar (with one needle), *e.g., P. monophylla*.

Bifoliar (with two needles), *e.g., P. merkusii* and *P. sylvestris*.

Trifoliar (with three needles), *e.g. P. gerardiana* and *P. roxburghii*.

Pentafoliar (with five needles), *e.g., P. wallichiana, P. excelsa*.

Internal structure

(1) **Root :** The young root of *Pinus* is identical with the dicot root. A T.S. of root reveals the following structures.

Epiblema : It is the outermost layer of compactly arranged cells. It gives out many thin and unicellular root hair.

Cortex : It is composed of many layeres of thin walled parenchymatous cells.

Endodermis : A single layer of suberized cells.

Pericycle : Endodermis is followed by multilayered pericycle.

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Vascular tissues : Radial vascular bundles are present.

Xylem : Exarch condition with bifurcated (Y-shaped) protoxylem. Resin canal is present between two arms. Xylem is devoid of vessels.

Phloem : Alternating with the xylem groups are present phloem patches. Companion cells are absent.

Pith : Pith is generally absent. If present, it is very small and made-up of parenchymatous cells.

Secondary growth : In young roots, cambium is absent but at maturity below the phloem patches, arches of cambium are formed. It cuts off secondary xylem on the inner side and secondary phloem on the outer side.

The cells of the outermost layer of pericycle form cork cambium (phellogen), which cuts off phellem (cork) on the outer side and phelloderm (secondary cortex) on the inner side. Finally epiblema ruptures and the cork layer is exposed.

(2) **Stem :** T.S. of a young shoot shows following tissue.

Epidermis : It is the outermost layer made up of small compactly arranged cells (heavily cuticularised).

Hypodermis : Below epidermis 4–5 layers of sclerenchymatous cells constituting hypodermis.

Cortex : Inner to the hypodermis is a wide zone of cortex, some cells are filled with tannin.

Endodermis : It is the innermost layer of the cortex, made-up of single layer of cells.

Vascular cylinder (Stele) : It is of eustelic type having a ring of 5–8 closely arranged vascular bundles. Vascular bundles are conjoint, collateral and open.

Xylem : It is endarch, consists of only tracheidal cells, vessels are absent. Therefore wood is known as non-porous.

Protoxylem consists of annular and spiral tracheids. Metaxylem tracheids have uniseriate bordered pits on their radial walls. These are also having bars of sanio.

Phloem : It is situated on the outer side of vascular bundle and is made-up of phloem parenchyma and sieve cells. Companion cells are lacking.

Cambium : In between the xylem and phloem of each vascular bundle, there is a strip of intrafascicular cambium.

Medullary ray : In between the vascular bundles is a zone of parenchymatous cells connecting the pith and the cortex.

Pith : In the centre of the stem is a zone of thin-walled parenchymatous cells known as pith. Some of the pith cells are filled with resinous substances.

Secondary growth : Secondary growth is similar to that of dicot stem. Wood is pycnoxylic and monoxylic. Vascular rays are linear (uniseriate) but fusiform (multiseriate) area of passage of resin ducts. These cambium cells cut cells on the inner side forming secondary xylem and on outer side secondary phloem.

The ring of primary cambium remains active only for a year. The activity of the cambium stops in the winter season and again resumes in the following spring. The secondary xylem thus formed clearly shows a number of annual rings. Each annual ring consists of a zone of spring wood and autumn wood.

Autumn wood : It is formed during autumn season and the cells of this wood are smaller, squarish and thick.

Spring wood : It is formed during spring season. The cells of this wood are thinner, large and polygonal. The wood is termed as pycnoxylic (compact and hard).

(3) **Leaf (Needle) :** The outline of foliage leaf varies according to the number of needles in the spur, *i.e.*, in monofoliar spur of *P. monophylla*, it is circular, in bifoliar spur of *P.sylvestris*, it is semicircular and is triangular in trifolial spur of *P. roxburghii*. Internal structure of the needle is same in all species of *Pinus*. Needle shows xerophytic characters.

Epidermis : It has a single-layered, thick-walled epidermis, covered with thick cuticle and is interrupted by sunken stomata throughout the surface (amphistomatic).

Stomata : Each stoma has two guard cells and two subsidiary cells. It opens outside into a cavity called vestibule and inside into a substomatal cavity.

Hypodermis : Below the epidermis is present a few layered thick sclerenchymatous hypodermis. It helps in mechanical support.

Mesophyll : There is no differentiation into palisade and spongy parenchyma. The cells of this region are thin-walled, parenchymatous, polygonal, compactly arranged, having chloroplasts and starch grains. Peg-like infoldings arise from the inner surface.

Vascular cylinder : It is surrounded by single-layered endodermis having barrel-shaped cells with casparian strips.

Pericycle : Just below the endodermis is multilayered pericycle having a T-shaped mass of sclerenchymatous cells between two vascular bundles. Transfusion tissue occurs on the side. Each bundle is collateral, open and endarch.

The needle of *P.monophylla* has a **single** vascular bundle whereas in *P.roxburghii*, the number is **two**.

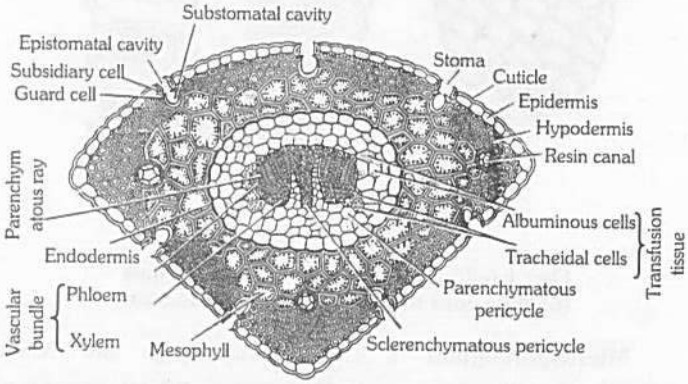

Fig : 1.6-24 T.S. neddle of *Pinus roxburghii*

Reproduction

Pinus reproduces only by means of spores. Unlike *Cycas*, here the micro and megasporophylls form compact male and female cone or strobilus respectively.

Pinus plant is sporophyte (2x), heterosporous (producing two type of spores – microspore and megaspore), monoecious (male and female cones are borne on same plant) and autoecious (male and female cones are borne on different branches).

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(1) **Male cone or Staminate strobilus :** The male cones are borne in a cluster on a branch of unlimited growth behind the apical bud, in the axil of a scale leaf. A male cone is, thus, equivalent to a dwarf shoot.

In a cluster, there may be 15–140 male cones. The male strobilus is an ovoid structure measuring 2 to 4 *cm.* in length and 0.5 to 0.7 *cm.* in diameter. A cone consists of a central axis bearing 60–135 microsporophylls in spiral manner. It is, therefore, comparable to male flower of angiosperms.

Microsporophyll : The microsporophylls or 'stamens' are spirally arranged in a compact manner on the cone axis. The microsporophyll is a brown coloured triangular structure consisting of a short stalk or 'filament' and a leaf like flattened structure called 'anther'.

Each sporophyll is provided with two microsporangia on its abaxial surface. The terminal sterile portion of the sporophyll is turned upward to protect the upper sporangia. It is called apophysis. Some of the lower microsporophylls are sterile having no sporangia associated with them.

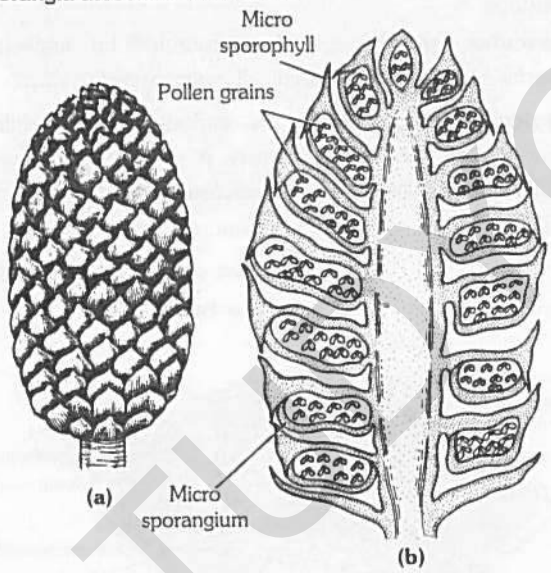

Fig : 1.6-25 (a) A young male cone of *Pinus*
(b) Male cone in radial longitudinal section

Microsporangium : The microsporangia are sessile elongated, cylindrical, structures. The sporangial development is of eusporangiate type. Each sporangium consists of a 2–3 layered wall. The inner most wall layer is called tapetum, which encloses a mass of sporogenous tissue. The sporogenous cells divide and re-divide and finally behave as microspore mother cells or pollen mother cells (PMC). The PMC undergo meiosis to form tetrahedral tetrads of microspores. The tapetum is a nutritive layer which degenerates at maturity of the anther.

(2) **Female cone (ovulate strobilus) :** The female cone is an elongated, ovoid structure comprising a central cone axis on which the ovuliferous scales and bracts are spirally arranged in acropetal order. Usually the cone is 15 – 20 *cm.* long but in *P. lambertiana* they are 60 *cm.* long. The female cones take three years time to develop and mature.

The cones are produced in clusters of 1 to 4 from places where normally dwarf or spur shoots have developed. They arise in a group of 1 – 4 cones on a long shoot in the axil of a scale leaf in place of a dwarf shoot. In the first year, the female cone is reddish-green measuring about 1–2 *cm* in length having compactly arranged sporophylls. The second year cone is much larger, again with compact sporophylls. In the third year, the cone axis elongated and hence the sporophylls separate from each other.

Megasporophyll : Each megasporophyll is differentiated into two parts – Lower part is bract scale and upper part is ovuliferous scale.

Bract scales : These are small, dry, membranous structures attached with the cone axis directly. These are also known as carpellary or cover scales.

Ovuliferous scale : This is a woody, brownish structure borne on the dorsal side of the bract scale. Each ovuliferous scale is triangular with narrow basal part and upper broader part in the form of disc, known as apophysis. The apophysis appears to be rhomboidal and possesses a small point known as **umbo**.

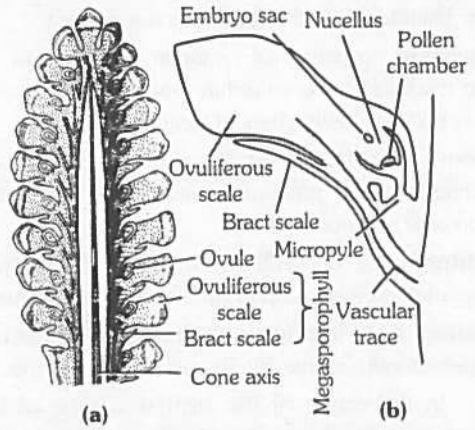

Fig : 1.6-26 *Pinus* (a) Longitudinal section of female cone (b) A megasporophyll

Megasporangium : Each ovule is an oval and anatropous structure consisting of a central mass of parenchymatous tissue, the nucellus, surrounded by a two lipped protective covering the integument which is united with nucellus except at the micropylar end where it prolongs to form a short tube beyond the nucellus. A small space is left in the upper region of nucellus below the integument, which is known as pollen chamber. Integument is differentiated into 3 layers although differentiation is not so distinct as in *Cycas*.

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Outer fleshy layer : Made up of thin walled cells which disappears at maturity.

Middle stony layer : Very conspicious.

Inner fleshy layer : Inner fleshy layer is well developed.

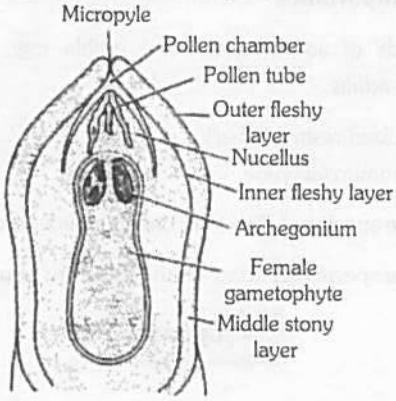

Fig : 1.6-27 *Pinus* : L.S. of ovule showing archegonia and pollen tubes

At the apex of the nucellus, a hypodermal cell gets enlarged and differentiated, it is called archesporial cell. The archesporial cell divides periclinally into an upper tapetal cell which forms **tapetum**, the nourishing layer, and the lower megaspore mother cell. This megaspore mother cell (sporogenous cell) divides reductionally to form a linear tetrad of haploid megaspores. Out of the four megaspores, three lying towards the micropyle degenerate. The chalazal one matures into a **functional megaspore**.

The gametophyte : The sporogenesis results in the formation of micro and megaspores representing the first gametophyte cells. They undergo gametogenesis so as to form the male and female gametophytes respectively.

Male gametophyte : The unicelled microspore undergoes three divisions of mircogametogenesis, so as to form a four-celled pollen grain or microgametophyte or male gametophyte.

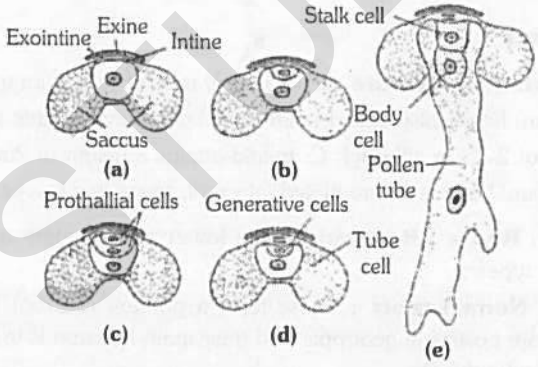

Fig : 1.6-28 *Pinus* : (a)-(e) Various stages of microgametogenesis

There are two prothallial cells, a generative cell and a tube cell. The pollen grains, at maturity are protected by three wall layers. The outermost wall layer, called exine or cappa is cutinised. the second wall layer is called exointine or capulla. It forms two balloon like outgrowths, on either side, called wings or saccus. The third wall layer is thin and called intine or tenuitas. At maturity the microsporangia dehisce by a longitudinal slit and the pollen grains are dispersed at 4 – celled stage. Since, a large number of grains are set free from a cluster of male cones in the form of pale-yellow cloud the phenomenon is often described as **shower of sulphur** or **shower of golden dust**.

Female gametophyte : The functional megaspore enlarges. A vacuole develops in the centre and then its nucleus divides freely to form about 2000 nuclei. Initially, multinucleate tube like cells are formed called **alveoli**. Later, wall formation starts from periphery and proceeds towards the centre. As a result, cellular female gametophyte or female prothallus or megagametophyte or **endosperm** is formed. The cells of the nucellus surrounding the female gametophyte now get modified and form a nutritive layer called endosperm jacket or spongy layer. The 'endosperm' of *Pinus* is a haploid gametophytic tissue formed before fertilization.

Archegonium : Near the micropylar end, one to five archegonia are differentiated in the prothallus. Each archegonium at maturity consists of eight neck cells arranged in two tiers of four cells each and a venter having a small ventral canal cell and a large egg. The ventral canal cell disorganizes before fertilization. **Neck canal cells are absent**.

Pollination : The pollination in *Pinus* is anemophilous. The wings of pollen grains are helpful in pollination. Just before pollination the female cone axis elongates separating megasporophyll from each other. This fascilitates pollen grains to reach ovules. There is a long interval of about a year between pollination and fertilization.

Post pollination changes in the male gametophyte : The exine ruptures and the intine protrudes out to form the pollen tube that grows through the nucellar tissue. Simultaneously, the generative cell divides to form a stalk cell and body cell. The body cell then divides to form two male gametes, which are non-flagellate.

Fertilization : The mode of fertilization was discovered by Goroschankin (1883). After reaching the neck of the archegonium, the tip of the pollen tube ruptures releasing the two male gametes. The ventral canal cell degenerates and the neck cell split apart. Out of the two, one male gamete fuses with the egg to form the zygote. The second male gamete along with the stalk and body nuclei disintegrate. This type of fertilization is called siphonogamous fertilization.

Embryogeny : The proembryonal development in *Pinus* was studied by Buchholz (1918). The zygotic nucleus moves toward the base and then divides to form four nuclei. These nuclei organise into four quadrately arranged (diagonally opposite) cells with open upper end. The four cells divide simultaneously thrice to form four tiers of four cells each. These tiers are designated from top downwards as open tier, rosette tier, suspensor tier and apical tier. Since only a part of the oospore is involved in the formation of the embryo, the development is said to be meroblastic.

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The cells of suspensor tier elongate pushing the embryonal cells into the 'endosperm'. The four suspensor cells due to considerable elongation may become coiled. These cells may divide transversely to form secondary suspensor or **embryonal tubes**.

Another type of polyembryony found in *Pinus* is simple polyembryony *i.e.*, when more than one embroys are developed as a result of fertilization of different archegonia. Thus in *Pinus* although both types of polyembryony are found but at maturity seed contains only one embryo as food is not sufficient for survival of many embryos. The embryo soon gets differentiated into radicle, plumule, hypocotyl and cotyledons. The number of cotyledons is always more than two (Schizocotyly).

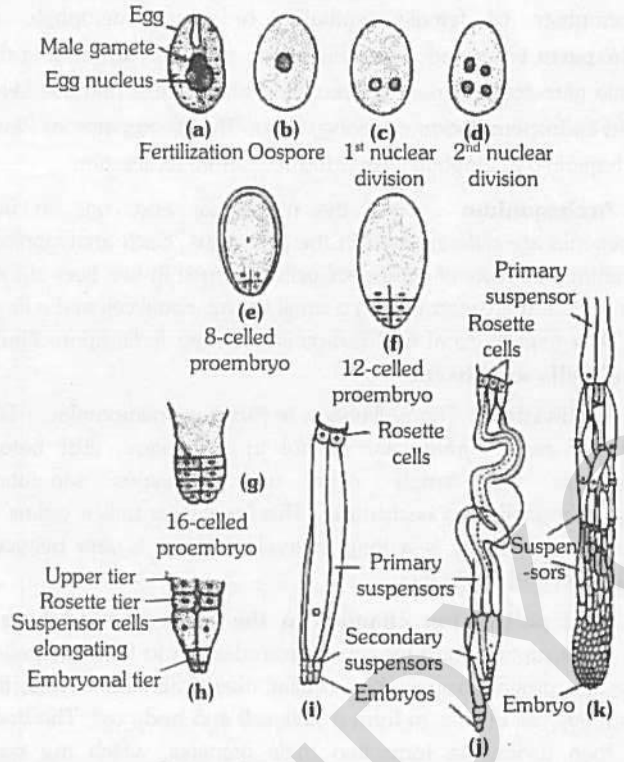

Fig : 1.6-29 *Pinus* : Embryogeny

Seed formation : Seed of *Pinus* is winged. The wing (saccus) develops from the upper surface of ovuliferous scale. Seed has thin with hard outer coat, which is peeled off, a stony coat, papery coat, cap like perisperm and food laden endosperm which encloses a central embryo. Embryo possesses 9–14 cotyledons (*P.roxburghii*). A seed represents three generations – parent sporophyte (testa, tegmen and perisperm, if present), new sporophyte (embryo) and female gametophyte or endosperm.

Seed germination : The seeds may remain dormant for several years. The germination of seed occurs when the environmental conditions are favourable. The radicle protrudes out through the micropyle and enters the soil forming the primary root. The plumule comes out and along with cotyledons it is pushed in air due to elongation of hypocotyl. The germination is, therefore, epigeal. The plumule forms a few **juvenile leaves** or prophylls. The juvenile leaves are spirally arranged on the branch of unlimited growth. Long shoots arise in their axis. Later on, they dry up as scales. The rate of growth of *Pinus* is quite slow.

Economic importance

(1) Seeds of some species are edible *e.g.*, *P. gerardiana* (chilgoza), *P. edulis*.

(2) Fossilized resin (amber) is obtained from *P. succinifera* and is of great commercial value.

(3) Some species of *Pinus* are cheap source of cellulose.

(4) Some species are used for manufacture of paper.

Cycas

Habitat

Cycas is an evergreen palm-like plant. It is the only genus of family Cycadaceae represented in India. *Cycas* has approximately 20 species found in Australia, New Zealand, Japan, China, India, Burma (Myanmar) and Pacific Islands.

In India, four *Cycas* species are common in Odisha, Bengal, Assam, Tamilnadu, Karnataka and Andaman.

(1) ***Cycas revoluta*** **:** It is a native of China and Japan and is locally called **Tesso**. In our country, it is called '**Sagopalm**'. Due to its primitive characters, it is also called living fossil. It is upto 10 ft tall.

(2) ***Cycas circinalis*** **:** Plants are about 12 to 15 ft tall and distributed upto 3500 ft. In Hindi, it is called as **Janglimadan mast-ka-phul**.

(3) ***Cycas rumphii*** **:** Plants are about 12 ft tall. It is also cultivated in Indian gardens. In Tamil, it is called **Kama**, **Paiyindu**.

(4) ***Cycas beddomei*** **:** It is found in Trimula-hills of Andhra Pradesh.

Structure

External structure : It looks very much like a palm tree or a tree fern, hence also called palm fern. Fully grown plants attain a height of 2– 5 *m* although *C. media* attains a height of 20*m*. The main plant body is differentiated into root, stems and leaves.

(1) **Roots :** Roots arise from lower part of stem and are of two types :

(i) **Normal roots :** These form a primary tap root system. These are positively geotropic and their main function is to absorb water and nutrients.

(ii) **Coralloid roots :** From the lateral branches of the normal roots are formed dichotomously branched, apogeotropic, bluish green coralloid roots. *Anabaena cycadacearum*, *Nostoc* and bacteria are found in their cortex. It is an example of symbiosis. It helps in fixation and absorption of nitrogen. As these roots possess lenticels, they also help in respiration.

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(2) **Stem :** Stem is thick, cylindrical, columnar, small, aerial and unbranched. It is covered with persistent leaf bases and scale leaves, which are found in alternate whorls. There is a crown of foliage leaves at the apex of the plant.

(3) **Leaves :** *Cycas* has two types of leaves (dimorphism).

(i) **Scale leaves :** These are reduced form of foliage leaves without lamella and are arranged in a compact spiral and alternate manner around the apex and bears no reproductive structures. These are protective in nature. A single scale leaf is a brown, dry, woody, triangular structure, covered with brown hairs or ramenta.

(ii) **Foliage leaves :** These are brown scales and green unpinnately compound present on the apex of the plant forming a crown. These leaves are upto 3 metres in *C. circinalis*. Leaves are leathery and thick, some leaflets at the base of the rachis are reduced to spines. These are mainly photosynthetic in nature. Leaves in *Cycas* show xerophytic characters.

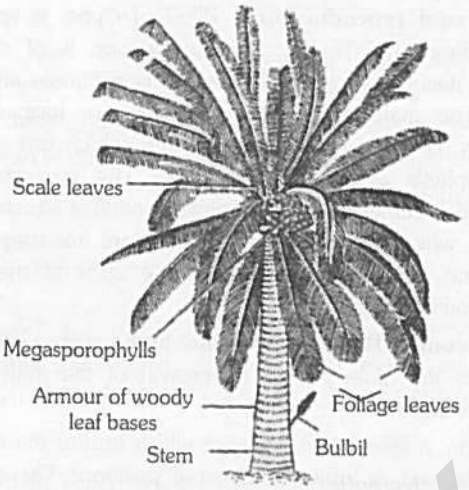

Fig : 1.6-30 External morphology of *Cycas*

Internal structure

(1) **Root**

Normal root : The structures of normal root resembles dicotyledonous root. T.S. of normal root reveals the following structures.

Epiblema : This is the outermost layer with unicelled root hairs.

Cortex : Just below the epiblema is multilayered parenchymatous cortex. Some tannin cells are present in the cortex.

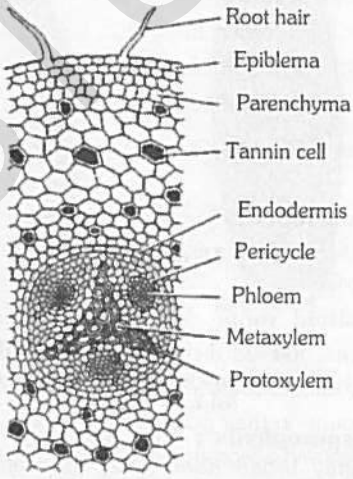

Fig : 1.6-31 T.S. normal root of *Cycas*

Endodermis : Below the cortex is present endodermis which is made up of barrel-shaped cells and below it is a layer of pericycle.

Vascular tissues : It consists of xylem and phloem which are radially arranged, *i.e.*, on different radii.

Pith : It is generally absent.

Secondary growth : It is like dicotyledonous plants.

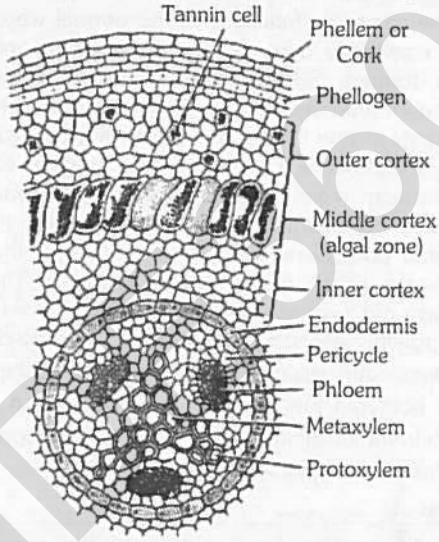

Fig : 1.6-32 T.S. coralloid root of *Cycas*

Coralloid root : Structure of stele is similar to normal roots but cortex is divided into three zones :

Outer cortex : Having several layers of parenchymatous cells.

Middle cortex (Algal zone) : Filled with blue green algae, *Anabaena* and *Nostoc*.

Inner cortex : Having several layers of parenchymatous cells. Roots are diarch, triarch and sometimes polyarch.

(2) **Stem :** It resembles a dicotyledonous stem having the following tissues :

Epidermis : It is the outermost incomplete layer ruptured due to persistent leaf bases. It is made up of compactly arranged thick-walled cells.

Cortex : Cortex is large, thin-walled, parenchymatous, having a number of mucilage canals. Starch grains are found in the cortex.

Endodermis and pericycle : These layers are not very clear.

Stele : Vascular cylinder is very small having numerous small closely arranged vascular bundles, which are conjoint, collateral and open. Xylem is endarch and consists of tracheids, which have spiral thickening in protoxylem and scalariform thickenings in metaxylem. Phloem is devoid of companion cells. Albuminous cells are found in phloem.

Leaf traces : There are several leaf traces present in the cortex. Four vascular bundles enter the base of leaf, two of these are direct and other two arise from the stele of opposite side and after making semicircle, they enter the leaf. These indirect leaf traces are known as girdling leaf traces or leaf girdles.

Pith : It is large, parenchymatous and is having a number of mucilage canals. Starch grains are also found in pith.

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Secondary growth : The secondary growth in initiated by the formation of a cambium ring due to the development of interfascicular cambium strips and their subsequent joining with the intrafascicular cambium. This ring cuts secondary xylem on the inner side and secondary phloem on the outer side in addition to secondary medullary rays on both sides. This cambium ring now ceases to function another cambium now arises from pericycle or inner layers of cortex.

The new cambium functions in the normal way like the old one. Thus, concentric rings of secondary xylem and secondary phloem are formed. Such a wood is called as polyxylic *i.e.*, comprising more than one xylem cylinders. Due to the presence of alternating rings of thin walled tissue (phloem) the wood of xylem remains loose and hence it is described as manoxylic. The growth in the extrastelar region takes place by the formation of a phellogen (cork cambium) which cuts off phellem (cork) on the outer side and phelloderm (secondary cortex) on the inner side. The three layers jointly constitute the periderm. The secondary growth pattern of *Cycas* resembles some dicots showing abnormal secondary growth. Secondary wood is devoid of vessels.

The secondary xylem is made up of tracheids showing multiseriate bordered pits. Bars of sanio have been observed by Sifton, 1915 in the tracheids of *C. revoluta*. The secondary phloem comprises sieve cells and fibers.

(3) **Leaf**

(i) **Rachis :** The cross section of the rachis is almost circular with two depressions on upper lateral sides where the leaflets are attached.

Epidermis : The outermost layer is epidermis with thick cuticle having stomata.

Hypodermis : Epidermis is followed by a well developed hypodermis, differentiated into outer chlorenchymatous and inner sclerenchymatous regions.

Ground tissue : Below the hypodermis is well developed parenchymatous ground tissue with mucilage canals. The vascular bundles are arranged forming an inverted omega (Ω). Each vascular bundle is surrounded by a sclerenchymatous sheath and is conjoint, collateral and open. In most parts of the rachis, xylem is mesarch, *i.e.*, centripetal xylem towards periphery and two patches of centrifugal xylem one on each side of protoxylem of centripetal xylem. Outside the centrifugal xylem is cambium and then phloem towards periphery.

(ii) **Leaflet :** Each leafleat is sessile has one midrib and no lateral veins and in *C. revoluta* the margin is curved inwardly. In young condition young leaves show circinate ptyxis like fern leaves.

Epidermis : Epidermis is single layered with thick cuticle. The upper epidermis is complete whereas the lower epidermis is interrupted by several stomata present only in the region of blade (hypostomatic). Upper and lower epidermis are covered by layer of thick cuticle.

Hypodermis : Just below the upper epidermis, there are several layers of sclerenchymatous hypodermis while above the lower epidermis it is present only in the midrib portion.

Mesophyll : Mesophyll is differentiated into palisade parenchyma on upper side and spongy parenchyma on lower side. Palisade tissue is made up of vertically elongated cells without intercellular spaces. Both tissues contain chloroplasts.

Vascular bundle : In the midrib there is a large vascular bundle. The vascular bundle is collateral and closed. The xylem is mesarch, *i.e.*, diploxylic condition with centripetal and centrifugal xylem.

Transfusion tissue : On each side of the midrib in between the palisade and spongy tissues is present transfusion tissue made up of horizontally arranged tracheids which supply water and mineral to mesophyll tissue upto margins.

Reproduction

Cycas plants are dioecious and reproduce by following methods :

(1) **Vegetative propagation :** It occurs by means of bulbils (resting adventitious buds) which are produced on the stem in the axil of scale leaves. They break up from the parent plant and germinate to give rise to new plant.

(2) **Sexual reproduction :** Plant of *Cycas* is sporophyte (2*n*) and dioecious. The sexual reproduction is of oogamous type, *i.e.*, takes place by the fusion of distinct male and female gametes. The male and female gametes are formed by the germination of micro and megaspores which are born on microsporophylls and megasporophylls. The microsporophylls are grouped together to form a compact conical structure called male cone, whereas the megasporophylls are not aggregated to form a cone, they are produced at the apex of the stem in succession with the leaves.

Male cone : The male cones are borne every year singly at the apex of the male plant. The growth of the male plant is, therefore, checked.

Later on, a lateral bud develops which pushes the male cone to one side and occupies a terminal position. The process is repeated during the formation of subsequent male cones. As such, the growth pattern of male plant is sympodial.

The male cone is a shortly stalked, oval or elliptical structure measuring about 40 – 60 *cm* in length. It may sometimes attain a length of 75 *cm*. in *C. circinalis*. Each cone consists of a central axis bearing numerous microsporophylls arranged in spiral manner.

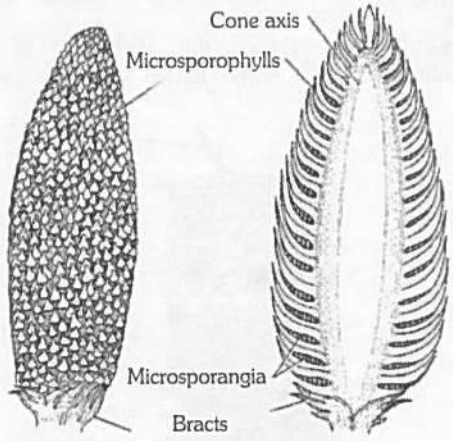

Fig : 1.6-33 *Cycas* : (a) External view of male cone (b) L.S. of male cone

Microsporophylls : They are wedge - shaped structures with a slightly broad base. They are soft and fleshy in the younger stages. At maturity, they are hard and woody. They

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measure about 3 – 4 *cm.* in length and 1.2 – 2.3 *cm.* in width. They bear sori of sporangia on the abaxial (lower) surface. The terminal sterile portion of the sporophyll is called **apophysis**. In the apophyseal region the sporophyll gradually tapers and points upward.

Microsporangium : The microsporangia are borne in sori on the abaxial surface of the sporophyll. Each sorus contains 2 – 6 microsporangia. The number of microsporangia may be upto 700 in *C.circinalis*, 1000 in *C. revoluta* and 1150 in *C.media*. In between the sporangia are present uni or bicelled epidermal hair. The microsporangia are short-stalked, oval or elliptlical structures. The development of the sporangium is of eusporangiate type. Each sporangium consists of a 5 – 6 layered wall. The outer most wall layer is called as exothecium whereas the innermost layer is the **tapetum**.

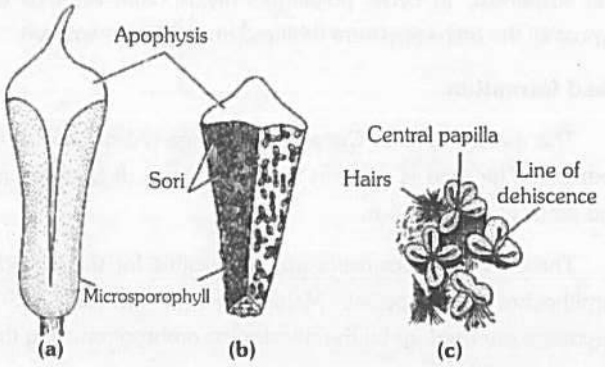

Fig : 1.6-34 *Cycas* : (a) Dorsal view of microsporophyll (b) Ventral view of microsporophyll (c) Microsporangia in sori (undehisced)

The tapetum encloses the sporogenous tissue. The sporogenous cells divide and re-divide to form the microspore mother cells or pollen mother cells (PMC). The PMC undergo meiosis to form tetrahedral tetrads of spores. The cells of exothecium develop a thickening along their radial and inner tangential walls. The cells of tapetum and inner wall layers degenerate at maturity to provide nutrition to the developing pollen grains. The wall of a mature sporangium, thus comprises exothecium only.

Megasporophyll : The megasporophylls are spirally borne in acropetal order on the female plant. Since they are loosely arranged, there is no female cone formation. Each megasporophyll is regarded as a **modified foliage leaf** and is about 5 – 10 inches long. In the female plant therefore, the apical meristem remains unaffected. Hence, the growth pattern in the female plant is monopodial.

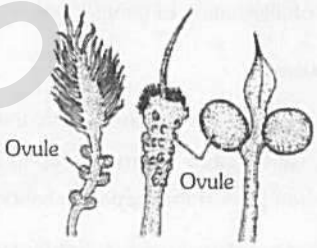

Fig : 1.6-35 Megasporophylls of different species of *Cycas*

The megasporophylls are flat, dorsiventral structures distinguishable into a proximal stalk or rachis part and a distal lamina. The margin of lamina is serrate or dentate in *C. circinalis, C. beddomei and C. rumphii*. In the upper part of the rachis are present 1 – 6 pairs of ovules, laterally. This number is variable in different species *e.g.*, 1 – 6 pairs in *C. revoluta, C. circinalis* and only one pair in *C. normanbyana*.

Megasporangium (Ovule) : The ovules of *Cycas* are **largest** in nature, can be seen by naked eyes. In *C. circinalis*, the ovules are largest in size, *i.e.*, about 6 *cm* in length and 4 *cm* in diameter.

The ovules are orthotropous and unitegmic. The main body of the ovule is nucellus, covered by a single thick integument except at the top where a small opening is left called micropyle.

The integument is distinguishable into three layers, an outer fleshy layer (sarcotesta), middle stony layer (sclerotesta) and inner fleshy layer (sarcotesta). The outer and inner fleshy layers are vascularised as also the nucellus by separate bundles. The apex of the nucellus develops a beak-like process, the nucellar beak, which projects into the micropyle.

Somewhere in the deep layers of nucellus a megaspore mother cell in differentiated. It has a prominent nucleus and dense cytoplasm. It undergoes meiosis to form a linear tetrad of megaspores. Of these, three micropylar megaspores degenerate and the lowest functions. The functional megaspore has a thick papillate outer wall called exospore and a thin, fibrillar inner wall, the endospore.

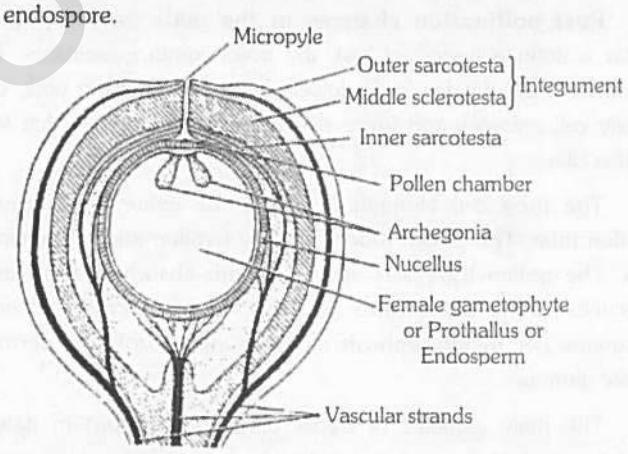

Fig : 1.6-36 L.S. megasporangium (ovule) of *Cycas*

The gametophyte : As a result of sporogenesis, the micro and megaspores are formed. They are the first gametophytic cells. The microspores give rise to the male gametophyte whereas the megaspores form the female gametophyte. The gametophytes reproduce sexually.

Male gametophyte : The unicelled microspore undergoes two divisions of microgametogenesis and as a result three cells are formed. These three cells are serially designated as tube cell, generative cell and prothallial cell. At this stage the pollen grain is double layered. The outer wall exine is much thicker than intine. The microsporangium dehisces by a longitudinal slit and pollen grains are dispersed at **3-celled stage**.

Female gametophyte : The nucleus of the functional megaspore divides freely to form a free-nuclear gametophyte. A vacuole appears in the centre. Wall formation now begins from periphery and gradually proceeds towards the centre. As a result,

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cellular female prothallus or megagametophyte or endosperm is formed. The 'endosperm' in *Cycas* is a haploid gametophytic tissue formed before fertilization. This is nutritive in function. Simultaneously, a tiny space develops on the upperside of the ovule between nuclellus and the female gametophyte due to degeneration of certain nucellar cells. This is called as archegonial chamber.

Archegonium : The archegonia are formed from the gametophytic cells lining the archegonial chamber. The number of archegonia formed in a gametophyte is variable *e.g.*, 2 – 8 in *C. revoluta*, 3 – 6 in *C.rumphii* and 3 – 8 in *C. circinalis*. An archegonium consists of a two celled neck but there is no neck canal cell. There is no venter either. The egg and the ventral canal nucleus remain surrounded by the cells of prothallus. *Cycas* produces largest egg in the plant kingdom measuring 0.5 *mm*. in diameter.

Pollination : The pollination is anemophilous. The pollen grains of *Cycas* are light in weight and easily blown away by wind at 3-celled stage (prothallial cell, generative cell, tube cell). At the time of pollination, a large pollination drop comes out of micropylar end of ovule by disorganisation of nucellar beak. The pollen grains are entangled on this drop and as it dries, the pollens are drawn into the pollination chamber.

Post pollination changes in the male gametophyte : After a definite period of rest, the pollen grain germinates. The generative cell divides into a lower stalk cell and upper body cell. Body cell enlarges and forms several blepharoplasts, which later forms cilia.

The tube cell elongates, pierces the exine and forms a pollen tube. The pollen tube is slightly swollen and branched at tip. The pollen tube acts as haustorium absorbing food from nucellus. Body cell divides into two daughter cells and each daughter cell metamorphosis into one antherozoid or sperm or male gamete.

The male gametes of *Cycas* are largest (300μ) in nature, visible to naked eye and are oval in form, broad (top-shaped) and naked at posterior end and spirally coiled in the anterior half with thousands of small cilia. The sperms pass into pollen tube and reach the tip of the tube.

Fertilization

After reaching the archegonial chamber, the tip of the pollen tube ruptures releasing the two male gametes. Besides, the tube also discharges a fluid having high concentration. When an antherozoid touches the neck cells, it is sucked in violently. By the time the ventral canal nucleus has already degenerated. As a result of syngamy, the zygote is formed.

The fertilization in *Cycas* is, therefore, siphonogamous (by pollen tube) accompanied by zoidogamy (by flagellate gametes). Thus the fertilization brings to an end of the gametophytic generation and the zygote is the initial stage of sporophytic generation.

Embryogeny

The zygote, which is the first sporophytic cell, undergoes free-nuclear divisions. A vacuole develops in the centre pushing the nuclei to the peripheral position. In the upper region there are only a few nuclei but the lower region contains numerous nuclei. This is followed by wall formation that begins from periphery and proceeds to centre (centripetal). The cellular proembryo consists of –

Upper : Haustorial region, **Middle :** Suspensor region and **Lower :** Embryonal region.

Embryo consists of radicle, plumule, 2 cotyledons, haustorium and suspensor. In cycas polyembryony is often seen as egg of almost all the archegonia are fertilized and produce embryo.

Seed formation

The mature seed of *Cycas* is an orange-red or reddish-brown structure. The seed is covered by a thick testa. It is sweet in taste and emits pleasant odour.

These two characteristics are responsible for their zoochorus, (ornithochorous) dispersal. Major parts of nucellus and inner sarcotesta are used up by the developing embryo reducing them to thin, papery layers.

The embryo is distinguishable into a haustorial tip, a long suspensor, radicle, hypocotyl, plumule and two cotyledons.

Seed germination

There is hypogeal germination of *Cycas* seed. In germination, the radicle forms a tap root. The cotyledons remain in the endosperm under the surface of soil. The plumule grows up and forms some scale leaves and later foliage leaves. *Cycas* seed represents 3 generations :

Old sporophytic generation (represented by seed coat and nucellus), Female gametophytic generation (represented by endosperm), and Future sporophytic generation (represented by embryo).

Life history of *Cycas* is diplohaplontic. It shows heteromorphic or heterologous type of alternation of generations.

Economic importance

(1) A starch called sago is obtained from the pith of *Cycas*, that is why *Cycas* is called **sago palm**. In Japan starch extracted from stem of *C. revoluta* is used for preparing saboodana.

(2) Seed of some *Cycads* are used as fodder for animals.

(3) Leaves are used for making mats and baskets.

(4) *Cycas* is an ornamental plants.

(5) Boiled young leaves are eaten as vegetables.

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(6) Extract of young *Cycas* leaves are used in the treatment of many skin diseases.

The decoction of seeds is used as purgative. Tincture prepared from its seeds is used by Indians in headache, nausea, bad throat, etc.

Angiosperms

(Gk. *Angeion* = covered; *sperma* = seed)

Introduction

The angiosperms, or flowering plants, constitute the most dominant and ubiquitous vascular plants of present day flora which changed the green and yellow melancholy of the earth's vegetation by the colourful brightness and fragrance of their flower. The term angiosperm means 'enclosed seed' because the ovules or potential seeds are enclosed within a hollow ovary. In this respect they are considered most highly evolved and advanced as compared with the naked seeded gymnosperms.

Characteristic features

(1) Angiospermous plants grow in almost every kind of habitats. In the deserts, these plants grow, flower, shed seeds and complete their life cycle in a few weeks of rainy season. Some flowering plants like *Zostera*, occur in shallow seas. A small orchid even lives underground. It survives as a saprophyte on decaying organic matter because of the mycorrhizal association which helps to obtain nourishment. In rain forests, some plants grow on the branches of other plants but do not obtain water or food from them. They are called epiphytes (*e.g.*, *Vanda*).

(2) The angiospermous leaves show reticulate or parallel venation forming areoles. The libriform fibres are present in the xylem and the companion cells are present in the phloem. The true vessels are present in the xylem of angiosperms.

(3) The angiosperms produce flowers which normally consist of 4 whorls of appendages – the two outer accessory and reproductive structure such as sepals and petals and the two inner essential parts – stamens and carpels.

(4) The stamens (microsporophylls) are bilaterally symmetrical. Each stamen consists of a filament and an anther.

(5) The anthers produce tectate pollen grains with exine differentiated into rod-like columellae covered by a tectum.

(6) In angiosperms, the insects and animals also act as pollinating agents. For this purpose the flowers possess bright and showy petals, edible pollen and nectar.

(7) The carpels (= megasporophylls) are rolled and partly sterile so that they enclose the ovules within a hollow ovary that is connected with the stigma and style.

(8) The female gametophyte is highly reduced and consists of single egg cell, two synergids, three antipodals and two polar nuclei. The archegonia are absent.

(9) The most characteristic feature of angiosperms is double fertilization.

(i) The male gamete fuses with the egg producing diploid zygote that develops into embryo or new sporophyte.

(ii) Another male gamete fuses with the polar nuclei (triple fusion) resulting in the formation of triploid endosperm.

(10) After fertilization, the ovules ripens into seeds and ovary ripens into fruits.

Size

(1) **The smallest** angiosperm is *Wolffia*. The plant body of *Wolffia* consists of tiny flat oval green stem (phylloclade) having a few small roots. The plants are about 1 *mm* in diameter and found free floating in aquatic habitats like ponds, etc.

(2) **The tallest** angiosperm is *Eucalyptus*. Their trees may attain a height upto 100 *meters* or more.

(3) **Banyan** (*Ficus bengalensis*) tree covers a large area. It's slanting aerial branches spread in all directions. The tree spreads with the help of prop or pillar roots.

Longevity

Based on the duration of life, the plants are divided into following 4 categories :

(1) **Ephemerals :** This category includes the plants which live only for a few weeks because of a very short growing season. Such plants are found near deserts or in very cold countries. For example, *Arabidopsis* species have a life span of 20–28 days.

(2) **Annuals :** The plants of this category live and complete their life-cycle in a single favourable season. During this period, they grow in size, produce flowers, shed their seeds, undergo senescence and die. They pass the unfavourable period in the form of seeds. Many crop plants (*e.g.*, wheat, rice, maize, etc.) are annuals. The smallest angiosperm – *Wolffia* is an aquatic annual.

(3) **Biennials :** The plants of this category complete their life-cycle in two favourable seasons (*i.e.*, in two years). They grow vegetatively in the first season and produce flowers and set seeds in the next. Often they produce some storage organs, as in the sugar beet, where food is stored in their swollen roots.

(4) **Perennials :** Plants of this category live for more than two years. Generally they live for many years and bear the flowers and fruits during specific seasons. Some perennials continue their vegetative growth for several years and produce fruits and seeds only once in their life time, *e.g.*, *Agave*, Bamboos, etc. They are called monocarpic. Others produce flowers and fruits every year after attaining a definite stage of maturity, *e.g.*, Mango, Lemon, Apple, etc. Such plants are called polycarpic.

Habit

Depending upon the habit of plants, the angiosperms belong to following categories :

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(1) **Herb :** These are small, soft, non-woody plants without persistent parts aboveground. The height of plants usually reaches upto 1 *m*. The plants may be annual (*Brassica*), biennial (Sugar beet) or perennial (*Canna*). The perennial herbs usually possess underground rhizomes which form the new aerial shoots every year. The plants of banana are perennial herbs.

(2) **Shrubs :** These are woody plants of relatively low height (1-4 *m*). They typically branch at or near the base and do not have a main trunk, *e.g.*, Rose. They are mostly perennial.

(3) **Trees :** These are perennial woody plants with one main trunk. The trunk may or may not be branched. These are of the following types :

(i) **Caudex :** The stem is unbranched and usually bears a crown of leaves at the apex. *e.g.*, Date-palm.

(ii) **Excurrent :** The lower part of stem is thicker which gradually tapers above. Branches arise from the main stem in acropetal succession and plant appears conical *e.g.*, *Pinus*.

(iii) **Deliquescent :** The apical bud of the main stem dies after some time and branches and sub-branches spread in different directions. *e.g.*, *Tamarindus*, *Ficus*.

(4) **Culms :** In these plants, nodes and internodes are extremely clear. Internodes of such plants are usually hollow. These plants are grasses but cannot be considered as herb or shrub or tree. *e.g.*, *Bambusa* (Bans).

The plants of Angiosperms divided into two major groups as – Dicotyledons and Monocotyledons.

(1) **Dicotyledons :** They show following distinguished characteristics.

(i) Tap roots found in the members of this group.

(ii) The leaves in members of these class exihibit reticulate (net like) venation.

(iii) The flowers are tetramerous or pentamerous having four or five members in the various floral whorls, respectively.

(iv) The vascular bundles arranged in a ring, numbering 2–6, open and with cambium.

(v) The seeds of dicotyledons are with two cotyledons as the name indicate.

(2) **Monocotyledons :** They show following distinguished characteristics :

(i) Adventitious roots found in the members of this group.

(ii) The leaves are simple with parallel venation.

(iii) The flowers are trimerous having three members in each floral whorl.

(iv) The vascular bundles scattered in the ground tissue, many in number, closed and without cambium.

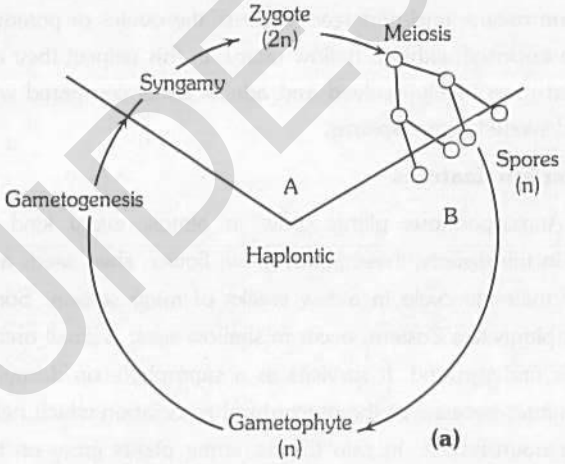
(v) The seeds of monocotyledons are with one cotyledons as the name indicate. *e.g.*, Cereals, bamboos, sugarcane, palms, banana, lillies and orchids.

Plant Life Cycles and Alternation of Generations

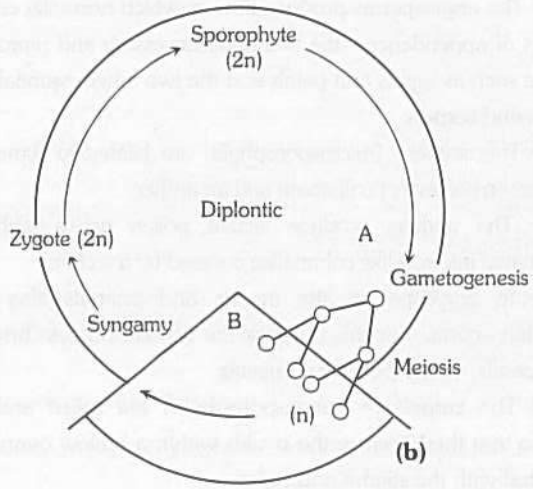
In plants, both haploid(n) and diploid($2n$) cells can divide by mitosis. The haploid plant body produces gametes by mitosis (cell division). This plant body represents a gametophyte. After fertilisation the zygote also divides by mitosis to produce a diploid sporophytic plant body. Haploid spores are produced by this plant body by meiosis. These in turn, divide by mitosis to form a haploid plant body once again. Thus during the life cycle of any sexually reproducing plant, there is an alternation of generations between gamete producing haploid gametophyte and spore producing diploid sporophyte.

The different patterns of life cycle in different plants are as follows :

(i) Haplontic life cycle is exhibited by many algae like *Spirogyra*, some *Chlamydomonas* species and *Volvox*. Sporophytic generation is represented only by the one-celled zygote. There are no free living sporophytes. Meiosis in the zygote results in the formation of haploid spores. The haploid spores divide mitotically and form the gametophyte. The dominant, photosynthetic phase in such plants is the free living gametophyte. This kind of life cycle is termed as **haplontic**.



(ii) On the other extreme, is the type wherein the diploid sporophyte is the dominant, photosynthetic independent phase of the plant. The gametophytic phase is represented by the single to few-celled haploid gametophyte. This kind of life cycle is termed as **diplontic**. All seed-bearing plants i.e., gymnosperms and angiosperms, follow this pattern.



(iii) Bryophytes and pteridophytes, interestingly. exhibit an intermediate condition (Haplo-diplontic) both phases are multicellular. However, they differ in their dominant phases.

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A dominant, independent, photosynthetic, thalloid or erect phases is represented by a haploid gametophyte and it alternates with the short-lived multicelluler sporophyte totally or partially dependent on the gametophyte for its anchorage and nutrition. All bryophytes represent this pattern.

The diploid sporophyte is represented by a dominant, independent, photosynthetic, vascular plant body. It alternates with multicellular, saprophytic/ autotrophic, independent but short-lived haploid gametophyte. Such a pattern is known as haplo-diplontic life cycle. All pteridophytes exhibit this pattern

Interestingly, while most algal genera are haplontic some of them such as *Ectocarpus*. *Polysiphonia*, kelps are haplo-diplontic. *Fucus*, an alga is diplontic.

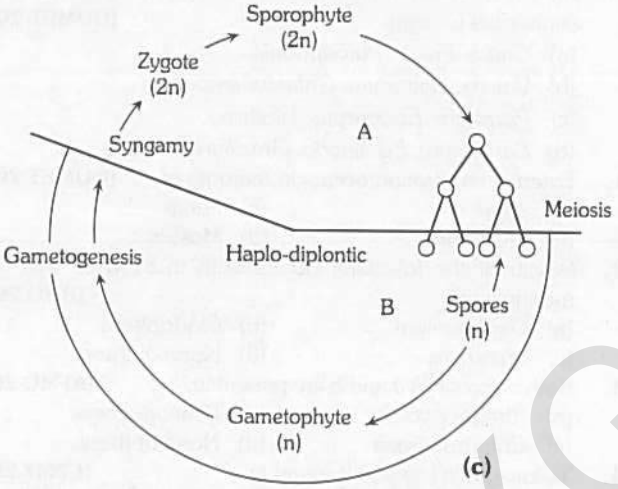

Fig : 1.6-37 Life cycle patterns : (a) Haplontic (b) Diplontic (c) Haplo-diplontic

Tips & Tricks

- Father of Indian phycology : "M.O.P. Iyengar."
- Thallophytes : The term was coined by Endlicher (1863) for placing algae, fungi and bacteria in it. Plant body of thallophytes is called thallus. It does not show differentiation of stem, leaves and roots. An embryo stage is absent. They are most primitive members of plant kingdom.
- Algae : The term was coined by Linnaeus (1754) for hepaticae and others but was used for its present meaning by A.L. de Jussieu (1789).
- Multicellular algae are revolutionary older than land pants.
- The first algal antibiotics chlorellin was extracted from *chlorella*.
- *Cymbella* used as a bacterial filter.
- Bryophytes : The term coined by Robert Braun (1864). Bryophytes are nonvascular plants with multicellular sexorgans.
- Bryology : The science dealing with bryophytes. S.R. Kashyap is father of Indian Bryology.
- Sporogonium : Sporophyte of Bryophytes which is parasitic over gametophytic plant body and its mainly meant for producing meiospores.
- Erect gametophyte of bryophyte is called gametophore.
- A capsule of *Marchantia* forms about 3,000,000 spores.
- Smallest bryophyte is *Zoopsis*.
- Tallest bryophytes is *Dawsonia*.
- Tracheophytes : Sinnott (1935) coined the term to include vascular plants. (Pteridophytes and seed plants).
- Elaters : Elongated structures which help in spore dispersal.
- Cormophytes : Plants with distinction of stem, leaves and roots.
- Rudimentary seed habit occurs in *Selaginella*.
- *Acrostichum aureum* is a halophyte.
- *Marsilea* occurs as terrestrial, amphibious as well as aquatic plant.
- *Salvinia* is an aquatic pteridophyte weed.
- *Equisetum* is commonly known as Horse tails or Scouring rushes. A few species of *Equisetum* contain gold.
- *Lycopodium* is commonly known as club moss.
- *Psilophytes* (*Cooksonia*, *Rhynia* etc.) primitive pteridophytes of Silurian and Devonian period.
- Chondrus (Irish moss) is used in the preparation of various pharmaceuticals including laxatives and cosmetics.
- Vessels are major water conducting cell in angiosperm.
- The primitive haplochelic type of stomata are found in *Cycas*, *Pinus*, *Ginkgo*, *Ephedra* etc.
- *Ophioglossum* (Adder's tongue fern) has maximum number of chromosomes ($2n = 1262$) in plant kingdom.
- The vascular supply given for a leaf from the main stele is called leaf trace.
- The vascular supply given out for a branch from main stele is called 'branch trace'.
- Sperms of *Cycas revoluta* are largest in the plant kingdom and measure about 200 to 300μ wide.
- In gymnosperm endosperm is haploid and develops before fertiilzation.
- The only gymnosperms showing limited growth is *Welwitschia* (45 *cm* tall).
- Embryosac of gymnosperm is haploid.
- In gymnosperm the arrangement of megaspore tetrad is linear.
- Sulphur shower is due to pollen of *pinus/cedrus*.

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- Bamboo or *Agave* are monocarpic perennial plants.
- Vessels are major water conducting cell in angiosperm.
- Double fertilization is a unique character of angiosperm.
- Anthophytes : Plants with flower/ flowering plants.
- Marine angiosperm : *Zostera*, *Thalassia*.
- National tree : *Ficus bengalensis* (Banyan).
- Takakia is a bryophyte without rhizoids. It bears mucilage hairs for water conduction.
- *Cereus giganteus* is largest cactus of 52 feet height.
- F.E. Fritsch (1935) divided algae into eleven classes mainly on the basis of pigmentation, reserve food and flagellation thallus structure, modes of reproduction and life cycles.
- Therophytes plants are those which survive in winter as a seed and complete their life cycle between the spring and autumn.
- In ferns, leaves are photosynthetic as well as reproductive in function .
- Sperms of Cycas and Ginkgo are motile and multiciliated.
- Salvinia is an aquatic weed and called sorrow of Kashmir.

Ordinary Thinking

Objective Questions

Algae (General)

1. Who is regarded as the "*Father of Indian Phycology*" **[BHU 1999]**
(a) Prof. M.O.P. Iyenger (b) Prof. J.N. Mishra
(c) Prof. R.R. Mishra (d) Prof. R.N. Singh

2. Phycology is the study of **[AMU (Med.) 1998, 2005; KCET 2002; Odisha JEE 2005; RPMT 2006]**
(a) Algae (b) Fungi
(c) Bacteria (d) All the above

3. Who is popularly known as the "*Father of Phycology*"
(a) Fritsch (b) Papenfus
(c) Smith (d) Morris

4. Group of algae in which sexual reproduction is absent **[Odisha JEE 2008]**
(a) Cyanophyceae (b) Bacillariophyceae
(c) Chlorophyceae (d) None of these

5. Mannitol (sugar alcohol) is the stored food in **[CBSE PMT 2009; WB JEE 2011]**
(a) *Chara* (b) *Porphyra*
(c) *Fucus* (d) *Gracillaria*

6. Red tide is caused by **[AFMC 2008]**
(a) Noctiluca (b) Gymnodinium
(c) Gonyaulax (d) All of these

7. *Agar–Agar* is obtained from **[CPMT 1996, 98, 2009; AFMC 1997; KCET 2000; BHU 2006; Kerala PMT 2007; Odisha JEE 2009; MP PMT 2013]**
(a) *Gigartina* (b) *Gelidium*
(c) *Gracillaria* (d) All the above

8. Algae have cell wall made up of **[NCERT; CBSE PMT (Pre.) 2010]**
(a) Cellulose, hemicellulose and pectins
(b) Cellulose, galactans and mannans
(c) Hemicellulose, pectins and proteins
(d) Pectins, cellulose and proteins

9. Consider the following statements regarding the major pigments and stored food in the different groups of algae and select the correct options given
A. In chlorophyceae the stored food material is starch and the major pigments are chlorophyll-*a* and *d*
B. In phaeophyceae, laminarin is the stored food and major pigments are chlorophyll-*a* and *b*
C. In rhodophyceae, floridean starch is the stored food and the major pigments are chlorophyll-*a*, *d* and phycoerythrin **[Kerala PMT 2008; AMU (Med.) 2012]**
(a) A is correct, but B and C are wrong
(b) A and B are correct, but C is wrong
(c) A and C are correct, but B is wrong
(d) B is correct, but A and C are wrong
(e) C is correct, but A and B are wrong

10. In which of the following, all listed genera belong to the same class of algae **[DUMET 2009]**
(a) *Chara, Fucus, Polysiphonia*
(b) *Volvox, Spirogyra, Chlamydomonas*
(c) *Porphyra, Ectocarpus, Ulothrix*
(d) *Sargassum, Laminaria, Gracillaria*

11. External fertilization occurs in majority of **[DUMET 2009]**
(a) Algae (b) Fungi
(c) Liverworts (d) Mosses

12. Which of the following occurs both in fresh as well as in marine water **[BHU 2008]**
(a) Oedogonium (b) Cladophora
(c) Spirogyra (d) None of these

13. Both chlorophyll *a* and *b* are present in **[AFMC 2009]**
(a) Rhodophyceae (b) Phaeophyceae
(c) Chlorophyceae (d) None of these

14. Yellow-green pigment is found in **[CPMT 2009]**
(a) Xanthophyta (b) Chlorophyta
(c) Phaeophyta (d) Rhodophyta

15. If you are asked to classify the various algae into distinct groups, which of the following characters you should choose **[CBSE PMT 2007]**
(a) Types of pigments present in the cell
(b) Nature of stored food materials in the cell
(c) Structural organization of thallus
(d) Chemical composition of the cell wall

16. Which one of the following statements is wrong **[AIPMT (Cancelled) 2015]**
(a) Agar-agar is obtained from *Gelidium* and *Gracilaria*
(b) *Chlorella* and *Spirulina* are used as space food
(c) Mannitol is stored food in Rhodophyceae
(d) Algin and carragen are products of algae

17. Which one is a parasitic algae **[CBSE PMT 2001; BHU 2001, 04; BVP 2002; RPMT 2006]**
(a) *Vaucheria* (b) *Polysiphonia*
(c) *Cephaleuros* (d) *Batrachospermum*

18. Incorrect character of brown algae is **[DPMT 2007]**
(a) Presence of chl a and b
(b) It remain attached to substratum
(c) Presence of chl a and c
(d) Presence of fucoxanthin

19. Which of the following is a flagellated alga **[HP PMT 2005]**
(a) *Chlamydomonas* (b) *Ulothrix*
(c) *Spirogyra* (d) *Acetabularia*

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20. Algae which form motile colony is **[Odisha JEE 2005]**
(a) *Volvox* (b) *Nostoc*
(c) *Spirogyra* (d) *Chlamydomonas*

21. Sporophytic generation is represented by zygote only in **[CBSE PMT 1992]**
(a) *Funaria* (b) *Chlamydomonas*
(c) *Pinus* (d) *Selaginella*

22. In biotechnological studies, the alga that is exploited as a rich source of protein is **[AIIMS 2003, 08; Odisha JEE 2009]**
(a) *Spirogyra* (b) *Spirulina*
(c) *Chlamydomonas* (d) *Scytonema*

23. More than one pyrenoid are present in
(a) *Ulothrix* (b) *Spirogyra*
(c) *Oedogonium* (d) All the above

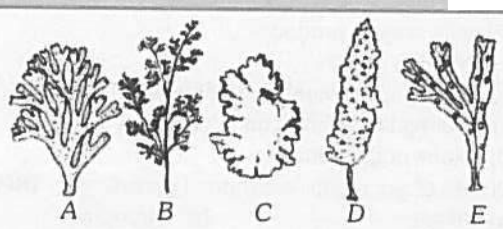
24. True nucleus is absent in **[AIPMT (Cancelled) 2015]**
(a) Mucor (b) Vaucheria
(c) Volvox (d) Anabaena

25. Which one of the following statements concerning the algae is wrong
(a) Most algae are photosynthetic
(b) Algae can be classified according to their pigments
(c) All algae are filamentous
(d) Spirogyra does not produce zoospores

26. Consider the following statements with respect to algae
A. Fusion between one large, non-motile female gamete and a smaller, motile male gamete is termed as oogamous
B. Fusion of two gametes dissimilar in size is termed as isogamous
C. Fusion of two gametes similar in size is called anisogamous
D. In chlorophyceae the major pigments are chlorophyll a and b, and the food is stored as starch
E. In rhodophyceae the major pigments are chlorophyll a and d, and the food is stored as mannitol
Of the above statements **[Kerala PMT 2012]**
(a) A and E alone are correct
(b) C and E alone are correct
(c) A and B alone are correct
(d) A and D alone are correct
(e) B and D alone are correct

27. Which of the following is not correctly matched **[Kerala PMT 2006]**
(a) *Chlamydomonas* – Unicellular flagellated
(b) *Laminaria* – Flattened leaf like thallus
(c) *Chlorella* – Unicellular non-flagellated
(d) *Spirogyra* – Filamentous structure
(e) *Volvox* – Colonial form non-flagellated

28. Algae are important, we should study algae because
(a) They are good organisms to experiment with
(b) They can be grown in large tank cultures
(c) They may form important constituent of human food (diet) in future
(d) They produce oxygen and organic acids

29.


In the diagram given above, some of the algae have been labelled as 'A', 'B', 'C', 'D' and 'E'. These algae are respectively identified as **[NCERT; Kerala PMT 2010]**
(a) *Dictyota, Polysiphonia, Porphyra, Fucus* and *Laminaria*
(b) *Porphyra, Dictyota, Laminaria, Fucus,* and *Polysiphonia*
(c) *Dictyota, Polysiphonia, Porphyra, Laminaria* and *Fucus*
(d) *Fucus, Phorphyra, Dictyota, Polysiphonia,* and *Laminaria*
(e) *Laminaria, Polysiphonia, Porphyra, Dictyota and Fucus*

30. Comparable to angiosperms, which of the following algae exhibits diplontic life cycle **[DUMET 2010; Kerala PMT 2010]**
(a) *Spirogyra* (b) *Ectocarpus*
(c) *Polysiphonia* (d) *Fucus*

31. Choose the correct order of colours with respect to pigments, chlorophyll, phycoerythrin and fucoxanthin **[CBSE PMT 1997; MP PMT 2005; Kerala PMT 2012]**
(a) Green, red and brown
(b) Brown, green and red
(c) Red, green and brown
(d) Green, brown and red
(e) Brown, red and green

32. In the Chlorophyta, the reserve food of protein surrounded by starch, form a compact body termed **[JIPMER 1993]**
(a) Paramylum (b) Pyrenoid
(c) Volutin (d) Eye spot

33. Algae are in the same major group of plants as are the **[CBSE PMT 1993]**
(a) Mosses (b) Liverworts
(c) Fungi (d) Ferns

34. An alga which can be employed as food for human being is **[CMC Vellore 1993; CBSE PMT 1997, 2014; BVP 2001, 04; CPMT 2004, 09; Kerala PMT 2012]**
(a) *Chlorella* (b) *Spirogyra*
(c) *Oscillatoria* (d) *Ulothrix*

35. Which of the following is a character of rhodophyceae **[Kerala PMT 2012]**
(a) Major pigments are chlorophyll a and chlorophyll-b
(b) Commonly called brown algae
(c) Stored food materials are mannitol and laminarin
(d) Flagellum is absent
(e) Cell wall contains cellulose and algin

36. Non motile, greatly thickened asexual spore in *Chlamydomonas* is known as **[Odisha JEE 2010]**
(a) Zoospore (b) Akinete
(c) Hypnospore (d) Endospores

37. Isomorphic alternation of generations is found in **[MP PMT 2010]**
(a) *Oedogonium* (b) *Chara*
(c) *Vaucheria* (d) *Ectocarpus*

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38. Palmella stage is produced
(a) In rainy season
(b) During unfavourable conditions
(c) During favourable conditions
(d) None of the above

39. All cells of sex organs are formed gametes in **[RPMT 1995]**
(a) Algae (b) Bryophyta
(c) Pteridophyta (d) Gymnosperm

40. Pyrenoids are made up of **[NCERT; CBSE PMT 1995; RPMT 1995]**
(a) Core of starch surrounded by sheath of protein
(b) Core of protein surrounded by fatty sheath
(c) Proteinaceous centre and starchy sheath
(d) Core of nucleic acid surrounded by protein sheath

41. Floridean starch is found in **[BHU 1995; Odisha JEE 2011]**
(a) Chlorophyceae (b) Rhodophyceae
(c) Myxophyceae (d) Cyanophages

42. Pyrenoids are characteristically found in the chloroplast of **[MP PMT 1995]**
(a) Fungi (b) Algae
(c) Pteridophytes (d) Angiosperms

43. The giant algae or sea weeds belong to class **[Bihar MDAT 1995]**
(a) Phaeophyceae (b) Rhodophyceae
(c) Chlorophyceae (d) Xanthophyceae

44. Most important alga in research centres is **[CPMT 1996; RPMT 2006]**
(a) Mycoplasma (b) *Spirogyra*
(c) *Chlorella* (d) Blue-green algae

45. Alginic acid is obtained from **[HP PMT 2005; CPMT 2010]**
(a) Red algae (b) Green algae
(c) Diatoms (d) Brown algae

46. Algae differ from Bryophyta in possessing **[MP PMT 1998]**
(a) Naked sex organs
(b) Sex organs covered with sterile covering
(c) Chlorphylls α and β
(d) Aerobic respiration

47. Red rust of tea is caused by **[CPMT 1999; JIPMER 2001; BHU 2003]**
(a) *Cephaleuros* (b) *Synchytrium*
(c) *Mucor* (d) *Fusarium*

48. In which of the following algal classes the starch and oil are present **[CPMT 1998]**
(a) Chlorophyceae (b) Phaeophyceae
(c) Rhodophyceae (d) Xanthophyceae

49. Which of the following pigments is present in all algae **[CPMT 1998; J & K CET 2002]**
(a) Chlorophyll–*a* (b) Chlorophyll–*b*
(c) Chlorophyll–*c* (d) Chlorophyll–*d*

50. Select the correct match from the options given below

(A)	Phaeophyceae	-	Mannitol
(B)	Rhodophyceae	-	Dictyota
(C)	Chlorophyceae	-	Non-motile gametes
(D)	Rhodophyceae	-	*r*-Phycoerythrin

[Kerala PMT 2011; J & K CET 2012]
(a) A, B and C (b) B, C and D
(c) A and C (d) C and D
(e) A and D

51. The element present in thyroxin is obtained from **[CPMT 2000]**
Or
Iodine is found in **[Odisha JEE 2011]**
(a) *Laminaria* (b) *Polysiphonia*
(c) *Porphyra* (d) *Gelidium*

52. Which of the following is obtained from algae **[CBSE PMT 2000]**
(a) Wax (b) Butter
(c) Chocolate (d) Carragenin

53. Marine algae flourished well during which period **[CBSE PMT 2001]**
(a) Triassic (b) Devonian
(c) Permian (d) Ordovician

54. Stomata are not found in **[MP PMT 2001]**
(a) Algae (b) Mosses
(c) Ferns (d) Gymnosperm

55. Smallest plant which contain green pigment such as higher green plant is **[CPMT 2002; RPMT 2005]**
(a) Schizomycetes (b) Rhodophyceae
(c) Chlorophyceae (d) Phaeophyceae

56. *Chlamydomonas* does not occur in **[CPMT 2002; RPMT 2005]**
(a) Fresh water (b) Pond and lake
(c) River (d) Ocean

57. Sexual reproduction in algae results in the formation of **[DPMT 2003; BVP 2004]**
(a) Oospore (b) Zoospore
(c) Zygote (d) Zygospore

58. *Macrocystis* is a **[CPMT 2010]**
(a) Red algae (b) Fungi
(c) Bryophyta (d) Brown algae

59. Which of the following form contain algae **[BHU 2005]**
(a) *Equisetum* (b) *Selaginella*
(c) *Marsilea* (d) None of these

60. Zygotic meiosis is characteristic of **[J & K CET 2005; NEET 2017]**
(a) *Marchantia* (b) *Fucus*
(c) *Funnaria* (d) *Chlamydomonas*

61. Reserve food material of algae is **[Bihar CECE 2005, 06]**
(a) Starch (b) Glycogen
(c) Fat (d) Sugar

62. Meiotic division in zygote takes place in **[RPMT 1995]**
(a) Thallophyta (b) Angiosperms
(c) Gymnosperms (d) Pteridophyta

63. Thallophyta includes **[CPMT 1994; JIPMER 2000]**
(a) Fungi and bryophyta
(b) Algae and bryophyta
(c) Algae, fungi and bryophyta
(d) Algae and fungi

64. Sea weeds are important source of **[AFMC 2004]**
(a) Chlorine (b) Fluorine
(c) Iodine (d) Bromine

65. The thallus of *Volvox* is called **[Pb. PMT 2004]**
(a) Trichome (b) Coenobium
(c) Coenocyte (d) Parenchymatous

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66. *Batrachospermum* is found in **[MHCET 2001]**
(a) Marine water (b) Fresh water
(c) Tree (d) Arctic zone

67. In oogamy, fertilization involves **[CBSE PMT 2004]**
(a) A large non-motile female gamete and a small non-motile male gamete
(b) A large motile female gamete and a small non-motile male gamete
(c) A small non-motile female gamete and a large motile male gamete
(d) A large non-motile female gamete and a small motile male gamete

68. Agar agar is obtained from **[BVP 2001, 02; AFMC 2004; CPMT 2004]**
(a) Green algae (b) Red algae
(c) Brown algae (d) Blue green algae

69. Agranal chloroplast are found in **[DPMT 2004]**
(a) Bryophytes (b) Gymnosperms
(c) Green algae (d) Angiosperms

70. Algae attached to stone is called **[Odisha JEE 2004]**
(a) Epilithic (b) Epifolic
(c) Coenolithic (d) None of these

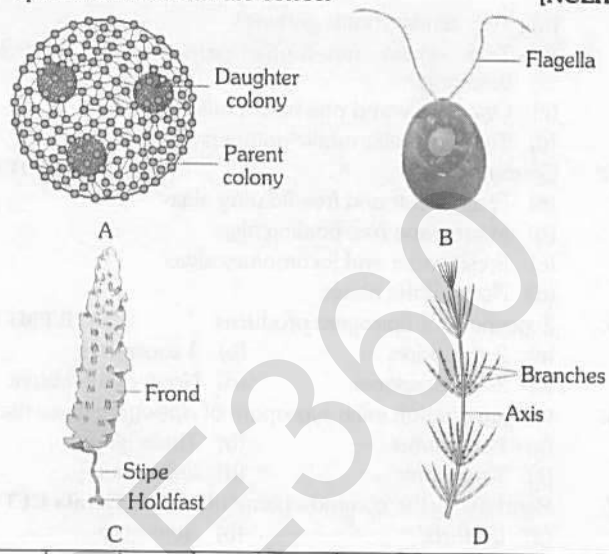
71. Monoecious plant of *Chara* shows occurrence of **[NEET 2013]**
(a) Upper oogonium and lower antheridium on the same plant
(b) Antheridiophore and archegoniophore on the same plant
(c) Stamen and carpel on the same plant
(d) Upper antheridium and lower oogonium on the same plant

72. Select the wrong statement **[NCERT; NEET 2013]**
(a) *Chlamydomonas* exhibits both isogamy and anisogamy and *Fucus* shows oogamy
(b) Isogametes are similar in structure, function and behaviour
(c) Anisogametes differ either in structure, function or behaviour
(d) In Oomycetes female gamete is smaller and motile, while male gamete is larger and non-motile

73. Which of the following is **not** correctly matched for the organism and its cell wall degrading enzyme **[NEET 2013]**
(a) Fungi – Chitinase (b) Bacteria – Lysozyme
(c) Plant cells – Cellulase (d) Algae – Methylase

74. Syngamy can occur outside the body of the organism in **[NEET (Karnataka) 2013]**
(a) Mosses (b) Algae
(c) Ferns (d) Fungi

75. Observe the diagram A, B, C, D. In which one of the four options all the items are correct **[NCERT]**



	A	B	C	D
(a)	*Chlamydomonas*	*Chara*	*Laminaria*	*Volvox*
(b)	*Laminaria*	*Volvox*	*Chlamydomonas*	*Chara*
(c)	*Chara*	*Laminaria*	*Volvox*	*Chlamydomonas*
(d)	*Volvox*	*Chlamydomonas*	*Laminaria*	*Chara*

76. Which one of the following is wrong about *Chara* **[CBSE PMT 2014]**
(a) Upper antheridium and lower oogonium
(b) Globule is male reproductive structure
(c) Upper oogonium and lower round antheridium
(d) Globule and nucule present on the same plant

77. Male gametes are flagellated in **[AIPMT (Cancelled) 2015]**
(a) *Anabaena* (b) *Ectocarpus*
(c) *Spirogyra* (d) *Polysiphonia*

78. Which one of the following statements is wrong **[NEET (Phase-II) 2016]**
(a) *Laminaria* and *Sargassum* are used as food
(b) Algae increase the level of dissolved oxygen in the immediate environment
(c) Algin is obtained from red algae, and corrageenan from brown algae
(d) Agar-agar is obtained from *Gelidium* and *Gracilaria*

79. An example of colonial alga is **[NEET 2017]**
(a) *Chlorella* (b) *Volvox*
(c) Ulothrix (d) Spirogyra

Spirogyra and Ulothrix

1. Two adjacent filaments of *Spirogyra affinis* having 10 cells each are participating in reproduction. How many new *Spirogyra* plants are produced during sexual reproduction **[EAMCET 2009]**
(a) 5 (b) 10
(c) 20 (d) 40

2. *Spirogyra* increases its body length by the division of **[AFMC 2001]**
(a) The apical cell
(b) The basal cell
(c) Every cell of the body
(d) Accumulation of food in his body

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3. Sexual reproduction in *Spirogyra* involves fusion of [MP PMT 1994; BVP 2003]
(a) Two similar motile gametes
(b) Two similar non-motile gametes but physiological disssimilar
(c) One motile and one non-motile gametes
(d) Two dissimilar motile gametes

4. *Spirogyra* is a [CPMT 1996]
(a) Fresh water and free floating alga
(b) Marine and free floating alga
(c) Fresh water and locomotory alga
(d) None of the above

5. Zygospore of *Spirogyra* produces [CBSE PMT 1993]
(a) 2 zoospores (b) 4 zoospores
(c) 2– 4 zoospores (d) None of the above

6. On germination each zygospore of *Spirogyra* gives rise to
(a) Four plants (b) Three plants
(c) Two plants (d) One plant

7. *Pond silk'* is the common name of [Kerala CET 2003]
(a) *Ulothrix* (b) *Spirogyra*
(c) *Vaucheria* (d) *Oedogonium*

8. In *Ulothrix*, sexual reproduction is by [Bihar PMT 1994; CBSE PMT 1997]
(a) Isogamy (b) Anisogamy
(c) Oogamy (d) Conjugation

9. In *Spirogyra* lateral conjugation takes place in the cells of [Odisha JEE 2010]
(a) Same filament
(b) Two filaments of same species
(c) Two filaments of different species
(d) Both (a) and (b)

10. In *Spirogyra* during the germination of zygospore how many haploid nuclei take part [Bihar MDAT 1995; CPMT 2001; AIIMS 2001]
(a) One (b) Two
(c) Three (d) All four

11. Sexual reproduction in which cells of two different *Spirogyra* filaments conjugate is known as [KCET 1998; CPMT 1999]
(a) Lateral conjugation (b) Scalariform conjugation
(c) Parthenocarpy (d) Azygospory

12. The product of conjugation of *Spirogyra* is called [CBSE PMT 2000; CPMT 2000]
(a) Zoospore (b) Akinete
(c) Chlamydospore (d) Zygospore

13. *Spirogyra* differs from moss protonema in having
(a) Pyrenoid (b) Branched filament
(c) Discoid chloroplast (d) Rhizoidal branches

14. The sexual reproduction in *Spirogyra* is
(a) Oogamous (b) Anisogamous
(c) Cleistogamous (d) None of the above

15. Sexual reproduction in *Spirogyra* can be described as [MP PMT 1995, 98, 2001; BHU 2002]
(a) Morphological anisogamy and physiological isogamy
(b) Morphological as well as physiological isogamy
(c) Morphological as well as physiological anisogamy
(d) Morphological isogamy and physiological anisogamy

16. When three *Spirogyra* filaments are participating in conjugation, the possibilities are that
(a) The middle one may be female and outer ones are male
(b) The middle one may be male and outer ones are female
(c) Both (a) and (b)
(d) None of the above

17. In *Spirogyra*, ladder like structure is formed in
(a) Lateral conjugation (b) Fragmentation
(c) Palmella stage (d) Scalariform conjugation

18. In *Spirogyra* sometimes the gametes behave directly as zygospores without fusion. Such reproductive bodies are called [AIIMS 1992]
(a) Azygospores (b) Hypnospores
(c) Zygospores (d) Aplanospores

19. The cell wall of *Spirogyra* is made up of [MP PMT 1996]
(a) Cellulose (b) Pectin
(c) Lignin (d) Chitin

20. Zoospores are absent in [Odisha JEE 2012]
(a) *Vaucheria* (b) *Spirogyra*
(c) *Cladophora* (d) *Chlamydomonas*

21. In *Spirogyra* [Odisha JEE 2002]
(a) The filaments showing scalariform conjugation are homothallic
(b) The filaments showing lateral conjugation are homothallic
(c) The filaments showing lateral conjugation are heterothallic
(d) Asexual reproduction occurs by zoospores

22. Which one of the following is an example of chlorophyllous thallophyte [KCET 2011]
(a) *Volvariella* (b) *Spirogyra*
(c) *Nephrolepis* (d) *Gnetum*

23. Which is correct statement for *Ulothrix* [CBSE PMT 1998]
(a) Filamentous alga with flagellated reproductive stages
(b) Filamentous alga with nonflagellated reproductive stages
(c) Membranous alga producing zoospores
(d) Nonmotile colonial alga lacking reproductive stages

24. A cell of *Ulothrix* has chloroplasts [RPMT 1995, 96]
(a) 1 (b) 2
(c) 3 (d) 4

25. Pigments present in *Ulothrix* are [RPMT 2002]
(a) Chl. *a*, Chl *b* and phycocyanin
(b) Chl. *a*, Chl *c*, phycocyanin and fucoxanthin
(c) Chl. *a*, Chl *b*, carotenes and xanthophylls
(d) Chl. *a* and fucoxanthin

26. Which of the following shows aplanetism [BHU 2012]
(a) *Ulothrix* (b) *Spirogyra*
(c) *Saprolegnia* (d) *Chlamydomonas*

27. Cells of *Ulothrix* are
(a) Round (b) Spherical
(c) Cylindrical (d) Rectangular

28. *Spirogyra* differs from *Mucor* in having [CPMT 1994]
(a) Uninucleate gametangia (b) Multicellular gametes
(c) Anisogamete (d) Sexual reproduction

29. Meiosis in *Ulothrix* takes place during [CBSE PMT 1993; CPMT 1995; MHCET 2001; MP PMT 2002; AIIMS 2004]
(a) Zoospore formation (b) Gamete formation
(c) Zygote germination (d) Zoospore germination

30. The chloroplast in *Spirogyra* is [Kashmir MEE 1995; BVP 2003]
(a) Spiral band shaped and wavy margin
(b) Cup shaped and smooth margin
(c) Star shaped and wavy margin
(d) Girdle shaped and smooth margin

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31. Which one of the following shows isogamy with non-flagellated gametes **[NEET 2013; CBSE PMT 2014]**
(a) *Ulothrix* (b) *Spirogyra*
(c) *Sargassum* (d) *Ectocarpus*

32. In *Ulothrix*, the cell contains **[AFMC 1994]**
(a) A chloroplast with many pyrenoids
(b) A chloroplast with few pyrenoids
(c) A few chloroplasts with few pyrenoids
(d) Many chloroplasts with few pyrenoids

33. Indian species of *Spirogyra* in which Prof. Iyengar discovered direct lateral conjugation is
(a) *Spirogyra sahnii* (b) *Spirogyra indica*
(c) *Spirogyra jogensis* (d) *Spirogyra karnalae*

34. *Ulothrix* is
(a) Attached unbranched filament
(b) Attached branched filament
(c) Colonial alga
(d) Free floating

35. A spore of *Spirogyra* sp. after resting period is **[MP PMT 1997]**
(a) Haploid (b) Diploid
(c) Aplanospore (d) Zygospore

36. Zygotic meiosis takes place in **[MP PMT 1998]**
(a) *Selaginella* (b) *Spirogyra*
(c) *Pinus* (d) *Brassica*

37. Which one of the following is wrongly matched **[NEET (Karnataka) 2013]**
(a) *Spirogyra* – Motile gametes
(b) *Sargassum* – Chlorophyll C
(c) Basidiomycetes – Puffballs
(d) *Nostoc* – Water blooms

38. *Spirogyra* has a **[MP PMT 1999, 2002]**
(a) Haplontic life cycle
(b) Diplontic life cycle
(c) Haplobiontic life cycle
(d) Diplobiontic life cycle

39. Chloroplast in Ulothrix is **[RPMT 1999; Kerala PMT 2004]**
(a) Reticulate (b) Cuplike
(c) Spiral (d) Girdle shaped

40. *Ulothrix* produces **[BVP 2001]**
(a) Isogametes (b) Anisogametes
(c) Ascospores (d) Heterogametes

41. Presence of basal rhizoidal cell in *Ulothrix* is an example of **[RPMT 1998]**
(a) Dead cell
(b) Vestigial cell
(c) Accessory cell
(d) Beginning of division of labour

42. Basal cell of *Ulothrix* is **[JIPMER 1999]**
(a) Antheridium (b) Meristematic
(c) Holdfast (d) Zoogonidium

43. Number of flagella present in the gametes of *Ulothrix* is
(a) Four (b) Three
(c) One (d) Two

Bryophytes (General)

1. Which of these is mismatched **[Kerala PMT 2006]**
(a) Phaneros – Visible
(b) Kryptos – Concealed
(c) Gymmo – Naked
(d) Bryon – Liverworts
(e) Trachea – Windpipe

2. The largest bryophyte is
(a) *Funaria* (Moss) (b) *Marchantia*
(c) *Megaceros* (d) *Dowsonia*

3. Who amongst the following is regarded as the "Father of Indian Bryology" **[CPMT 1998]**
(a) Prof. K.C. Mehta (b) Prof. D.D. Pant
(c) Prof. S.R. Kashyap (d) Prof. P.N. Mehra

4. Bryophytes have probably evolved from **[Odisha JEE 2008]**
(a) Blue green algae (b) Green algae
(c) Blue algae (d) Red algae

5. Venter is the part of
(a) Sporogonium (b) Sporangium
(c) Antheridium (d) Archegonium

6. Choose the wrong pair **[Kerala PMT 2008, 12]**
(a) Hepaticopsida – Marchantia
(b) Lycopsida – Selaginella
(c) Bryopsida – Anthoceros
(d) Pteropsida – Dryopteris
(e) Sphenopsida – Equisetum

7. In which of the following groups would you place a plant which produces spores and embryos but lacks seeds and vascular tissue
(a) Fungi (b) Bryophytes
(c) Pteridophytes (d) Gymnosperms

8. Bryophytes are of
(a) Great economic value
(b) No value at all
(c) Great ecological importance
(d) A lot of aesthetic value

9. Botanical name of peat moss is **[NCERT; AFMC 2010]**
Or
Which of the following is responsible for peat formation **[CBSE PMT 2014]**
(a) *Sphagnum* (b) *Funaria*
(c) Anthoceros (d) Polytrichum

10. Last stage of gametophytic generation is **[RPMT 1995]**
(a) Gametes (b) Zygote
(c) Spore mother cells (d) Spores

11. Which one of the following is true moss
(a) Club moss (b) Reindeer moss
(c) Irish moss (d) Bogg moss (*Sphagnum*)

12. Bryophytes differ from pteridophytes in **[BHU 1995, 2000; AFMC 1995; CPMT 1996; MP PMT 2013]**
(a) Swimming antherozoids
(b) An independent gametophyte
(c) Archegonia
(d) Lack of vascular tissue

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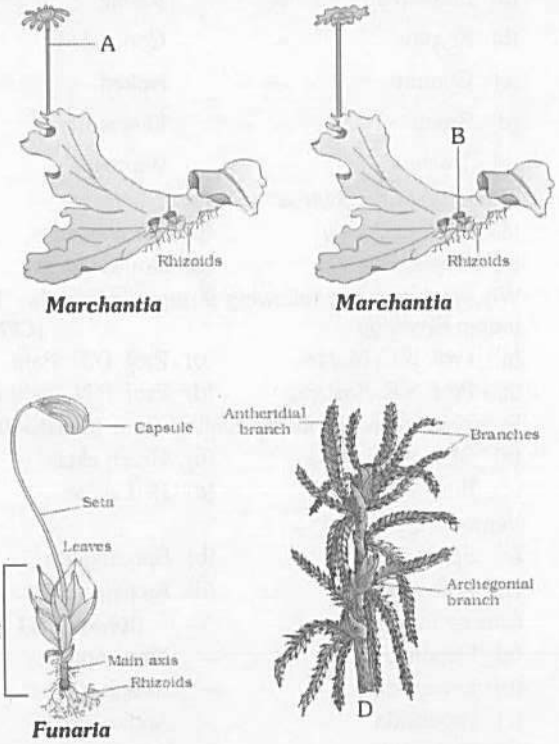
13. Observe the diagrams (A - D) given below and select the right option in which all the four items A - D are correctly identified **[NCERT; CBSE PMT (Mains) 2011]**



	A	B	C	D
(a)	Antheridia	Archegonia	Gemma cup	*Sphagnum*
(b)	Archegonia	Antheridia	Gemma cup	*Sphagnum*
(c)	Archegoni o-phore	Gemma cup	Gametophyte	*Sphagnum*
(d)	Gemma cup	Archegonio-phore	Sporophyte	*Sphagnum*

14. Elaters are present in sporogonium of **[CMC Vellore 1993; AIIMS 2002]**
(a) *Riccia* (b) *Marchantia*
(c) *Selaginella* (d) *Sphagnum*

15. Gametophytic generation is dominant in **[NCERT; RPMT 1995; CPMT 1998; Pb. PMT 2000; KCET 2001, 11; Odisha JEE 2005]**
(a) Pteridophyta (*Pteris*) (b) Bryophyta (*Riccia*)
(c) Angiosperms (Rose) (d) Gymnosperms (*Pinus*)

16. First land inhabiting plants are **[CBSE PMT 1993; MP PMT 2004]**
(a) Angiosperms (b) Gymnosperms
(c) Bryophytes (d) Pteridophytes

17. One of the following is of considerable economic importance **[CBSE PMT 1993]**
(a) *Riccia* (b) *Funaria*
(c) *Marchantia* (d) *Sphagnum*

18. Bryophytes can be separated from algae, because they **[CBSE PMT 1997, 99]**
(a) Are thalloid forms
(b) Have no conducting tissue
(c) Possess archegonia
(d) Contain chloroplast

19. Compared with the gametophytes of the bryophytes the gametophytes of vascular plants tend to be **[CBSE PMT (Pre.) 2011]**
(a) Smaller and to have smaller sex organs
(b) Smaller but to have larger sex organs
(c) Larger but to have smaller sex organs
(d) Larger and to have larger sex organs

20. Bryophytes resemble algae in the following aspects **[KCET 2009]**
(a) Filamentous body, presence of vascular tissues and autotrophic nutrition
(b) Differentiation of plant body into root, stem and leaves and autotrophic nutrition
(c) Thallus like plant body, presence of root and autotrophic nutrition
(d) Thallus-like plant body, lack of vascular tissues and autotrophic nutrition

21. Archegoniophore is present in **[CBSE PMT (Pre.) 2011]**
(a) *Funaria* (b) *Marchantia*
(c) *Chara* (d) *Adiantum*

22. The evidence for aquatic origin of bryophytes is **[CPMT 1995, 2000; KCET 2000]**
(a) Ciliated sperms (b) Green colour
(c) Protonema thread (d) Some are still aquatic

23. Saprophytic bryophyte is **[MP PMT 2003]**
(a) *Buxbaumia aphylla* (b) *Ricciocarpus natans*
(c) *Riccia fluitans* (d) *Radula sp*

24. Sporophyte dependent upon gametophyte is found in **[BHU 1995]**
(a) Algae (b) Fungi
(c) Bryophytes (d) Pteridophytes

25. Which place in India is called "The Golden Mine of Liverworts" **[Kerala CET 2003]**
(a) Eastern Himalayas (b) Western Himalayas
(c) Western Ghats (d) Eastern Ghats

26. Bryophytes comprise **[CBSE PMT 1999; MP PMT 2013]**
(a) Sporophyte is of longer duration
(b) Dominant phase of sporophyte which is parasitic
(c) Dominant phase of gametophyte which produces spores
(d) Small sporophyte phase and generally parasitic on gametophyte

27. Which of the following is true about bryophytes **[CBSE PMT 1999; BHU 2004]**
(a) They possess archegonia (b) They contain chloroplast
(c) They are thalloid (d) All of these

28. Dichotomous branching is found in **[CBSE PMT 1999]**
(a) Fern (b) *Funaria*
(c) Liverworts (d) *Polytrichum*

29. Bryophytes are dependent on water because **[CBSE PMT 1998; BHU 2012]**
(a) Archegonium has to remain filled with water for fertilization
(b) Water is essential for fertilization for their homosporous nature
(c) Water is essential for their vegetative propagation
(d) The sperms can easily reach upto egg in the archegonium

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30. What is incorrect for bryophytes [RPMT 1997]
(a) Vascular tissue lacking
(b) Independent sporophyte absent
(c) Gametophyte reduced and dependent
(d) Asexual reproduction by zoospores absent

31. The term bryophyta was given by [Pb. PMT 2000]
(a) Darwin (b) Braun
(c) Aristotle (d) Galen

32. Which of the following is called amphibians of plant kingdom [AFMC 2009; Kerala PMT 2012]
(a) Bryophytes (b) Pteridophytes
(c) Gymnosperms (d) Algae

33. Female reproductive part of bryophytes is [MHCET 2000; BVP 2001; Odisha JEE 2004; PET (Pharmacy) 2013]
(a) Antheridium (b) Oogonium
(c) Archegonium (d) Sporangium

34. A bryophyte which harbours a nitrogen fixing blue-green alga in its thallus is [CPMT 2004]
(a) *Pogonatum* (b) *Riccia*
(c) *Marchantia* (d) *Anthoceros*

35. In bryophytes, which part of archegonium encloses egg [BVP 2000]
(a) Neck (b) Cover cell
(c) Venter (d) Neck canal cells

36. In Bryophyta the adult plant body is [Kerala PMT 2004]
(a) Sporophyte (b) Epiphyte
(c) Sporophyll (d) Gametophyte
(e) Antheridium

37. A bryophyte suddenly started reproducing parthenogenetically. The number of chromosomes of the second generation compared to parent plant will be [MHCET 2001]
(a) Same (b) One-half
(c) Double (d) Triple

38. Spore dissemination in some liverworts is aided by [CBSE PMT 2007]
(a) Elaters (b) Indusium
(c) Calyptra (d) Peristome teeth

39. Largest gametophyte is found in ..... [KCET 2004]
(a) Angiosperm (b) Polytrichum
(c) Nephrolepis (d) Cycas

40. In which of the following pyrenoids are present [RPMT 2006]
(a) *Marchantia* (b) *Riccia*
(c) *Anthoceros* (d) All of these

41. Have capacity of absorbing water, used to replace cotton and used as a fuel is [BHU 2005; AMU (Med.) 2009]
(a) *Marchantia* (b) *Riccia*
(c) *Sphagnum* (d) *Funaria*

42. Moss peat is used as a packing material for sending flowers and live plants to distant places because [CBSE PMT 2006]
(a) It reduces transpiration (b) It serves as a disinfectant
(c) It is easily available (d) It is hygroscopic

43. During development of embryo in archegonium of Bryophyta its posterior part form protective embryo cover which is called [RPMT 2006]
(a) Calyptra (b) Paraphysis
(c) Apophysis (d) Hypophysis

44. Which of the following is not a bryophyte [MP PMT 2010]
(a) Pteris (b) Funaria
(c) Porella (d) Pellia

45. Which of the following statements is/are incorrect regarding bryophytes [NCERT; Odisha JEE 2010]
(a) Zygote undergoes meiosis to produce sporophyte
(b) Zygote undergoes mitosis to form embryo proper
(c) Fertilization takes place in presence of water
(d) Sporophyte is parasitic over gametophyte

46. Male and female gametophytes are independent and free-living in [CBSE PMT (Pre.) 2010]
(a) Sphagnum (b) Mustard
(c) Castor (d) Pinus

47. The plant body is thalloid in [NEET (Karnataka) 2013]
(a) *Sphagnum* (b) *Salvinia*
(c) *Marchantia* (d) *Funaria*

Funaria and Riccia

1. Primitive types of stomata are found in the [AIIMS 1998, 99; BHU 2006]
(a) Leaves of moss plants
(b) Axis of the moss plant
(c) Apophysis of capsule of moss
(d) All the above

2. Calyptra develops from [KCET 2000; BHU 2006; MP PMT 2009]
(a) Venter wall of archegonium
(b) Outgrowth of gametophyte
(c) Neck wall of archegonium
(d) Paraphysis of the archegonial branch

3. Protonema is [AIIMS 1993; BVP 2000; Kerala CET 2003; CPMT 2005]
(a) Fossil pteridophyte
(b) A part of the sporophyte of *Funaria*
(c) The juvenile phase of the moss gametophyte
(d) None of the above

4. In a moss the sporophyte [CBSE PMT 2006]
(a) Arises from a spore produced from the gametophyte
(b) Manufactures food for itself, as well as for the gametophyte
(c) Is partially parasitic on the gametophyte
(d) Produces gametes that give rise to the gametophyte

5. *Funaria* is attached to substratum by [CPMT 2005]
(a) Roots (b) Rhizoids
(c) Haustoria (d) Stem

6. The archegonia of *Funaria* is distinguished from that of *Pinus* by the structure of [MP PMT 2013]
(a) Long neck (b) Several neck canal cells
(c) Stalked venter (d) All of the above

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7. In moss, reduction division takes place in
(a) Capsule (b) Archegonia
(c) Antheridium (d) At the tip of rhizoids

8. Which is not a part of moss capsule
(a) Peristome (b) Protonema
(c) Theca from operculum (d) Annulus

9. Life cycle of *Funaria* is not completed without water. Choose the correct statement **[NCERT; CMC Vellore 1993]**
(a) As *Funaria* is a bryophyte plant
(b) As branches will not develop
(c) As fertilization takes place in presence of water only
(d) As plant is delicate and will become dry and die without water

10. A feature common to gametophytes and sporophytes of mosses and ferns is
(a) Independent existence (b) Autotrophic nutrition
(c) Unbranched habit (d) Branched habit

11. If a moss protonema is developed from few cells of the moss capsule wall, then most probably it will be
(a) Haploid (b) Diploid
(c) Triploid (d) Polyploid

12. Protonema is found in the life cycle of **[Kerala CET 2003; MP PMT 2009; CPMT 2010]**
(a) *Spirogyra* (b) *Rhizopus*
(c) *Funaria* (d) *Escherichia*

13. Which one of the following is absent in sporophyte of *Funaria* **[MP PMT 2000; AIIMS 2010]**
(a) Foot (b) Seta
(c) Elaters (d) Columella

14. In moss capsule, dispersal of spores takes place through **[CPMT 1995; MP PMT 2009]**
(a) Peristome teeth (b) Annulus
(c) Calyptra (d) Operculum

15. The dehiscence of moss capsule takes place by rupture of
(a) Operculum (b) Peristome
(c) Annulus (d) Calyptra

16. In archegonium of moss (*Funaria*) plant, the number of neck canal cells is
(a) 2 (b) 3
(c) 5 (d) 6 to 18

17. *Funaria* gametophyte is **[AIIMS 2001; MP PMT 2001, 04]**
(a) Dioecious and autoecious
(b) Monoecious and autoecious
(c) Dioecious and heteroecious
(d) Monoecious and heteroecious

18. Acrocarpous, solitary sporangia are found in **[Odisha JEE 2012]**
(a) *Opuntia* (b) *Cycas*
(c) *Pinus* (d) *Funaria*

19. The sporophytic phase in *Funaria* is well developed and is composed of
(a) Foot, seta and capsule (b) Spore sac
(c) Capsule only (d) Foot and capsule

20. In moss, medulla has
(a) Endodermis (b) Hadrome
(c) Hypodermis (d) Piliferous layer

21. Vegetative reproduction in *Funaria* takes place by **[Kashmir MEE 1995]**
(a) Primary protonema (b) Gemmae
(c) Secondary protonema (d) All the above

22. The dominant phase in the life cycle of *Funaria* is
(a) Protonema (b) Leafy gametophyte
(c) Spore (d) Sporophyte

23. Apophysis in moss capsule is **[BHU 1994]**
(a) Upper part (b) Middle part
(c) Lower part (d) Fertile part

24. The peristome of *Funaria* has **[MP PMT 1993; CPMT 1999; BHU 1999; BCECE 2005]**
(a) 4 teeth in one ring (b) 32 teeth in 2 rings
(c) 16 teeth in one rings (d) 16 teeth in 2 rings

25. Where are the antheridia and archegonia situated in moss **[AIIMS 2000]**
(a) On the apex of leaves (b) In the axil of leaves
(c) On the apex of stem (d) On the base of stem

26. The antherozoids of *Funaria* are **[CBSE PMT 1999]**
(a) Aciliated (b) Biciliated
(c) Multiciliated (d) Monociliated

27. Largest gametophyte is found in **[MP PMT 2011]**
(a) *Funaria* (b) *Selaginella*
(c) *Pinus* (d) *Cycas*

28. *Funaria* has **[MP PMT 1993; J & K CET 2002]**
(a) Unicellular simple rhizoids
(b) Tuberculated rhizoids
(c) Distinct branched coenocytic rhizoids
(d) Multicellular, oblique septate rhizoids

29. The middle sterile portion in the capsule of moss (*Funaria*) is **[RPMT 1997]**
(a) Spore sac (b) Protonema
(c) Collumela (d) Apophysis

30. Female sex organ in *Funaria* is called **[BHU 2000]**
(a) Paraphysis (b) Oospores
(c) Archegonium (d) Artheridium

31. In *Funaria*, stomata are present on the **[MP PMT 1996, 2000; CPMT 1996; CBSE PMT 2001; MHCET 2001]**
(a) Leaf (b) Stem
(c) Upper part of capsule (d) Lower part of capsule

32. An archegonium of *Riccia* has **[Bihar PMT 1994]**
(a) 4 neck canal cells, 1 venter canal cell and one oosphere
(b) 4 neck canal cells, 2 venter canal cells one oosphere
(c) 4 neck canal cells, one venter canal cell and two oospheres
(d) 6 neck canal cells, 2 venter canal cells and one oosphere

33. Spores of *Riccia* are liberated by
(a) Peristome teeth and seta
(b) Shrinkage of annulus and explosion of capsule
(c) Death and decay of thallus and external pressure on calyptra
(d) Xerochasy of elaters

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34. The sporophyte of *Funaria* begins development within **[MP PMT 1998, 2002]**
(a) Antheridia (b) Capsule
(c) Protonema (d) Archegonium

35. Rhizoids in *Riccia* are **[RPMT 1995, 2002, 06]**
(a) Unicellular smooth-walled
(b) Unicellular tuberculate
(c) Both smooth-walled and tuberculate unicellular
(d) Multicellular smooth-walled and tuberculate

36. Which of the following stage of *Funaria* is haploid **[CPMT 1996]**
(a) Gametophyte (b) Sporophyte
(c) Both (a) and (b) (d) None of these

37. In *Riccia / Marchantia* the rhizoids are
(a) Branched unicellular (b) Branched multicellular
(c) Unbranched multicellular (d) Unbranched unicellular

38. Sex organs are embedded in the thallus in **[BHU 1996]**
(a) Moss (b) *Riccia*
(c) *Azolla* (d) Fern

39. Sporophyte of *Riccia* contains **[RPMT 1998]**
(a) Spores, elaters and nutritive cells
(b) Spores and nutritive cells
(c) Elaters and spores
(d) Spores only

40. *Riccia* gametophyte develops from spore and ends in **[RPMT 1996; BHU 2001]**
(a) Thallus (b) Capsule
(c) Zygote (d) Spore

41. The development of *Funaria* gametophyte always initiated from **[MP PMT 2003]**
(a) Antheridium (b) Protonema
(c) Archegonia (d) Capsule

42. Plant body of *Riccia* is
(a) Sporophyte (b) Gametophyte
(c) Aquatic (d) Sporophyte

43. Thallus of *Riccia* is **[CPMT 2003]**
(a) Triploid (b) Diploid
(c) Haploid (d) Tetraploid

44. Meiosis (reduction division) in *Funaria* occurs in **[AFMC 2001]**
(a) Egg (b) Zygote
(c) Antherozoids (d) Spore mother cells

45. In moss capsule, the number of peristome whorls are **[CPMT 1999; BHU 1999]**
(a) 1 (b) 2
(c) 3 (d) 4

46. In *Funaria* (moss) spore germinates to produce **[MP PMT 1999; Pb. PMT 2004; Odisha JEE 2011]**
(a) Protonema (b) Prothallus
(c) Proembryo (d) Embryo

Pteridophytes (General)

1. Which one of the following belongs to vascular cryptogams **[RPMT 1997; BVP 2000; AMU (Med.) 2005; Odisha JEE 2011]**
(a) Bryophyta (b) Pteridophyta
(c) Gymnosperms (d) Angiosperms

2. Who among the following was a paleobotanist **[MDAT Bihar 1995; AIIMS 2004]**
(a) P. Maheshwari (b) S.R. Kashyap
(c) Sahani (d) V. Puri

3. Which one of the following is a vascular cryptogam **[CBSE PMT 2009]**
(a) Equisetum (b) Ginkgo
(c) Marchantia (d) Cedrus

4. Which one of the following is heterosporous **[CBSE PMT 2008; Kerala PMT 2010]**
(a) *Adiantum* (b) *Equisetum*
(c) *Dryopteris* (d) *Salvinia*

5. In the prothallus of a vascular cryptogam, the antherozoids and eggs mature an different times. As a result **[CBSE PMT 2007]**
(a) There is no change in-success rate of fertilization
(b) There is high degree of sterility
(c) One can conclude that the plant is apomictic
(d) Self fertilization is prevented

6. *Nephrolepis* is a **[MHCET 2004]**
(a) Bryophyte (b) Pteridophyte
(c) Gymnosperm (d) Angiosperm

7. Heterothallism refers to
(a) Fusion is not accompanied with zygote formation
(b) Fusion between morphologically similar strain
(c) Fusion between the strains of structurally similar and physiologically different
(d) All the above

8. Club moss' belongs to **[BHU 2006]**
(a) Algae (b) Pteridophyta
(c) Fungi (d) Bryophyta

9. Prothallus is **[KCET 1999; AIIMS 1999; Bihar CECE 2006]**
(a) Gametophyte, monoecious, Autotrophs present in pteridophyte
(b) Gametophyte, monoecious, Autotrobhs present in bryophytes
(c) Gametophyte, dioecious, Autotrophs present in pteridophyte
(d) Sporophyte, dioecious, heterotroph present in bryophyte

10. Common characteristic between bryophytes and pteridophytes is **[MHCET 2004]**
(a) Vascularisation (b) Terrestrial habit
(c) Water for fertilization (d) Independent sporophyte

11. During fertilization in ferns, male gamete reaches the female gamete through the agency of **[HP PMT 2005]**
(a) Water (b) Insects
(c) Chemicals (d) Winds

12. "*Botanical snakes*" are
(a) Algae (b) Fungi
(c) Bryophytes (d) Pteridophytes

13. Heterosporous pteridophytes always produce
(a) Monoecious gametophytes
(b) Dioecious gametophytes
(c) Homothallic gametophytes
(d) None of the above

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14. Pteridophytes are called vascular cryptogams, because they are non-seeded plants containing [KCET 2012]
(a) Xylem and phloem (b) Only xylem
(c) Only phloem (d) Neither xylem nor phloem

15. Most primitive members in which roots not present is [BHU 2005]

Or

Which of the following is a fossil pteridophyte
(a) *Psilotum* (b) *Rhynia*
(c) *Lycopodium* (d) *Selaginella*

16. Which pteridophyte is called as horse-tail [NCERT; Odisha JEE 2005]
(a) *Equisetum* (b) *Lycopodium*
(c) *Marsilea* (d) *Selaginella*

17. First vascular plant is [Odisha JEE 2005]
(a) Thallophyta (b) Bryophyta
(c) Pteridophyta (d) Spermatophyta

18. A collection of sporangia attached to placenta and covered over by indusium is known as
(a) Sporophyll (b) Sorus
(c) Cone (d) Ramenta

19. In pteridophytes, phloem is without [Odisha JEE 2005]
(a) Sieve cells (b) Sieve tubes
(c) Companion cells (d) Both (b) and (c)

20. Mosses and ferns are found in moist and shady places because both [AIIMS 2004; RPMT 2005]
(a) Require presence of water for fertilization
(b) Do not need sunlight for photosynthesis
(c) Depend for their nutrition on micro-organisms which cane survive only at low temperature
(d) Can not compete with sun-loving plants

21. Which of the following Pteridophytes belong to class Pteropsida [Kerala PMT 2011]
(a) *Equisetum* and *Psilotum*
(b) *Lycopodium* and *Adiantum*
(c) *Selaginella* and *Pteris*
(d) *Pteris* and *Adiantum*
(e) *Dryopteris* and *Psilotum*

22. A plant having vascular supply, producing spores but lacking seed is a [BHU 1995, 99; Manipal MEE 1995; CBSE PMT 1999; Odisha JEE 2004; MP PMT 2005]
(a) Byophyte (b) Pteridophyte
(c) Gymnosperm (d) Angiosperm

23. Formation of gametophyte directly from spore mother cell without meiosis is called [CPMT 1995]
(a) Apospory (b) Apogamy
(c) Apomictic (d) Apomixis

24. Seed habit originated firstly in some [CBSE PMT 1996]
(a) Pteridophytes (b) Pines
(c) Monocots (d) Dicots

25. Which of the following is not a pteridophyte [RPMT 1997]
(a) *Ginkgo* (b) *Selaginella*
(c) *Polypodium* (d) *Azolla*

26. Which of the following helps in coal formation [NCERT; AFMC 2000]
(a) Bacteria (b) Gymnosperm
(c) Pteridophytes (d) Archaebacteria

27. Apogamous cells are
(a) Haploid (b) Diploid
(c) Polyploid (d) Triploid

28. Ectophloic siphonostele is found in [CBSE PMT 2005]
(a) *Adiantum* and *Cucurbitaceae*
(b) *Osmunda* and *Equisetum*
(c) Marsilea and Botrychium
(d) *Dicksoni* and *Maidenhair fern*

Pteridium, Pteris, Dryopteris

1. Monoecious condition is found in
(a) *Cycas* (b) *Selaginella*
(c) *Pinus* (d) *Pteridium*

2. Distinct alternation of generation is found in [BHU 1999]
(a) *Rhizopus* (b) Bacteria
(c) Viruses (d) *Pteris* (Fern)

3. Multiflagellate male gametes (sperms) are found in
(a) *Chlamydomonas* (b) *Funaria*
(c) *Dryopteris* (d) *Riccia*

4. Eusporangiate fern is produced from [Odisha JEE 2009]
(a) A group of sporangial, initial cell
(b) Single initial cell
(c) Epidermal cells
(d) Hypodermal cells

5. Fern gametophyte is [Odisha JEE 2010]
(a) Homothallic (b) Monoecious
(c) Heterothallic (d) Both (a) and (b)

6. *Pteridium* possess [RPMT 2002]
(a) Polycyclic dictyostele (b) Actinostele
(c) Siphonostele (d) Amphiphloic siphonostele

7. Placenta in *Dryopteris* is the place of attachment of
(a) Ovules (b) Ramenta
(c) Sporangia (d) Archegonia

8. In *Dryopteris*, the sori are borne
(a) Laterally (b) Abaxially
(c) Adaxially (d) Marginally

9. In Pteridophytes/ *Dryopteris* meiosis occurs at the time of [JIPMER 1997; AIIMS 1998; CBSE PMT 2000; Wardha 2001]
(a) Gamete formation (b) Spore formation
(c) Formation of prothallus (d) Formation of sex organs

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10. Fern prothallus is developed from [BVP 2002; MP PMT 2003]
(a) Elaters (b) Spore mother cells
(c) Spore (d) Zygote

11. Which one controls dehiscence of sporangium in *Dryopteris* [CBSE PMT 1995]
(a) Annulus (b) Tapetum
(c) Sorus (d) Indusium

12. Presence of ciliated antherozoids in *Dryopteris* indicates [CPMT 1995]
(a) Terrestrial habit (b) Aquatic ancestry
(c) Both (a) and (b) (d) None of these

13. Neck canal cells in *Dryopteris* are [CPMT 1994; CBSE PMT 2001; Odisha JEE 2002]
(a) One with two nuclei (b) Two
(c) One with one nucleus (d) Four

14. Brown hair found at the base of *Pteris* leaves are [APMEE 2002]
(a) Modified stipules (b) Modified leaflets
(c) Ramenta (d) Spines

15. Kidney- shaped covering of *Dryopteris* is
(a) Ramentum (b) Placenta
(c) Indusium (d) Sporophyll

16. Fern spores are usually [MP PMT 2009]
(a) Haploid (b) Diploid
(c) Triploid (d) Tetraploid

17. A fern differs from a moss in having [MP PMT 2009]
(a) Swimming archegonia
(b) Swimming antherozoids
(c) Independent gametophytes
(d) Independent sporophytes

18. Prothallus of the fern produces [MP PMT 2009]
(a) Spores
(b) Gametes
(c) Both spores and gametes
(d) Cones

19. A fern prothallus is bisexual. If fertilization takes place between their gametes then it is known as [BHU 2005]
(a) Cross fertilization (b) Self fertilization
(c) Isogamous (d) Viviparous

20. Dispersal of spores in fern takes place through [AFMC 2005]
(a) Annulus (b) Stomium
(c) Both (a) and (b) (d) Indusium

21. Fern plant is a [MP PMT 1995]
(a) Haploid gametophyte (b) Diploid gametophyte
(c) Diploid sporophyte (d) Haploid sporophyte

22. The aquatic fern which is an excellent biofertilizer is [CBSE PMT 1999, 2001]
(a) *Azolla* (b) *Salvinia*
(c) *Marsilia* (d) *Pteridium*

23. The gametophyte of fern bears [MHCET 2004; Pb. PMT 2004]
(a) True roots (b) Antheridia
(c) Archegonia (d) Both (b) and (c)

24. The circinate venation is the characteristic feature of ferns. It refers to [CPMT 2004; Manipal 2005; RPMT 2005]
(a) Coiling of young leaves
(b) Arrangement of leaves on stem
(c) Attachment of sori on leaves
(d) Heterophilly

25. Fern prothallus is
(a) Homothallic (b) Heterothallic
(c) Heterotrophic (d) Heteromorphic

26. Sporangia and spore bearing leaf in fern is called as [CPMT 1993; AFMC 1996; CBSE PMT 2001; DPMT 2006]
Or
New leaf of ferns is called [RPMT 1995]
(a) Ramentum (b) Sorus
(c) Indusium (d) Sporophyll/Frond

27. Heart shaped prothallus of fern bears [BVP 2001]
(a) Male sex organs (b) Female sex organs
(c) Bisexual (d) None of these

28. Young sporophyte of *Pteris* fern draws nourishment from prothallus through [CPMT 2009]
(a) Root (b) Rhizoids
(c) Foot (d) Haustoria

29. The first plants to appear after a forest fire are the ferns, this is because of the survival of their [Kerala PMT 2004]
(a) Spores (b) Leaves
(c) Fronds (d) Rhizomes
(e) Both (c) and (d)

30. Jacket of fern antheridium is composed of [DPMT 2004]
(a) 2 cells (b) 3 cells
(c) 4 cells (d) 5 cells

31. The number of spores in the sporangium of fern is [AFMC 1996; MHCET 2004]
(a) 16 (b) 32
(c) 64 (d) 128

32. In *Dryopteris* [JK CMEE 2002]
(a) Sporophyte is parasitic over gametophyte
(b) Sporophyte is independent
(c) Gametophyte is independent
(d) Both (b) and (c)

33. What is correct [Odisha JEE 2002]
(a) Protonema of moss and prothallus of *Dryopteris* are sporophytic
(b) Protonema of moss and prothallus of *Dryopteris* are gametophytic
(c) Moss protonema is sporophytic, *Pteris* prothallus is gametophytic but plant body of *Pteris* and *Funaria* are gametophytic
(d) Plant body of moss is gametophytic while that of *Dryopteris* is both gametophytic and sporophytic

34. In *Dryopteris* the opening mechanism of sporangium is effectively operated by [MHCET 2003]
(a) Stalk (b) Stomium
(c) Annulus (d) None of these

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35. In fern, young leaves are protected by
(a) Rhizome (b) Indusium
(c) Sori (d) Ramenta

36. Which of the following is not involved in the fertilization of fern
(a) Pollen tube (b) Water
(c) Archegonia (d) Flagellated sperms

37. Fern stele is **[CPMT 1994; Odisha JEE 2012]**
(a) Dictyostele (b) Siphonostele
(c) Protostele (d) None of these

38. Spore of fern represents
(a) Sporophytic stage
(b) Gametophytic stage
(c) Sporophytic and gametophytic stage
(d) Apomictic stage

39. The sperm of fern is **[AFMC 1995]**
(a) Biciliate and coiled
(b) Multiciliate and sickle-shaped
(c) Multiflagellate and coiled
(d) Biciliate and sickle-shaped

40. Sometime prothallus of fern give rise to a fern plant. It is an example of **[AIIMS 2013]**
(a) Apospory (b) Parthenogenesis
(c) Parthenocarpy (d) Apogamy

41. Antherozoids of fern are **[Bihar MDAT 1992]**
(a) Spherical (b) Coiled
(c) Multiflagellate (d) All of the above

42. In fern, spores are formed in
(a) Sporangium (b) Oogonium
(c) Archegonium (d) Stomium

43. The cells of fern prothallus contains nucleus with
(a) 4*n* chromosomes (b) 3*n* chromosomes
(c) 2*n* chromosomes (d) *n* chromosomes

44. In fern plant, the ejection of spores with force is achieved by the
(a) Sporangiophore (b) Annulus
(c) Stomium (d) Indusium

45. In fern, sporangia are borne on the
(a) Margin of leaf (b) Abaxial side of leaf
(c) Adaxial side of leaf (d) Only on the tip of leaf

46. The shape of sporangium in fern is
(a) Biconvex (b) Circular
(c) Biconcave (d) Plano-convex

Selaginella

1. Which one of the following is considered important in the development of seed habit **[Pune CET 1998; CBSE PMT 2009; Odisha JEE 2011]**

Or

Selaginella has the character of evolutionary importance. That character is **[JIPMER 1993; BHU 1994; MP PMT 2012]**
(a) Dependent sporophyte (b) Heterospory
(c) Haplontic life cycle (d) Free-living gametophyte

2. Number of megaspore in *Selaginella rupestris* is **[AFMC 1995]**
(a) One (b) Two
(c) Six (d) Seven

3. In *Selaginella trabeculae* are the modification of **[MP PMT 2000, 09]**
(a) Epidermal cells (b) Cortical cells
(c) Endodermal cells (d) Pericycle cells

4. Polystelic stem is seen in
(a) *Cycas* (b) *Riccia*
(c) *Selaginella* (d) *Funaria*

5. Which of the following does not belong to *Selaginella*
(a) Ramenta (b) Trabeculae
(c) Rhizophore (d) Ligule

6. In *Selaginella* male gametes are **[MP PMT 2000]**
(a) Aflagellated (b) Monoflagellated
(c) Biflagellated (d) Multiflagellated

7. Megasporangium of *Selaginella* is equivalent to which structure of *Pinus*
(a) Ovule (b) Nucellus
(c) Female gametophyte (d) Seed

8. Antherozoids of *Selaginella* has **[CBSE PMT 1990]**
(a) Elongated body with many flagella
(b) An elongated body with two flagella at one end
(c) Top shaped body with many flagella
(d) Oval body with two flagella at one end

9. *Selaginella* differs from *Pteris* (fern) in which of the following character **[CMC Vellore 1993]**
(a) Absence of seed
(b) Absence of vessels in xylem
(c) Need water for fertilization
(d) Heterosporous condition

10. Rhizophore in *Selaginella* is **[Pune CET 1998]**
(a) A modified leaf (b) A root
(c) A shoot (d) *Organ sui genesis*

11. Trabeculae endodermis is found in **[MP PMT 2000]**
(a) Axis and capsule of moss plant
(b) Stem of *Selaginella*
(c) Stem of *Cycas*
(d) Stem of *Pinus*

12. Which of the following is not correct with reference to *Selaginella*
(a) *Selaginella* is commonly distributed on hills and plains
(b) Some species of *Selaginella* are truly xerophytic
(c) The vascular cylinder is protostelic
(d) The endodermis is trabeculated

13. Heteromorphic alternation of generations is found in **[MP PMT 1998]**
(a) *Spirogyra* (b) *Mucor*
(c) *Selaginella* (d) *Pinus*

14. In which one of the following species of *Selaginella*, the apex continues its vegetative growth beyond the formation of strobilus
(a) *S. helvetica* (b) *S. cuspidiata*
(c) *S. rupestris* (d) None of these

15. Which of the following is not common in *Funaria* and *Selaginella* **[CBSE PMT 1994]**
(a) Roots (b) Archegonium
(c) Embryo (d) Motile sperms

16. The number of male prothallial cells in *Selaginella* are **[MP PMT 1993]**
(a) One (b) Two
(c) Four (d) Nil

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17. The stem of *Selaginella* is anatomically characterised by the presence of **[MP PMT 1994]**
(a) Siphonostele (b) Amphiphloic siphonostele
(c) Protostele (d) Ectophloic siphonostele

18. Adaxial outgrowth from the base of leaves in *Selaginella* is called **[MHCET 2001; BHU 2005]**
(a) Stipule (b) Ligule
(c) Trabaculae (d) Velum

19. Physiological heterospory is seen in **[DPMT 2004]**
(a) *Chlamydomonas* (b) *Rhizopus*
(c) *Selaginella* (d) *Hycopodium*

20. Spores with chloroplast is present in **[DPMT 2004]**
(a) *Selaginella* (b) *Equisetum*
(c) *Puccinia* (d) *Rhizopus*

21. *Selaginella* and *Salvinia* are considered to represent a significant step toward evolution of seed habit because **[CBSE PMT (Mains) 2011]**
(a) Megaspores possess endosperm and embryo surrounded by seed coat
(b) Embryo develops in female gametophyte which is retained on parent sporophyte
(c) Female gametophyte is free and gets dispersed like seeds
(d) Female gametophyte lacks archegonia

22. The main plant body of *Selaginella* sp. is **[MP PMT 1997]**
(a) Gametophyte
(b) Sporophyte
(c) Both gametophyte and sporophyte
(d) Halophyte

23. Which of the following is known as 'resurrection plant' **[CPMT 1999; HPMT 2005]**
(a) *Selaginella* (b) *Welwitschia*
(c) *Rafflesia* (d) *Chlorella*

24. In *Selaginella*, reduction division occurs during the formation of **[CBSE PMT 1994; AIIMS 1998]**
(a) Sperms (b) Microspores only
(c) Megaspores only (d) Both (b) and (c)

Gymnosperm (General)

1. Which gymnospermic order includes all fossil plants **[Odisha JEE 2009]**
(a) Cycadofilicales (b) Coniferales
(c) Gnetales (d) Cycadales

2. Which one of the following classes in included under gymnosperms **[Kerala PMT 2009]**
(a) Lycopsida (b) Bryopsida
(c) Cycadopsida (d) Pteropsida
(e) Sphenopsida

3. Naked seeds of gymnosperms meant for absence of which of the following **[BHU 2008]**
(a) Seed coat (b) Integument
(c) Embryo (d) None of these

4. In gymnosperms, the ovule is naked because **[CPMT 2004; MP PMT 2009]**
(a) Ovary wall is absent (b) Integuments are absent
(c) Perianth is absent (d) Nucellus is absent

5. During adverse season, therophytes survive by **[CBSE PMT 1997]**
(a) Bulbs (b) Corms
(c) Rhizomes (d) Seeds

6. In which of the following groups would you place a plant which produces seeds but lacks flower and fruits **[CPMT 1996; AMU (Med.) 2005]**
(a) Fungi (b) Bryophytes
(c) Pteridophytes (d) Gymnosperms

7. Most of the gymnosperms have
(a) Only antheridia
(b) Both antheridia and archegonia
(c) Archegonia but no antheridia
(d) Both absent

8. Gymnosperms do not have
(a) Trees (b) Shrubs
(c) Lianas (d) Herbs

9. In gymnosperms pollination is exclusively by **[NCERT; CBSE PMT 1993; RPMT 1999]**
(a) Animals (b) Wind
(c) Water (d) Insects

10. Fruits are not found in gymnosperms plants because **[AFMC 1995; Odisha JEE 2010]**
(a) They are seedless plants
(b) They are not pollinated
(c) They have no ovary
(d) Process of fertilization does not take place in them

11. Mark the gymnospermous plant in which archegonium is absent **[MP PMT 2012]**
(a) *Pinus* (b) *Ephedra*
(c) *Cycas* (d) *Gnetum*

12. The young meristematic cells of leaves and stem of a gymnosperm has 16 chromosomes, the number of chromosomes in the endosperm of the same gymnosperm shall be **[MP PMT 2013]**
(a) 16 (b) 32
(c) 24 (d) 8

13. In gymnosperms, the pollen chamber represents **[CBSE PMT 2007]**
(a) A cell in the pollen grain in which the sperms are formed
(b) A cavity in the ovule in which pollen grains are stored after pollination
(c) An opening in the megagametophyte through which the pollen tube approaches the egg
(d) The microsporangium in which pollen grains develop

14. Consider the following statements regarding gymnosperms and choose the correct option
(A) In gymnosperms, the male and female gametophytes have an independent existence
(B) The multicellular female gametophyte is retained with in the megasporangium
(C) The gymnosperms are heterosporous of these statements **[Kerala PMT 2010]**
(a) (A) and (B) are true but (C) is false
(b) (A) and (C) are true but (B) is false
(c) (B) and (C) are false but (A) is true
(d) (A) and (C) are false but (B) is true
(e) (B) and (C) are true but (A) is false

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15. Canada balsam is an oleoresin obtained from [NCERT]
(a) *Abies balsamea* (b) *Impatiens balsamia*
(c) *Pinus* sp. (d) *Helianthus annus*

16. The lateral conduction in gymnospermic leaf is by [MHCET 2002]
(a) Veins (b) Xylem parenchyma
(c) Transfusion tissue (d) Medullary rays

17. Which of the following gymnosperm is a bushy trailing shrub [Kerala PMT 2007]
(a) *Ephedra* (b) *Cycas*
(c) *Pinus* (d) *Araucaria*
(e) *Cedrus*

18. Gymnosperms are also called soft wood spermatophytes because they lack [NCERT; CBSE PMT (Pre.) 2012]
(a) Cambium (b) Phloem fibres
(c) Thick-walled tracheids (d) Xylem fibres

19. In which class of gymnosperms, fossils are present [CPMT 1995]
(a) Cycadophyta (b) Coniferophyta
(c) Gnetopsida (d) Both (a) and (b)

20. What is the similarity between gymnosperms and angiosperms [CPMT 1996]
(a) Phloem of both have companian cells
(b) Endosperm is formed before fertilization in both
(c) Origin of ovule and seed is similar in both
(d) Both have leaves, stem and roots

21. Which of the following is living fossil [CBSE PMT 1996, 97; Odisha JEE 2005, 08]
(a) *Pinus* (b) *Ginkgo biloba*
(c) *Thuja* (d) *Deodar*

22. Vessels are found in [DPMT 2004]
(a) *Ephedra* (b) *Selaginella*
(c) *Funaria* (d) All gymnosperms

23. Resin duct of a gymnospermous stem is an example of [BHU 1999; Pb. PMT 2004]
(a) Big vacuole (b) Lysigenous cavity
(c) Intercellular space (d) Schizogenous cavity

24. The arrangement of megaspores in a tetrad in a gymnosperm is [CPMT 2000]
(a) Decussate (b) Tetrahedral
(c) Linear (d) Isobilateral

25. Which of the following is a character of gymnospermous wood [MP PMT 2010, 12]
(a) Porous (b) Ring porous
(c) Diffused porous (d) Non-porous

26. Which of the following is not the feature of gymnosperms [BHU 2005; CPMT 2009]
(a) Parallel venation
(b) Perennial plants
(c) Distinct branches (long and short branches)
(d) Xylem with vessels

27. In gymnosperms how many male gametes are produced by each pollen grain [HP PMT 2005]
(a) 4 (b) 3
(c) 2 (d) 1

28. A typical gymnospermous plant has 8 chromosomes in leaf cells. What will be number of chromosomes in the cells of its gametophyte [HP PMT 2005]
(a) 16 (b) 8
(c) 4 (d) 24

29. Conifers differ from grasses in the [CBSE PMT 2006]
(a) Absence of pollen tubes
(b) Formation of endosperm before fertilization
(c) Production of seeds from ovules
(d) Lack of xylem tracheids

Pinus

1. The phenomenon of sulphur shower in pine forest is due to [Odisha JEE 2008]
(a) Presence of Sulphur
(b) Presence of insects
(c) Release of pollen grains in prodigious amount
(d) Large number of fruits

2. Which one of the following plants is monoecious [NCERT; [RPMT 1997, 99; MP PMT 1997, 99; CBSE PMT 2009; CBSE PMT (Mains) 2010]
(a) *Marchantia* (b) *Pinus*
(c) *Cycas* (d) *Papaya*

3. Annual rings are well seen in [Pune CET 1998]
(a) *Selaginella* stem (b) *Cycas* wood
(c) *Pinus* wood (d) All the above

4. Pollination of pollen grains in *Pinus* takes place at
(a) One celled stage (b) Two celled stage
(c) Three celled stage (d) Four celled stage

5. Non-motile male gametes are formed in [MP PMT 2000]
(a) *Funaria* (b) *Selaginella*
(c) Fern (d) *Pinus*

6. Which one of the following is matched incorrectly [AMU (Med.) 2010]
(a) *Pinus* : coralloid roots (b) *Sequoia* : tap roots
(c) *Cycas* : unbranched stem (d) *Cedrus* : branched stem

7. Popular dry fruit "chilgoza" is produced by [NCERT; CPMT 1995; MP PMT 2011]
(a) *Pinus sylvestris* (b) *Pinus monophylla*
(c) *Pinus gerardiana* (d) *Pinus roxburghii*

8. Pinus belongs to the class [KCET 2011]
(a) Gnetopsida (b) Cycadopsida
(c) Coniferopsida (d) Sphenopsida

9. Consider the following four statements whether they are correct or wrong
(A) The sporophyte in liverworts is more elaborate than that in mosses
(B) *Salvinia* is heterosporous
(C) The life-cycle in all seed-bearing plants is diplontic
(D) In *Pinus* male and female cones are borne on different trees
The two wrong statements together are [CBSE PMT (Mains) 2011]
(a) Statements (B) and (C) (b) Statements (A) and (B)
(c) Statements (A) and (D) (d) Statements (A) and (D)

10. The male cone of *Pinus* is modified
(a) Long shoot (b) Needle leaves
(c) Dwarf shoot (d) None of the above

11. Which of the following structures in *Pinus* are haploid [JIPMER 1993; MP PMT 2002]
(a) Megaspore, integument, root
(b) Endosperm, megaspore, pollen grain
(c) Pollen grain, leaf, root
(d) Megaspore, endosperm, embryo

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12. Pine wood consists of almost entirely
(a) Tracheids
(b) Vessels
(c) Equal number of tracheids and vessels
(d) More vessels and less tracheids

13. Winged seeds are found in [CMC Vellore 1993; CPMT 1995; BVP 2002; MP PMT 2004, 12]
(a) *Cycas* (b) *Pinus*
(c) *Papaver* species (d) None of the above

14. In *Pinus* seeds there are
(a) Two cotyledons (b) One cotyledon
(c) Fleshy cotyledons (d) Many cotyledons

15. Male prothallus (gametophyte) in *Pinus* is having
(a) 1 prothallial cell (b) 2 prothallial cells
(c) 4 prothallial cells (d) A mass of cells

16. Which of the following tissue is present in the leaves of *Pinus* and serve to conduct water and food [CBSE PMT 1998; CPMT 1999, 2001; AFMC 2002; Manipal 2005]
(a) Xylem (b) Phloem
(c) Transfusion tissue (d) Conducting tissue

17. In the embryo of *Pinus* rosette cells lie
(a) Above suspensor cells
(b) Between suspensor and embryonal cells
(c) Between primary and secondary suspensor cells
(d) Between embryonal and apical cells

18. Resin and turpentine are obtained from [NCERT]
(a) *Cycas* (b) *Pinus*
(c) *Abies* (d) *Cedrus*

19. The winged pollen grain of *Pinus* sp. are produced in [MP PMT 1997, 2004; BVP 2002]
(a) Pollen chamber (b) Anther
(c) Tapetum (d) Microsporangium

20. Of the following, the false character with respect to *Pinus* is
(a) Bract and ovuliferous scales
(b) Embryo with two cotyledons
(c) Resin canals in needles
(d) Tracheids with bordered pits

21. Cataphylls are
(a) Leaves of *Selaginella* (b) Scaly leaves of *Pinus*
(c) Needles of *Pinus* (d) Foliar leaves of *Pinus*

22. Male gametophyte (mature pollen grain) of *Pinus* is found to be
(a) 10 celled (b) 6 celled
(c) 4 celled (d) 2 celled

23. The wood of *pinus* is [MP PMT 2000, 12; AMU (Med.) 2006]
(a) Pycnoxylic and monoxylic
(b) Pycnoxylic and heteroxylous
(c) Manoxylic and homoxylous
(d) Manoxylic and heteroxylous

24. Which statement is correct with reference to *Pinus*
(a) It is of much economic value
(b) It is cosmopolitan in distribution
(c) If grows in deserts and exhibits xerophytic character
(d) If form deciduous trees in temperate region

25. *Pinus* produces [CMC Vellore 1994; CPMT 1995]
(a) No seeds (b) Flowers
(c) No vascular tissues (d) Naked seeds in cones

26. In *Pinus*, the spur (dwarf shoot) has [MP PMT 1993]
(a) One needle (b) Two needles
(c) Three needles (d) All correct

27. The secondary wood of *Pinus* is characterised by [MP PMT 1993]
(a) Presence of resin cells (b) Presence of resin ducts
(c) Absence of resin ducts (d) Presence of vessels

28. Which one of the following alternatives represents the gametophytic phase in *Pinus* [MP PMT 1994]
(a) *Pinus* plant (b) Zygote
(c) Micro and megaspores (d) Male and female cones

29. Endosperm of *Pinus* is
(a) Male gametophyte (b) Female gametophyte
(c) Sporophyte (d) None of the above

30. The gametophyte is not an independent, free-living generation in [CBSE PMT (Pre.) 2011; AIPMT (Cancelled) 2015]
(a) *Pinus* (b) *Polytrichum*
(c) *Adiantum* (d) *Marchantia*

31. The wing in *Pinus* seed originates from [MP PMT 1993]
(a) Integument
(b) Adaxial surface of ovuliferous scale
(c) Bract scale
(d) Cone axis

32. Seed of *Pinus* shows three generations as [J & K CET 2002]
(a) Parent sporophyte, gametophyte and future sporophyte
(b) Parent gametophyte, sporophyte and future gametophyte
(c) Parent sporophyte, sporophyte, future gametophyte
(d) None of these

33. In *Pinus* male gametes are produced in the pollen tube by the division of which of the following cells [BHU 2001]
(a) Body cell (b) Stalk cell
(c) Tube cell (d) Prothallial cell

34. The seed of *Pinus* sp. is [MP PMT 1997]
(a) Uneconomic and nonendospermic
(b) Abaxial and rounded
(c) Adaxial and endospermic
(d) Hypogeal and monocotyledonous

35. In *Pinus* male and female reproductive structures occur [MP PMT 1996]
(a) On different branches of the same plant
(b) On different plants
(c) On same branch
(d) None of these

36. The pollination in *Pinus* is [AFMC 1995]
(a) Entomophilous (b) Anemophilous
(c) Hydrophilous (d) Malscophilous

37. In *Pinus* only lower part of oospore is concerned with the development of embryo, such development is [CBSE PMT 1993]
(a) Meroblastic (b) Periblastic
(c) Mesoblastic (d) None of these

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38. Female cone of *Pinus* is considered equivalent to **[MP PMT 2009]**
(a) Dwarf shoot (b) Long shoot
(c) Needles (d) Scale leaves

39. Siphonogamous fertilization takes place in
(a) Bryophytes (b) *Selaginella*
(c) Fern (d) *Pinus*

40. *Pinus* shows **[CBSE PMT 2001; BHU 2006]**
(a) Simple polyembryony
(b) Cleavage polyembryony
(c) Both simple and cleavage polyembryony
(d) None of the above

41. A microsporophyll in *Pinus* has **[Pune CET 1998; Kerala PMT 2004]**
(a) One microsporangium on the adaxial side
(b) One microsporangium on the abaxial side
(c) Two microsporangia on the abaxial side
(d) Two microsporangia on the adaxial side
(e) Four microsporangia on the lower side

Cycas

1. Diploxylic or polyxylic vascular bundles are found in
(a) *Pinus* (b) *Dryopteris*
(c) *Cycas* (d) *Funaria*

2. In which plant largest sperms (antherozoids) are found **[CBSE PMT 1998; CPMT 1998; MHCET 2000; BHU 2012]**
(a) *Cycas* (b) *Pinus*
(c) Mango (d) Sunflower

3. Fern character in *Cycas* is **[AFMC 2001]**
(a) Coralloid roots (b) Tap root system
(c) Circinate venation (d) Reticulate venation

4. Coralloid roots of Cycas are useful in **[MHCET 2004; BHU 2005]**
(a) N_2-fixation (b) Absorption of water
(c) Transpiration (d) Fixation

5. *Cycas circinalis* is a source of **[BVP 2004; CPMT 2005]**
(a) Resin (b) Timber
(c) Essential oil (d) Starch (Sago)

6. The stem of female *Cycas* plant is a **[MHCET 2002]**
(a) Monopodium (b) Sympodium
(c) Rhizomatous (d) Dichotomous

7. Sterile part of *Cycas* microsporophyll is **[MHCET 2004]**
(a) Apophysis (b) Sporophore
(c) Middle part (d) Lower part

8. Polyembryony seen in *Cycas* is
(a) Potential true polyembryony
(b) Potential true polyembryony and cleavage polyembryony
(c) Adventive polyembryony
(d) All of these

9. *Cycas* leaflets are **[MHCET 2004]**
(a) Sessile, straight, oval
(b) Sessile, straight, linear-lanceolate
(c) Sessile, straight, spiny
(d) Sessile, smooth, twisted

10. The secondary growth in stem of *Cycas* is brought about by
(a) Persistent cambium
(b) Short lived cambium
(c) Number of cambia produced in succession
(d) Isolated strips of cambium

11. Which one of the following is a living fossil **[CBSE PMT 2004]**
(a) *Saccharomyces* (b) *Spirogyra*
(c) *Cycas* (d) Moss

12. Top-shaped multiciliate male gametes, and the mature seed which bears only one embryo with two cotyledons, are characteristic features of **[CBSE PMT 2005]**
(a) Polypetalous angiosperms
(b) Gamopetalous angiosperms
(c) Conifers
(d) Cycads

13. Negatively geotropic roots are found in **[Odisha JEE 2005]**
(a) *Colocasia* (b) *Cycas*
(c) *Cactus* (d) *Coleus*

14. Spermatozoid of *Cycas* is **[APMEE 1995; JIPMER 2000]**
(a) Biflagellate (b) Nonflagellate
(c) Uniflagellate (d) Multiciliated

15. Which is not a characteristic feature of *Cycas*
(a) Naked ovules (b) Circinate vernation
(c) Vessels (d) Girdling leaf traces

16. *Cycas* has the largest
(a) Ovule (b) Egg
(c) Sperm (d) All of these

17. *Cycas* is
(a) Hermaphrodite (b) Dioecious
(c) Monoecious (d) None of these

18. *Cycas revoluta* is **[Pb. PMT 1997; Chd. CET 1999; CPMT 2002, 10; RPMT 2005]**
(a) Date Palm (b) Sea Palm
(c) Royal Palm (d) Sago Palm

19. Wood of *Cycas* is **[APMEE 1996; Wardha 2002; DPMT 2004]**
(a) Monoxylic and manoxylic
(b) Manoxylic and polyxylic
(c) Diploxylic
(d) Monoxylic

20. *Cycas* contains
(a) Mucilage ducts (b) Laticiferous vessels
(c) Resin ducts (d) Oil ducts

21. In *Cycas*, pollination is by **[DPMT 1999]**
(a) Wind (b) Insect
(c) Water (d) Both (a) and (b)

22. In *Cycas*, the ovules are attached to megasporophyll
(a) Laterally (b) Dorsally
(c) Ventrally (d) Apically

23. *Cycas* resembles angiosperms in having **[MP PMT 1996]**
(a) Circinate vernation in leaves
(b) Vessels
(c) Motile sperms
(d) Ovules

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24. *Cycas* is living fossil as it has **[BHU 1992]**
(a) Ciliated sperms
(b) Structure like that of Tree Fern
(c) Restricted occurrence in certain areas
(d) Been found in fossil state also

25. In *Cycas*, the endosperm is
(a) Sporophytic structure (b) Gametophytic structure
(c) New structure (d) Formed after fertilization

26. Male gametes of cycads are **[CPMT 1992]**
(a) Rounded and nonciliate
(b) Sickle – shaped biflagellate
(c) Boat – shaped nonciliate
(d) Large, top-like, spirally twisted with cilia

27. Coralloid roots of *Cycas* possess a symbiotic alga
[CPMT 1993; Bihar PMT 1996; BHU 1998; Pb. PMT 1999]
(a) *Aulosira* (b) *Spirogyra*
(c) *Ulothrix* (d) *Anabaena*

28. Select one of the following pairs of important features distinguishing Gnetum from Cycas and Pinus and showing affinities with angiosperms **[CBSE PMT 2008]**
(a) Perianth and two integuments
(b) Embryo development and apical meristem
(c) Absence of resin duct and leaf venation
(d) Presence of vessel elements and absence of archegonia

29. In *Cycas* Pollination takes place in
[CPMT 1990, 93; BHU 2005, 12; Odisha JEE 2010]
(a) 3-celled stage (b) 4-celled stage
(c) 2-celled stage (d) 1-celled stage

30. Sago of *Cycas* is given to patients with stomach disorders because it is **[AIIMS 1997]**
(a) Cheap
(b) Easily digestible with less starch
(c) Tastier
(d) With high nutritive value

31. Which is incorrect about *Cycas* **[CBSE PMT 1998]**
(a) Its xylem has vessels
(b) It has circinate venation
(c) It does not have well organised female flower
(d) Its roots possess some blue–green algae

32. Vegetative reproduction in *Cycas* occurs by **[RPMT 1998]**
(a) Scale leaves (b) Sporophylls
(c) Bulbils (d) Fragmentation

33. Megasporophyll of *Cycas* is homologous to **[AIIMS 2002]**
(a) Carpel (b) Stamen
(c) Petal (d) Sepal

34. *Cycas* has two cotyledons but it is not included under angiosperms because it has **[CBSE PMT 2001]**
(a) Circinate ptyxis (b) Compound leaves
(c) Monocot like stem (d) Naked seeds

35. Diploxylic condition occurs in *Cycas* in **[APMEE 2002]**
(a) Root (b) Stem
(c) Coralloid root (d) Leaflet

36. Microsporangia of *Cycas* occur over microsporophyll
[AIIMS 1996; RPMT 2000]
(a) Adaxially (b) Abaxially
(c) Laterally (d) Marginally

37. A characteristic of *Cycas* that resembles ferns is
[AFMC 2001; Odisha JEE 2012]
(a) Circinate ptyxis
(b) Sori in microsporophyll
(c) Uniflagellated male gamete
(d) Both (a) and (b)

38. *Cycas* and *Adiantum* resemble each other in having
[CBSE PMT (Pre.) 2012]
(a) Seeds (b) Motile Sperms
(c) Cambium (d) Vessels

39. Ptyxis in *Cycas* is
(a) Simple (b) Circular
(c) Circinate (d) None of these

40. Early embryogeny in *Cycas* is characterized by
(a) Absence of suspensor cell
(b) Presence of expanded free nuclear division
(c) Reduced free nuclear division
(d) Many cotyledons

41. Identify the pair that exhibit circinate vernation **[KCET 2010]**
(a) *Psilotum* and *Riccia*
(b) *Equisetum* and *Selaginella*
(c) *Nephrolepis* and *Cycas*
(d) *Riccia* and *Nephrolepis*

42. Which of the following taxa shows zooidogamous oogamy
(I) *Spirogyra* (II) *Funaria*
(III) *Pteris* (IV) *Cycas*
The correct answer is **[EAMCET 2009]**
(a) I, II, III (b) I, III, IV
(c) I, II, IV (d) II, III, IV

43. Algal zone is characteristic of **[CPMT 1994]**
(a) Normal root of *Cycas* (b) Root of *Pinus*
(c) Coralloid roots of *Cycas* (d) Stem of *Cycas*

Angiosperm

1. Seed are found in **[MP PMT 2005; AMU (Med.) 2006]**
(a) Angiosperm (b) Bryophyta
(c) Pteridophyta (d) Algae

2. Which of the following contain xylem vessel **[AFMC 1996; J & K CET 2002; Haryana PMT 2005; MP PMT 2005]**
(a) Bryophyte (b) Pteridophyta
(c) Both (a) and (b) (d) Angiosperm

3. Vessels and Companion cells are characteristics of
[BCECE 2005; MP PMT 2005, 07]
(a) Angiosperm (b) Gymnosperm
(c) Pteridophyta (d) Fern

4. The stele found in monocot is **[DPMT 2004]**
(a) Haplostele (b) Atactostele
(c) Dictyostele (d) Actinostele

5. Tap roots are commonly found in
(a) Gymnosperms (b) Angiosperms
(c) Dicots (d) Monocots

6. Which of the following is/are grouped under phanerogams
[BHU 2004]
(a) Angiosperms (b) Gymnosperms
(c) Pteridophytes (d) Both (a) and (b)

7. Which is not a monocot **[BHU 2005]**
(a) Rose (b) Orchids
(c) Palms (d) Banana

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8. Which of the following is a saprophytic angiosperm [MHCET 2001]
(a) *Cuscuta* (b) *Neottia*
(c) *Agaricus* (d) Mango

9. An angiosperm is different from a gymnosperm in the absense of
(a) Vascular tissue (b) Ovary
(c) Seed (d) Naked ovule

10. Which of the following is considered as more evolved
(a) Dicot plant (b) Monocot plant
(c) Data are incomplete (d) Both (a) and (b)

11. In which of the following secondary growth takes place [MP PMT 2001]
(a) *Riccia* (b) *Funaria*
(c) *Selaginella* (d) None of these

12. An angiosperm differs from a gymnosperm by possessing [MHCET 2002]
(a) Ovule (b) Xylem vessels
(c) Xylem tracheids (d) Seed

13. Largest flower *Rafflesia* is [RPMT 1995; CPMT 1998]
(a) Total stem parasite (b) Total root parasite
(c) Partial stem parasite (d) Partial root parasite

14. Which of the following is the tallest tree of the world [HP PMT 2005; AMU (Med.) 2006]
(a) *Eucalyptus regnans* (b) *Sequoia sempervirens*
(c) *Pinus logifolia* (d) *Pinus roxburgii*

15. Male gametophyte with least number of cells is present in [CBSE PMT 2014]
(a) *Lilium* (b) *Pinus*
(c) *Pteris* (d) *Funaria*

16. In majority of angiosperms [NEET (Phase-II) 2016]
(a) A small central cell is present in the embryo sac
(b) Egg has a filiform apparatus
(c) There are numerous antipodal cells
(d) Reduction division occurs in the megaspore mother cells

NCERT Exemplar Questions

1. Fusion of two gametes which are dissimilar in size is termed as [NCERT]
(a) Oogamy (b) Isogamy
(c) Anisogamy (d) Zoogamy

2. Holdfast, stipe and frond constitutes the plant body in case of [NCERT]
(a) Rhodophyceae (b) Chlorophyceae
(c) Phaeophyceae (d) All of the above

3. A plant shows thallus level of organization. It shows rhizoids and is haploid. It needs water to complete its life cycle because the male gametes are motile. Identify the group to which it belongs to [NCERT]
(a) Pteridophytes (b) Gymnosperms
(c) Monocots (d) Bryophytes

4. A Prothallus is [NCERT]
(a) A structure in pteridophytes formed before the thallus develops
(b) A sporophytic free living structure formed in pteridophytes
(c) A gametophyte free living structure formed in pteridophytes
(d) A primitive structure formed after fertilization in pteridophytes

5. Plants of this group are diploid and well adapted to extreme conditions. They grow bearing sporophylls in compact structures called cones. The group in reference is [NCERT]
(a) Monocots (b) Dicots
(c) Pteridophytes (d) Gymnosperms

6. If the diploid number of a flowering plant is 36. What would be the chromosome number in its endosperm [NCERT]
(a) 36 (b) 18
(c) 54 (d) 72

7. Protonema is [NCERT]
(a) Haploid and is found in mosses
(b) Diploid and is found in liverworts
(c) Diploid and is found in pteridophytes
(d) Haploid and is found in pteridophytes

8. The giant Redwood tree (*Sequoia sempervirens*) is a/an [NCERT]
(a) Angiosperm (b) Free fern
(c) Pteridophyte (d) Gymnosperm

Critical Thinking Objective Questions

1. Which one of the following is commonly called a "*Maidenhair fern*" [Kerala PMT 2006]
(a) *Pteridium* (b) *Adiantum*
(c) *Dryopteris* (d) *Pteris*

2. Pinus seed is originated in [MP PMT 2003]
(a) Capsule (b) Microsporophyll
(c) Microsporangia (d) Megasporophyll

3. In which one of the following male and female gametophytes do not have free living independent existence [CBSE PMT 2008]
(a) *Polytrichum* (b) *Cedrus*
(c) *Pteris* (d) *Funaria*

4. Consider the following statements with respect to gymnosperms and angiosperms
A. Double fertilization is an event unique to gymnosperms
B. Angiosperms range in size from microscopic, Wolfia to tall trees of Sequoia
C. In gymnosperms the seeds are not covered
D. In gymnosperms the male and female gametophytes have an independent free living existence
Of the above statements [Kerala PMT 2012]
(a) A and B alone are correct
(b) C alone is correct
(c) B and C alone are correct
(d) C and D alone are correct
(e) D alone is correct

5. Two type of cells hyaline and green or with various shades are characteristic of bryophytes in
(a) *Funaria hygrometrica*
(b) *Polytrichum commune*
(c) *Sphagnum pappiolossum*
(d) *Porella pelatyphylla*

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6. When the sperms of *Funaria* and *Pteris* are put together near the archegonia of *Pteris*, only the sperms of *Pteris* readily enter the archegonia and reach the egg. The reason being that **[CBSE PMT 1994]**
(a) Sperms of *Funaria* are killed when mixed with sperms of *Pteris*
(b) Archegonia of *Pteris* secrete a substance with repels sperms of *Funaria*
(c) Archegonia of *Pteris* secrete a chemical substance which attracts sperms of *Pteris* chemotactically
(d) Sperms of *Funaria* are less motile

7. Match the following with correct combination

	Column – I		Column – II
A.	*Anthoceros*	1.	Walking fern
B.	*Adiantum*	2.	Alga
C.	Sargassum	3.	Inferae
D.	Asterales	4.	Gametophyte
		5.	Hornwort
		6.	Liverwort

[Kerala PMT 2007]
(a) $A-6, B-5, C-1, D-3$ (b) $A-5, B-4, C-3, D-2$
(c) $A-5, B-1, C-2, D-4$ (d) $A-3, B-2, C-1, D-5$
(e) $A-1, B-4, C-3, D-5$

8. Read the following five statements (*A-E*) and answer as asked next to them
(A) In *Equisetum* the female gametophyte is retained on the parent sporophyte
(B) In *Ginkgo* male gametophyte is not independent
(C) The sporophyte in *Riccia* is more developed than that in *Polytrichum*
(D) Sexual reproduction in *Volvox is* isogamous
(E) The spores of slime moulds lack cell walls
How many of the above statements are correct **[CBSE PMT (Mains) 2012]**
(a) Two (b) Three
(c) Four (d) One

9. The ferns in which the entire sporangium develops from a single superficial cell of the sporophyll are known as
(a) Leptosporangiate (b) Eusporangiate
(c) Unisporangiate (d) Mesosporangiate

10. If the haploid number of chromosomes in *Pinus* is 12, the number in its endosperm cells will be **[BHU 1994; CPMT 1999; KCET 1999; MP PMT 2002]**
(a) 12 (b) 24
(c) 36 (d) 6

11. "Monkey's puzzle" is a common name for
(a) *Araucaria embricata* (b) *Cycas revolute*
(c) *Pinus longifolia* (d) *Gnetum genon*

12. The 13–celled male gametophyte of *Selaginella* shows **[CPMT 1999; BHU 2001,03; AIIMS 2001]**
(a) 8 cells of the antheridium + 5 prothallial cells
(b) 9 cells of the antheridium + 4 prothallial cells
(c) 10 cells of the antheridium + 3 prothallial cells
(d) 8 jacket cell + 4 androgonial + 1 prothallial cells

13. Which of the following alga shows heterotrichous habit
(a) *Oedogonium* (b) *Chlamydomonas*
(c) *Ulothrix* (d) *Stigeoclonium*

14. The number of antherozoids produced from an antheridium of *Selaginella* is
(a) 64 (b) 256 and above
(c) 25 to 50 (d) 128 to 256

15. Read the following five statements (A to E) and select the option with all correct statements
(A) Mosses and Lichens are the first organisms to colonise a bare rock.
(B) *Selaginella* is a homosporous pteridophyte.
(C) Coralloid roots in *Cycas* have VAM.
(D) Main plant body in bryophytes is gametophytic, whereas in pteridophytes it is sporophytic.
(E) In Gymnosperms, male and female gametophytes are present within sporangia located on sporophyte. **[AIPMT (Cancelled) 2015]**
(a) (B), (C) and (D) (b) (A), (D) and (E)
(c) (B), (C) and (E) (d) (A), (C) and (D)

16. The male cone of *Pinus* is formed of **[CPMT 2000; KCET 2000]**
Or
In Pinus, male cone bears a large number of **[BHU 2006]**
(a) Anthers (b) Megasporophylls
(c) Ligules (d) Microsporophylls

17. Of the following group which secrete and deposit calcium carbonate and appear like corals **[Kerala CET 2003]**
(a) Red algae (b) Brown algae
(c) Blue green algae (d) All of these

18. The gametophytic generation in pteridophytes is commonly called **[KCET 1999; AIIMS 1999]**
(a) Thallus (b) Plant body
(c) Prothallus (d) Protonema

19. Which one of the following pairs is wrongly matched **[CBSE PMT (Mains) 2012]**
(a) Ginkgo - Archegonia (b) Salvinia - Prothallus
(c) Viroids - RNA (d) Mustard - Synergids

20. A protective cap or hook like covering on the developing capsule in a moss or liverwort is known as **[BHU 2002]**
(a) Spine (b) Calyptra
(c) Lodicule (d) Calyptrogen

21. Number of cotyledons in Zea, *Cycas* and *Pinus* respectively are **[BHU 2000]**
(a) 1,1, many (b) 1,2,1
(c) 1,1,1 (d) 1,2,many

22. Which one of the following is common to multicellular fungi, filamentous algae and protonema of mosses **[CBSE PMT (Pre.) 2012]**
(a) Diplontic life cycle
(b) Members of kingdom plantae
(c) Mode of Nutrition
(d) Multiplication by fragmentation

23. A. Heterospory
B. Seed formation
C. Fertilization process
What is appropriate for gymnosperms **[RPMT 1997]**
(a) *AB* true *C* false (b) *BC* true *A* false
(c) *ABC* all true (d) *ABC* all false

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24. Flagellated male gametes are present in all the three of which one of the following sets **[CBSE PMT 2007]**
(a) *Anthoceros, Funaria* and *Spirogyra*
(b) *Zygnema, Saprolegnia* and *Hydrilla*
(c) *Fucus, Marsilea* and *Calotropis*
(d) *Riccia, Dryopteris* and *Cycas*

25. In *Pinus*, the approximate time for fertilization after pollination is **[Pune CET 1998]**
(a) Only a few hours (b) Only a few days
(c) Only a few weeks (d) About one year

26. Heteromorphic alternation of generations occurs is **[EAMCET 1995]**
(a) *Funaria, Spirogyra, Selaginella*
(b) *Funaria, Selaginella, Cycas*
(c) *Spirogyra, Rhizopus, Selaginella*
(d) *Rhizopus, Funaria, Spirogyra*

27. Make correct pair

A.	Cyanophyceae	a.	Green colour
B.	Chlorophyceae	b.	Blue green colour
C.	Phaeophyceae	c.	Red colour
D.	Rhodophyceae	d.	Brown colour

[RPMT 1997]
(a) *Aa, Bb, Cc, Dd* (b) *Ab, Bc, Cd, Da*
(c) *Ab, Ba, Cd, Dc* (d) *Ad, Bd, Ca, Db*

28. The endosperm of gymnosperm is **[CPMT 1993, 99; CBSE PMT 1999; RPMT 2006; Odisha JEE 2012]**
(a) Triploid (b) Haploid
(c) Diploid (d) Polyploid

29. In which of the following, multiciliated/multiflagelated antherozoids are present **[CPMT 1999; BHU 2003]**
(a) *Riccia* and *Funaria* (b) *Pteris* and *Cycas*
(c) *Riccia* and *Cycas* (d) *Marchantia* and *Riccia*

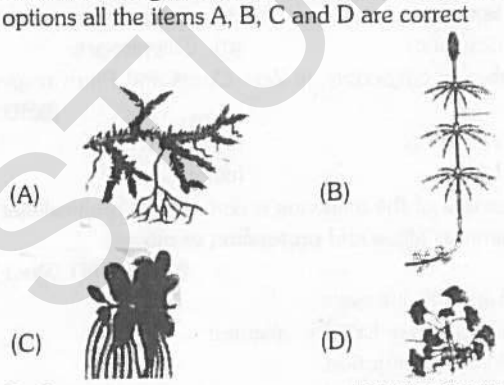
30. When the gametophyte is not formed by spores but by any other part of sporophyte, it is known as **[AIIMS 1998]**
(a) Multispory (b) Polyspory
(c) Apospory (d) Germination

31. A mature ligule, having a prominent basal portion, is called **[AIIMS 1998; CPMT 2000; CBSE PMT 2002]**

Or

The basal portion of ligule of *Selaginella* is hemispherical and is called
(a) Trichocyst (b) Heterocyst
(c) Rhizophore (d) Glossopodium

32. Examine the figures A, B, C and D. In which one of the four options all the items A, B, C and D are correct



Options: **[CBSE PMT(Mains) 2010]**

	A	B	C	D
(a)	*Chara*	*Marchantia*	*Fucus*	*Pinus*
(b)	*Equisetum*	*Ginkgo*	*Selaginella*	*Lycopodium*
(c)	*Selaginella*	*Equisetum*	*Salvinia*	*Ginkgo*
(d)	*Funaria*	*Adiantum*	*Salvinia*	*Riccia*

33. Match the columns

	Column-I		Column-II
A.	Hornwort	1.	Lycopodium
B.	Liverwort	2.	Ricciocarpus
C.	Stonewort	3.	Anthoceros
D.	Club moss	4.	Chara

[AIIMS 2010]

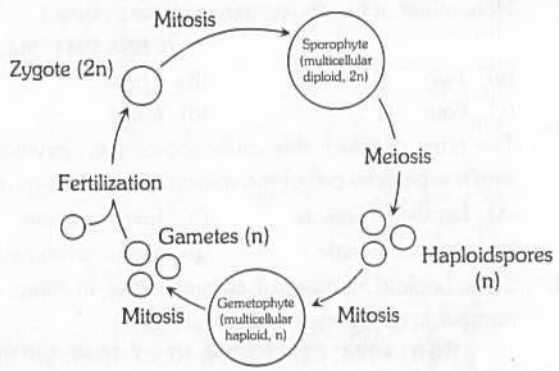
	A	B	C	D
(a)	2	3	4	1
(b)	2	3	1	4
(c)	3	2	1	4
(d)	3	2	4	1

34. Which one of the following is a correct statement **[CBSE PMT (Pre.) 2012]**
(a) Pteridophyte gametophyte has a protonemal and leafy stage
(b) In gymnosperms female gametophyte is free–living
(c) Antheridiophores and archegoniophores are present in pteridophytes
(d) Origin of seed habit can be traced in pteridophytes

35. Read the following statements (A – E) and answer the question which follows them
(A) In liverworts, mosses and ferns gametophytes are free living
(B) Gymnosperms and some ferns are heterosporous
(C) Sexual reproduction in *Fucus, Volvox* and *Allbugo* is oogamous
(D) The sporophyte in liverworts is more elaborate than that in mosses
(E) Both, *Pinus* and *Marchantia* are dioecious
How many of the above statements are correct **[NEET 2013]**
(a) Four (b) One
(c) Two (d) Three

36. What is common in all the three Funaria, Dryopteris and Ginkgo **[NEET (Karnataka) 2013]**
(a) Presence of archegonia (b) Well developed vascular tissues
(c) Independent gametophyte (d) Independent sporophyte

37. The given figure is showing life cycle of a plant if this belongs to life cycle of bryophytes, pteridophytes and gymnosperms, what will be respective A and B in their life cycle **[NCERT]**



	A	B
(a)	Bryophytes : Pteridophytes : Gymnosperms :	Strobili, capsule cones, sporangia flowers, cones
(b)	Bryophytes : Pteridophytes : Gymnosperms :	Protonema, gametophores strobili, sporangia flowers, cones
(c)	Bryophytes : Pteridophytes : Gymnosperms :	Capsule, protonema (gametophores) sporangia, cones, sporophyll fertile fronds, megasporangia and microsporangia
(d)	Bryophytes : Pteridophytes : Gymnosperms :	Sporangium, capsule strobili, sporangia flowers, cones

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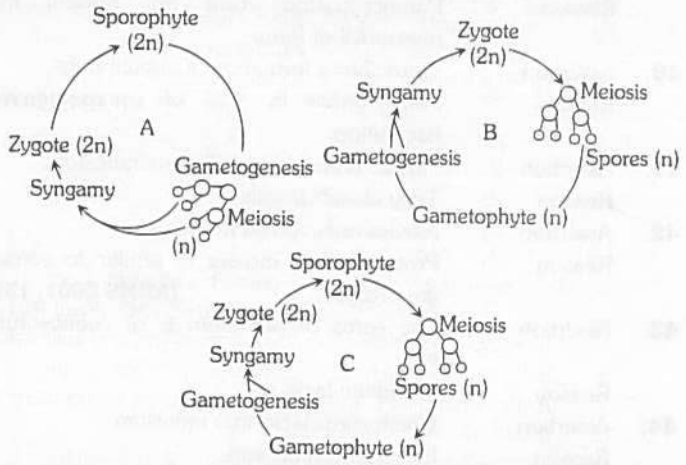
38. Which of the following options are correctly represents the type of life cycle patterns given below **[NCERT]**



(a) A – Diplontic, B – Haplontic, C – Haplodiplontic
(b) A – Haplontic, B – Diplontic, C - Haplodiplontic
(c) A – Haplodiplontic, B – Haplontic, C – Diplontic
(d) A – Diplontic, B – Haplodiplontic, C – Haplontic

39. Select the **correct** statement **[NEET (Phase-I) 2016]**
(a) Gymnosperms are both homosporous and heterosporous
(b) *Salvinia, Ginkgo* and *Pinus* all are gymnosperms
(c) *Sequoia* is one of the tallest trees
(d) The leaves of gymnosperms are not well adapted to extremes of climate

40. In bryophytes and pteridophytes, transport of male gametes requires **[NEET (Phase-I) 2016]**
(a) Wind (b) Insects
(c) Birds (d) Water

41. Select the mismatch **[NEET 2017]**
(a) *Pinus* – Dioecious
(b) *Cycas* – Dioecuous
(c) *Salvinia* – Heterosporous
(d) *Equisetum* – Homosporous

42. Life cycle of *Ectocarpus* and *Fucus* respectively are **[NEET 2017]**
(a) Haplontic, Diplontic (b) Diplontic, Haplodiplontic
(c) Haplodiplontic, Diplontic (d) Haplodiplontic, Haplontic

Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Biennial plants flower in two year.
Reason : The biennial plants live for two years.

2. Assertion : Bryophytes and tracheophytes have an embryo stage in their life cycle.
Reason : Embryophyta are terrestrial plants.

3. Assertion : Stamens are comparable to microsporophylls.
Reason : Ovules are comparable to megasporophylls.

4. Assertion : Algae and fungi are grouped in thallophyta.
Reason : Algae and fungi show no differentiation in thallus.

5. Assertion : Each group of algae has a characteristic colour.
Reason : Each group of algae show predominance of one pigment.

6. Assertion : Only red algae are able to flourish at the great depth of sea.
Reason : Red algae has the pigments *r*-phycoerythrin and *r*-phycocyanin.

7. Assertion : Spermatangium of red algae bears trichogyne.
Reason : Trichogyne helps in reproduction.

8. Assertion : *Spirogyra* is slippery in touch.
Reason : *Spirogyra* consists a gelatinous sheath.

9. Assertion : Isogamy is a primitive type of sexual reproduction.
Reason : The gametes are of different sizes.

10. Assertion : Angiosperms lack flagellate male gametes.
Reason : Sperms are not dependent on water for fertilization.

11. Assertion : Fertilized ovule forms seed.
Reason : Ripened ovary forms fruit.

12. Assertion : Pyrenoids are utilised during starvation.
Reason : Pyrenoids are proteinaceous bodies.

13. Assertion : In green algae, the eye-spot is present in the cell.
Reason : Eye-spot is meant for respiration.

14. Assertion : *Chlorella* could be utilised to keep the air pure in space vehicles.
Reason : The space travelers feed on *Chlorella* soup.

15. Assertion : Flower is aggregation of sporophylls.
Reason : Sporophylls are modified in angiosperms.

16. Assertion : *Chlorella* could serve as a potential source of food and energy.
Reason : When dried, chlorella has 15% protein, 45% fat, 10% carbohydrate, 20% fibre, and 10% minerals and vitamins. **[AIIMS 2009]**

17. Assertion : *Spirogyra* shows haplontic life cycle.
Reason : Zygotic meiosis occurs in *Spirogyra*.

18. Assertion : Red algae contribute in producing coral reef.
Reason : Some red algae secrete and deposit calcium carbonate our their walls. **[AIIMS 2004]**

19. Assertion : The sex organs in the bryophytes are jacketed.
Reason : Bryophytes are land plants.

20. Assertion : All bryophytes are land dwellers.
Reason : Water is necessary to complete their life-cycle.

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21. Assertion : The bryophytes exist in two phases – gametophyte and sporophyte.
Reason : The sporophyte is nutritionally independent.

22. Assertion : Unlike thallophytes, bryophytes show formation of embryo.
Reason : The embryo gives rise to gametophyte plant of bryophytes.

23. Assertion : Bryophytes possess archegonium as a female sex organ.
Reason : Algae also possess the archegonium.

24. Assertion : The embryo of bryophyte is independent.
Reason : The zygote of thallophyte is dependent.

25. Assertion : Liverworts fail to spread to a new locality through fragmentation.
Reason : Gemmae are helpful in propagating liverworts in different locality.

26. Assertion : *Pinus* displays the alternation of generations.
Reason : The gametophyte is dependent upon the sporophyte phase.

27. Assertion : *Pinus* embryo has two cotyledons.
Reason : *Pinus* shows polyembryony.

28. Assertion : The female cones take much time to mature.
Reason : The seeds are shed when the cone is 22 months old.

29. Assertion : The female cones are same in number as male cones.
Reason : Male and female cones appears alternately on the same branch of the *Pinus*.

30. Assertion : Sperms of *Riccia* are biflagellate.
Reason : Sperms show swimming nature.

31. Assertion : The sporogonium of *Riccia* is the simplest among the liverworts.
Reason : Sporophyte consists of capsule only.

32. Assertion : The young stem of *Funaria* is photosynthetic.
Reason : It contain hydroids.

33. Assertion : *Pinus* is monoecious.
Reason : Each sporophyll bears only one microsporangia.

34. Assertion : *Funaria* multiplied vegetatively by means of bulbils.
Reason : Bulbils and tubers are two different structures.

35. Assertion : Gemmae formation in *Funaria* occurs in favourable condition.
Reason : The gemmae form on the stem and leaves.

36. Assertion : *Funaria* is monoecious.
Reason : Cross fertilization occurs in *Funaria*.

37. Assertion : Antheridia of *Funaria* are sunk in pit.
Reason : Its antheridial cluster is surrounded by perigonial leaves.

38. Assertion : The peristome is a fringe of teeth-like projections found at the mouth of the capsule.
Reason : It may be of two types nematodontous and orthodontus.

39. Assertion : The mesophyll of *Pinus* shows no distinction as mesophyll and palisade.
Reason : Parenchymatous cells are present in mesophyll of *Pinus*.

40. Assertion : *Pinus* shows formation of annual rings.
Reason : *Pinus* grows in area of environmental fluctuation.

41. Assertion : Mosses are used as pollution indicators.
Reason : They absorb metals.

42. Assertion : Mosses are evolved from algae.
Reason : Protonema of mosses is similar to some green algae. **[AIIMS 2001, 13]**

43. Assertion : The sorus of *pteridium* is of coenosorus type.
Reason : *Pteridium* lacks sori.

44. Assertion : Coenosorus lacks true indusium.
Reason : Indusium covers sori.

45. Assertion : Ramenta are scales which cover young rhizome and leaves of *Dryopteris*.
Reason : *Pteridium* lacks rementa.

46. Assertion : The scale leaves on the long shoots are called cataphylls.
Reason : Cataphylls lack mid rib.

47. Assertion : Both bryophytes and pteridophytes contain well-developed antheridia.
Reason : Biflagellate sperms are formed by their antheridia.

48. Assertion : Water is not required for fertilization process in ferns.
Reason : Malic acid of archegonial neck attracts antherozoids.

49. Assertion : Sporophytes of pteridophyta are dominant individual.
Reason : They do not show the formation of true root.

50. Assertion : In gymnosperms, plants show well-developed vessels and fibres.
Reason : Companion cells are absent in gymnosperm.

51. Assertion : In leptosporangiate development, sporangia are formed from a group of initials.
Reason : Eusporangiate development of sporangia starts from single initial.

52. Assertion : *Adiantum caudatum* is called walking fern.
Reason : It can reproduce by its leaf tips.

53. Assertion : Gymnosperms seeds are naked.
Reason : They lack ovary wall.

54. Assertion : *Pinus* has a pyramidal appearance.
Reason : The older parts of long shoot have scars of fallen dwarf shoots.

55. Assertion : The female cone of *Cycas* is not true cone.
Reason : Its formation checks the growth of the stem.

56. Assertion : All living species of *Cycas* are dioecious.
Reason : *Cycas* contains male and female cones on the same plant.

57. Assertion : The male of *Cycas* change in size when the microspores became mature.
Reason : The microspores are dispersed by wind.

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Answers

Algae (General)

1	a	2	a	3	a	4	a	5	c
6	d	7	d	8	b	9	e	10	b
11	a	12	b	13	c	14	a	15	a
16	c	17	c	18	a	19	a	20	a
21	b	22	b	23	d	24	d	25	c
26	d	27	e	28	c	29	c	30	d
31	a	32	b	33	c	34	a	35	d
36	c	37	d	38	b	39	a	40	c
41	b	42	b	43	a	44	c	45	d
46	a	47	a	48	d	49	a	50	e
51	a	52	d	53	d	54	a	55	c
56	d	57	d	58	d	59	d	60	d
61	a	62	a	63	d	64	c	65	b
66	b	67	d	68	b	69	c	70	a
71	a	72	d	73	d	74	b	75	d
76	a	77	b	78	c	79	b		

Spirogyra and Ulothrix

1	b	2	c	3	b	4	a	5	d
6	d	7	b	8	s	9	a	10	a
11	b	12	d	13	a	14	b	15	d
16	c	17	d	18	a	19	a	20	b
21	b	22	b	23	a	24	a	25	c
26	b	27	c	28	a	29	c	30	a
31	b	32	b	33	c	34	a	35	a
36	b	37	a	38	a	39	d	40	a
41	d	42	c	43	d				

Bryophytes (General)

1	d	2	d	3	c	4	b	5	d
6	c	7	b	8	c	9	a	10	a
11	d	12	d	13	c	14	b	15	b
16	c	17	d	18	c	19	a	20	d
21	b	22	a	23	a	24	c	25	b
26	d	27	d	28	c	29	d	30	c
31	b	32	a	33	c	34	d	35	c
36	d	37	a	38	a	39	b	40	c
41	c	42	d	43	a	44	a	45	a
46	a	47	c						

Funaria and Riccia

1	c	2	a	3	c	4	c	5	b
6	d	7	a	8	b	9	c	10	b
11	b	12	c	13	c	14	a	15	c
16	d	17	b	18	d	19	a	20	b
21	d	22	b	23	c	24	b	25	c
26	b	27	a	28	d	29	c	30	c
31	d	32	a	33	c	34	d	35	c
36	a	37	d	38	b	39	b	40	c
41	b	42	b	43	c	44	d	45	b
46	a								

Pteridophytes (General)

1	b	2	c	3	a	4	d	5	d
6	b	7	c	8	b	9	a	10	c
11	a	12	d	13	b	14	a	15	b
16	a	17	c	18	b	19	c	20	a
21	d	22	b	23	a	24	a	25	a
26	c	27	a	28	b				

Pteridium, Pteris, Dryopteris

1	d	2	d	3	c	4	a	5	d
6	a	7	c	8	b	9	b	10	c
11	a	12	b	13	a	14	c	15	c
16	a	17	d	18	b	19	b	20	c
21	c	22	a	23	d	24	a	25	a
26	d	27	c	28	c	29	d	30	b
31	c	32	d	33	b	34	b	35	d
36	a	37	a	38	b	39	c	40	d
41	d	42	a	43	d	44	b	45	a
46	a								

Selaginella

1	b	2	a	3	c	4	c	5	a
6	c	7	b	8	b	9	d	10	d
11	b	12	a	13	c	14	b	15	a
16	a	17	c	18	b	19	c	20	a
21	b	22	b	23	a	24	d		

Gymnosperms (General)

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

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11	d	12	d	13	b	14	e	15	a
16	c	17	a	18	d	19	d	20	d
21	b	22	a	23	d	24	c	25	d
26	d	27	c	28	c	29	b		

Pinus

1	c	2	b	3	c	4	d	5	d
6	a	7	c	8	c	9	d	10	c
11	b	12	a	13	b	14	d	15	b
16	c	17	a	18	b	19	d	20	b
21	b	22	c	23	a	24	a	25	d
26	d	27	b	28	c	29	b	30	a
31	b	32	a	33	a	34	c	35	a
36	b	37	a	38	b	39	d	40	c
41	c								

Cycas

1	c	2	a	3	c	4	a	5	d
6	a	7	a	8	a	9	b	10	c
11	c	12	d	13	b	14	d	15	c
16	d	17	b	18	d	19	b	20	a
21	a	22	a	23	d	24	c	25	b
26	d	27	d	28	d	29	a	30	b
31	a	32	c	33	a	34	d	35	d
36	b	37	d	38	b	39	c	40	b
41	c	42	d	43	c				

Angiosperms

1	a	2	d	3	a	4	b	5	c
6	d	7	a	8	b	9	d	10	b
11	d	12	b	13	b	14	a	15	a
16	d								

NCERT Exemplar Questions

1	c	2	c	3	d	4	c	5	d
6	c	7	a	8	d				

Critical Thinking Questions

1	b	2	d	3	b	4	b	5	c
6	c	7	c	8	d	9	a	10	a
11	a	12	d	13	d	14	d	15	b
16	d	17	a	18	c	19	b	20	b
21	d	22	d	23	c	24	d	25	d
26	b	27	c	28	b	29	b	30	c
31	d	32	c	33	d	34	d	35	d
36	a	37	c	38	a	39	c	40	d
41	a	42	c						

Assertion and Reason

1	b	2	b	3	b	4	a	5	a
6	a	7	e	8	a	9	c	10	a
11	b	12	b	13	c	14	b	15	b
16	c	17	a	18	a	19	a	20	e
21	c	22	c	23	c	24	d	25	b
26	b	27	e	28	b	29	d	30	a
31	a	32	b	33	c	34	c	35	e
36	b	37	e	38	b	39	b	40	a
41	a	42	a	43	c	44	b	45	b
46	d	47	d	48	e	49	c	50	e
51	d	52	a	53	a	54	b	55	c
56	c	57	b						

Answers and Solutions

Algae (General)

1. (a) M.O.P Iyenger of Madras is regarded as the father of Indian phycology. He discovered *Fritschiella*, a heterotrichous terrestrial alga.

2. (a) The study of algae is called algalogy or phycology (Gr. *phykos* = algae) and its expert as phycologist / algalogist.

3. (a) F.E. Fritsch (1935) divided algae into following eleven classes in his book "Structure and Reproduction of the Algae", mainly on the basis of pigmentation, reserve food and flagellation, thallus structure, modes of reproduction and life cycles and he is known as father of algae.

7. (d) Agar-agar is a jelly like substance. It is a non-nitrogenous carbohydrate consisting of two polysaccharides namely agarose and agaropectin. It is obtained from several red algae. *e.g.*, *Gracillaria*, *Gelidium*, *Gigartinia*. It was discovered by Lady Hesse and used by Robert Koch to solidify culture medium.

15. (a) Different type of colour in Algae are due to different pigmentations and it provides a strong base to classify the Algae.

17. (c) *Cephaleuros virescens* is a member of class chlorophyceae and cause disease red rust of tea leaf (*Thea sinensis*).

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22. (b) *Spirulina viridisma* : It is a convoluted cyanophycian alga, which has 60% protein contents.

24. (d) All are eukaryotes except Anabaena. The later is prokaryotes where true nucleus is absent.

28. (c) Many algae important constituent of human food in future because the algae can grow easily and obtained protein, lipid carbohydrates and vitamins. *e.g.*, *Chlorella, Ulva*.

32. (b) Pyrenoids are the rounded bodies found in the chloroplast of green algae and are the centres of conversion of glucose to starch and also collection of starch.

33. (c) Because algae and fungi are the members of thallophyta.

34. (a) *Chlorella vulgaris* : This is the source of protein. This is rounded unicellular algae related to class chlorophyceae.

36. (c) Hypnospores are thick walled non-motile spores formed to tide over unfavourable condition. They germinate on the arrival of favourable condition ns. *e.g.*, *Chlamydomonas, Ulothrix*.

38. (b) In dry conditions, zoospores get surrounded by mucilaginous sheath. This is known as Palmella stage. Under favourable conditions each zoospore gives rise to a new plant *e.g.*, *Chlamydomonas*.

41. (b) In Rhodophyceae reserve food products are polysaccharides *i.e.*, Floridean starch (which stains red with iodine solution) and also soluble sugar called floridoside.

43. (a) The larger (giant) parenchymatous forms of brown algae called kelps or sea weed or trees of seas or forest of sea. Sea weed may be marine.

44. (c) *Chlorella* could be used to provide O_2 during space flight trips. The alga can reuse CO_2 during the process of photosynthesis and release O_2 for the use by *Astronauts*.

45. (d) Alginic acid is a non sulphated phycocolloid extracted from middle lamella/cell walls of *Laminaria, Lessonia, Fucus* etc.

46. (a) Algae differ from bryophyta because in algae sex organs are usually non-jacketed and in bryophyta sex organs are jacketed with sterile jacket.

47. (a) Parasitic algae like *Cephaleuros virescens* (green alga) causes red rust of tea leaves and *C.coffea* attacks coffee leaves. It is red due to haematochrome.

51. (a) *Laminaria* kelp is the source of iodine.

52. (d) Carragenin is obtained from chondrus. It is member of Rhodophyceae.

54. (a) Stomata are originated with the origin of bryophytes (Amphibian group). Algae are primitive than bryophytes.

55. (c) Chlorophyll a and b pigments are found in chlorophyceae.

57. (d) Fusion of gametes results in the formation of zygote, which by secreting a thick wall acts as perennating spore (zygospore) and helps in perennation, dispersal and multiplication.

59. (d) These are pteridophytes.

61. (a) In algae reserve food material is mainly starch.

64. (c) A large amount of iodine is extracted from kelps (brown sea weeds) like *Laminaria, Ecklonia* etc.).

65. (b) *Volvox* hollow ball like colony with a fixed number of cells is called coenobium.

67. (d) Oogamy is most advanced type of reproduction in which male gamete is motile smaller and non food storing called antherozoid while female gamete is food storing, nonmotile larger called oogonium.

69. (c) Grana is absent in green algae.

76. (a) Nucule/oogonium/upper sex organ
Globule/antheridium/lower sex organ.

77. (b) *Anabaena* – Non flagellated male gamete
Spirogyra – Aplanogamy
Polysiphonia – Non motile spermatia
Ectocarpus – Pear shaped motile male gametes

78. (c) Algin is obtained from brown algae and carrageenin from red algae

Spirogyra and Ulothrix

2. (c) *Spirogyra* increases its body length because every cell of the filament is capable of growth division and self maintainance (every cell has nucleus).

3. (b) Sexual reproduction in *Spirogyra* involves the fusion of two morphologically identical but physiologically dissimilar nonciliated gametes.

4. (a) *Spirogyra* is a free floating, filamentous, green, freshwater alga which is popularly called pond silk, hair of princess because its filaments are slimy to touch and shine in water.

5. (d) Zygospore under goes meiosis to form a new filament.

6. (d) Because single zygospore produce four spores but three are diminished and remaining one develop into a new plant.

7. (b) *Spirogyra* gives silky feeling on touching.

10. (a) Zygospore undergoes zygotic meiosis and forms 4 haploid nuclei of these three degenerate. So one haploid nuclei take part and one new filament is formed.

11. (b) In scalariform conjugation, two filament come to lie parallel and appressed. Their opposite cells develop conjugation tube. The conjugation tube between the two filaments look like a ladder.

14. (b) Sexual reproduction of *Spirogyra* is physiological anisogamous.

15. (d) Sexual reproduction in *Spirogyra* can be described as fusion of two morphologically identical, but physiologically dissimilar gametes.

16. (c) Rarely three filaments may take part in scalariform conjugation. Here the central filament shows relative sexuality and behave as male to one and female to other so that zygospore are formed in either central or lateral filaments.

18. (a) On failure in fusion of two gametes, both the gametes develop into azygospores. Under unfavorable condition, the filament of *S.varians* placed in sugar solution develop parthenospore or azygospore.

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19. (a) Each cell of *Spirogyra* is surrounded by two layered cell wall. Its inner layer is made up of cellulose and outer layer is made up of pectose but quantity of cellulosic substances is high in comparison to pectose.

21. (b) The filament showing lateral conjugation are homothallic because both male and female gametes are found in same filament.

23. (a) Filamentous alga with flagellated reproductive stage represented by gametes.

24. (a) Each cell contains a single chloroplast in *Ulothrix*.

25. (c) *Ulothrix* is green algae.

27. (c) *Ulothrix* is unbranched filament, consisting of numerous cylindrical cells joined end to end.

28. (a) Mucor have multinucleate gametangia.

29. (c) Favourable conditions each zygote germinates to produce 4–16 meiospores (zoospores or aplanospores). The first division of diploid zygotic nucleus is meiosis. The meio-zoospores or meioaplanospores germinate to produce new filaments.

31. (b) *Spirogyra* shows isogamy with non-flagellated gametes.

32. (b) Chloroplast contains few pyrenoids (1–3) for starch storage.

33. (c) Iyenger (1958) reported direct lateral conjugation in *Spirogyra jogensis*.

34. (a) *Ulothrix* is unbranched filament and attached to stone and submerged bodies (fixed floating).

35. (a) A spore of *Spirogyra* sp. after resting period (zygospore) is haploid because meiosis occurs in zygospore.

36. (b) Plant body of *Spirogyra* is haploid but after gametic fusion, diploid zygospore is formed, thus zygotic meiosis takes place.

38. (a) Life cycle in *Spirogyra* is haplontic as dominant phase in life cycle is haploid (n) and diploid phase is represented by only zygospore and it undergoes meiosis.

39. (d) Chloroplast in *Ulothrix* is girdle or ring shaped (*U.zonata*) or collar shaped.

40. (a) *Ulothrix* produces isogametes *i.e.*, gametes are biflagellate and similar (size, shape) but different in nature.

41. (d) Basal cell is nongreen but has nucleus and cytoplasm. Its presence show beginning of division of labour.

43. (d) The gametes are motile and biflagellate.

Bryophytes (General)

2. (d) Newzealand genera of moss *Dawsonia* which measures 60 *cms* in height.

5. (d) Venter is present in archegonia just above the egg.

7. (b) The vascular tissue (*i.e.*, xylem and phloem) are completely absent water and nutrients enter the cell by diffusion. Sporangium produces spores by meiosis. The zygote develops to form an embryo which produces the sporophyte.

8. (c) They are called pollution indicators. They prevent soil erosion by running water.

9. (a) Species of *sphagnum*, a moss provides peat that have long been used as fuel.

11. (d) Because club moss is pteridophyte while Reindeer moss and Irish moss are lichens.

12. (d) In Bryophytes vascular tissue (*i.e.*, xylem and phloem) are completely absent. Water and nutrients enter in cell by diffusion when in pteridophytes vascular tissue consists of xylem (without true vessels) and phloem (without companion cells).

14. (b) The sporogonium of *Marchantia* is differentiated into foot, seta and capsule. Capsule contains elaters ($2n$). Elaters are diploid, spindle shaped hygroscopic elongated structures with 2 spiral bands.

15. (b) The main plant of Bryophyte is gametophyte.

16. (c) Bryophyta are the most simple and primitive group of embryophyta. It includes app. 840 genera and 23,500 species.

17. (d) *Sphagnum* is used as fuel. *Sphagnum* has the capacity to retain water for long periods and as such is used to cover the plant roots during transportation. It is also used in seed beds because of its high water retention capacity.

18. (c) The female sex organ is archegonia. It is flask shaped structure distinguishable into a long neck and a globular swollen venter.

19. (a) Gametophytes are reduced and few celled in all vascular plants.

21. (b) Stalk bearing archegonial cluster at tip in *Marchantia* thallus.

22. (a) In bryophytes, water is essential for fertilization because antherozoids are flagellated or cilliary structure which represent the aquatic origin of bryophytes.

23. (a) Saprophytic bryophytes are *Buxbaumia aphylla*. Which are nongreen growing on rotten wood.

24. (c) In bryophytes, gametophyte is dominant phase and sporophyte is developed on this phase which is partially depends for food on gametophyte.

25. (b) Bryophyta grow in moist and shady places. More humid conditions are found in Western Himalayas.

26. (d) In Bryophytes, sporophyte is never independent but it is parasitic over gametophytic plant either partially for water and mineral supply or wholly for organic food.

27. (d) Male sex organ is globular called antheridium and female sex organ is called archegonium which is flask shaped. These are look like green in colour because they contain chloroplast. True roots, stem and leaves absent in Bryophytes.

30. (c) The main plant of bryophyta is gametophyte. Gametophytic stage is independent.

31. (b) Term Bryophyta was coined by Robert Braun in 1864 but he included algae, fungi, lichens and mosses under it.

33. (c) Female sex organ is called archegonium which is flask shaped with a tubular neck and a swollen venter.

34. (d) Thallus of *Anthoceros* shows symbiotic association with a nitrogen fixing blue green alga. *i.e.*, *Nostoc*.

35. (c) Below neck canal cells, there is a venter canal cell and an egg cell (oosphere) in the venter. Egg cell behaves as nonmotile female gamete.

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37. (a) The number of chromosomes of the second generation will be same because no reduction division take place.

40. (c) The chloroplast of *Anthoceros* contains a unique feature 'pyrenoid' made up of 25–30 discoid or spindle shaped bodies.

43. (a) The archegonial venter forms a protective covering around the embryo called calyptra.

Funaria and Riccia

1. (c) Stomata are primitive because guard cells are not found. Only stomatal pores are found.

3. (c) Protonema : It is green, septate, filamentous algae like which is borne after the germination of moss haploid spores.

4. (c) The sporophytic is parasitic over gametophyte. Thus there is heteromorphic or heterologous alternation of generations in *Riccia*. So life cycle in *Riccia* is diplohaplontic.

5. (b) Funaria is attached to substratum by rhizoids are branched, multicellular, arise from base of axis and have oblique septa to increase.

7. (a) When the capsule approaches maturity the sporogenous cells cease to divide, separate from one another and they are known as spore mother cells. Each spore mother cell undergoes two successive divisions, first of which is meiotic and forms four spores with haploid number of the chromosomes.

8. (b) Protonema is formed after germination of moss capsule spores.

9. (c) Life cycle of *Funaria* is not completed without water because antherozoids swim across the film of water and antherozoid fuse with the single egg to produce zygote (*2n*).

10. (b) Autotrophic nutrition is a common feature to gametophytes and sporophytes of mosses and fern because chlorophyll containing cells found in both which are assimilatory in function.

11. (b) Capsule wall is a diploid part of sporophyte, if protonema is develops from its cells, it must be diploid.

13. (c) Foot, seta and central sterile portion of theca is called columella found in Funaria. Elaters are absent in *Funaria, Sphagnum, Polytrichum, Riccia*, etc. They are the characteristic features of *Marchantia, Pellia, Porella*, etc.

14. (a) Dispersal of spores take place due to hygroscopic nature of peristomial teeth.

15. (c) Annulus assists in dehiscence of capsule.

16. (d) The neck is several cells high and is made up of six vertical rows of cells. It contains six or more elongated uninucleate neck canal cells.

17. (b) Monoecious means both male and female sex organs are borne on the same plant body and autoecious means green photosynthetic.

19. (a) In *Funaria* fully developed sporophyte (sporangium) is made of three regions, *i.e.*, Basal foot, seta and capsule.

20. (b) The axis has a central conducting strand of slightly thick walled parenchymatous elongated dead cells called hadrom.

22. (b) Leafy gametophyte develop from buds produced on protonema and is made up of axis with spirally arranged leaves, leafy gametophyte bears male and female sex organs.

23. (c) Apophysis is basal sterile portion of capsule in continuation with seta. In capsule of *Funaria* stomata present only in apophysis.

24. (b) Peristome teeth : Total 32 in two rows 16+16, outer 16 are thick bigger in size while inner 16 are smaller and thin. Teeth help in dispersal of spore filled in sporangium of capsule of *Funaria*.

25. (c) In funaria sex organs develop at tip stem antheridia develop on male branch and archegonia on female branch.

26. (b) The antherozoids in *Funaria* are anteriorly biflagellated coiled structures.

28. (d) On the lower portion of leafy gametophore, there are present branched, multicellular rhizoids with oblique septa.

29. (c) In *Funaria* central sterile portion of theca is called columella.

30. (c) Female sex organs (archegonia) are borne at the tip of female branch which is larger than male shoot.

31. (d) In capsule of *funaria* stomata are present only in apophysis.

32. (a) An archegonium of *Riccia* has neck encloses 4–6 neck canal cells. Venter wall is single layered and encloses one venter canal cell and one egg cell (oosphere).

35. (c) The lower surface of *Riccia* bears two type of unicellular rhizoids, smooth walled and tuberculate and help in fixation.

36. (a) Gametophyte stage of *funaria* is haploid because the main plant body is gametophyte.

38. (b) Sex organs are multicellular, jacketed and embedded in thallus on dorsal side.

40. (c) In *Riccia* antherozoids may enter into the archegonium and fuse with single egg to form zygote (*2n*), which is ending of gametophyte phase.

41. (b) Spore is the first cell of gametophytic generation In *Funaria* the spore germinates to form protonema.

43. (c) The main plant body of *Riccia* is gametophytic (*n*), which is thallose, *i.e.*, having no true roots, stem and leaves.

44. (d) Meiosis takes place in spore mother cells which results four haploid spores are formed.

45. (b) The peristome is distinguishable into two whorls of radially arranged peristomial teeth.

46. (a) Protonema is the branched filamentous portion which is produced by germination of spores.

Pteridophytes (General)

1. (b) Pteriodophytes are also known as 'Vascular cryptogams'. The term 'Cryptogams' is made of 2 Greek word, *i.e.*, Kryptose, hidden + gamous, wedded, *i.e.*, these are the plants which reproduce by means of spores and do not produce seeds.

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2. (c) Birbal sahani was a famous Indian palaeobotanist. He established famous Birbal Sahani institute of paleobotany in Lucknow (UP) and described *Williamsonia sewardiana*.

5. (d) Due to protandrus (maturation of antheridia before Archegonia) condition archegonia of same thallus do not accept the antherozoids of same thallus. Therefore self fertilization is not possible in Pteridophytes or vascular cryptogames.

8. (b) The club mosses (division Lycophyta) are now limited to representatives a few centimeters in height. Their leaves are small and scale like, resembling the leaf like structures of mosses, club mosses of the genus *Lycopodium*, commonly known as ground pine, form a beautiful ground cover in some temperate coniferous and deciduous forests.

9. (a) Gametophyte of fern is exosporic, flat, green, autotrophic, cordate (Heart shaped), multicellular, short lived, small reduced, dorsiventral, free living independent, nonvascular gametophyte called prothallus.

10. (c) Require water for fertilization as their sperms are motile.

12. (d) *Botanical snake* : The leaves of "*Ophioglossum*" pteridophyte is like hood of black snake cobra.

13. (b) Heterosporous pteridophytes (*e.g., Isoetes, Selaginella, Marsilea* etc.) produce unisexual (dioecious) gametophytes. The development of gametophyte is endosporic (grow within spore wall).

17. (c) Pteriodphytes are first vascular land (tracheophytes) to have independent, sporophyte diploid plant body with true root, stem and leaves.

18. (b) Sorus (sori = pleural) : It is a group of sporangia attached on placenta in ferns.

19. (c) In xylem, vessels are absent and in phloem, companion cells are absent. *Selaginella* and *Equisetum* are exception where vessels are present.

23. (a) Apospory was first observed by Druery (1884) in *Athyrium filix-femina*. Apospory is the formation of complete embryo sac from the sporophytic cell without meiosis so that the gametophyte remains diploid.

24. (a) Seed habit are fulfilled by few pteridophytes like *Selaginella rupestris, S.monospora, Marsilea* and *Isoetes*.

25. (a) *Ginkgo* is a Gymnosperm.

26. (c) They along with cycadofilicales are chief coal formers. The age of great coal forming forest belong to this period (carboniferous period). India coal belongs to permian period.

27. (a) Apogamous cells are part of gametophyte, thus they are haploid.

28. (b) The central pith is surrounded by xylem, phloem, pericycle and endodermis. The phloem occurs only out side the xylem *e.g., Osmunda*.

Pteridium, Pteris, Dryopteris

1. (d) In *Pteridium*, male and female sex organs are develop on one gametophyte.

2. (d) Ferns exhibits diplohaplontic life cycle and heteromorphic alternation of ganerations. The sporophytic and gametophytic phase are morphologically, functionally and cytologically distinct and occur in alternate manner due to meiosis and fertilization.

3. (c) Antheridium producing about 32 antherozoids. Each antherozoid is large uninucleate coiled and multiflagellate.

4. (a) Eusporangiate type of sporangium develops from a group of superficial initials. They divide periclinally in to outer and inner.

6. (a) A dictyostele consisting of two or more concentric rings of meristeles. *e.g., Pteridium aquilinum*.

7. (c) In *Dryopteris*, true indusium is present because this arises from placenta (placental tissue) from which sporangia arise.

8. (b) Sori are linear and submarginal in *pteris* and *pteridium* and median abaxial (lower) in *Dryopteris*.

9. (b) Inside the sporangium, there are 16 spore mother cells which on meiosis (reduction division) produce 64 spores.

10. (c) In ferns, sopres germinate to form a prothallus.

11. (a) They develop a thickening along their radial and inner tangential walls. This layer is called annulus.

13. (a) Neck is made up of 4 vertical rows of cells. Slightly curved and encloses on neck canal cell which is binucleated.

14. (c) Younger parts of leaves and rhizome are surrounded by brown hairy structures called scales (ramenta).

15. (c) In *Dryopteris* true inducium (A specially developed structure) is present.

21. (c) Dominant stage of fern is sporophyte which is always a diploid structure.

23. (d) Gametophyte is free living, photoautotrophic thalloid, also called prothallus. Prothallus bears rhizoids, antheridia and archegonia on its under surface.

24. (a) Young leaves show circinate ptyxis (venation) (water spring like coiling with the apex in the centre of the coil) to protect tip of frond.

25. (a) Fern prothallus bears male and female sex organs both.

26. (d) On sporophylls either on dorsal or on ventral side bear sporangium *e.g.*, Pteris, Dryopteris etc. Leaves are megaphylls showy feather like and called fronds.

28. (c) Foot is formed first, which absorbs water, minerals from prothallus.

29. (d) Ferns are generally the first colonizers of burnt down forest area. This is due to persistence of their underground rhizomes while the above ground parts get burnt up.

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30. (b) Antheridial Jacket is single layered and 3-celled.

31. (c) The number of spores per sporangium are fixed in every species and 64 is the maximum number of spores in sporangium.

35. (d) Ramenta : It is hairy structure which cover juvenile leaves in ferns.

36. (a) No pollen tube to carry sperms.

37. (a) Dictyostele : A siphonostele perforated by several overlapping leaf gaps. Each separate strand is called meristele. *e.g.*, *Dryopteris*, *Pteridium*, *Pteris* etc.

38. (b) Spores of ferns are always haploid so they represent gametophytic stage.

40. (d) Apogamy : Origin of haploid plant (rare) in pteridophytes *e.g.*, from prothallus cells.

42. (a) The plants of pteridophytes are sporophytes. They reproduce asexually by forming spores in sporangia.

43. (d) Prothallus is haploid.

44. (b) Annulus controls and assists in spore dispersal by losing water. Annulus also helps in the ejection of spores with force like a sling.

45. (a) Sporangia develop in groups called sori. Sori develop on the under surface of leaves and leaflets, laterally or marginally.

46. (a) Each sporangium has a multicellular stalk and a biconvex capsule.

Selaginella

1. (b) *Selaginella* show many of the several adoptions required to produce a seed. They are collectively called seed habit of *Selaginella*.

(1) Presence of heterospory.

(2) Retention of megaspores inside megasporangium in *S. apus* and *S. rupestris*.

(3) Formation of two types of gametophytes etc.

2. (a) The four megaspores derived from a megaspore mother cell may not always be functional. *e.g.*, In. *S. rupestris* single megaspore is functional.

3. (c) The endodermis is interrupted by large intercellular spaces. This is called the trabeculated endodermis (modified endodermal cell). This layer, due to presence of casparian strips is regarded as endodermis.

4. (c) Stele has polystelic structure with xylem in the center, phloem on the outside and pericycle covering the latter in Selaginella.

5. (a) Ramenta or scales are found is *Pteris*, *Dryopteris* (fern).

6. (c) Sperms (antherozoids) of *Selaginella* are 128–256 in number and biflagellated sickle shaped (curved).

7. (b) Nucellus is the megasporangium of *Pinus*.

9. (d) Heterosporous condition (Produce of two kind of spores *i.e.*, Megaspore and microspore) found in Selaginella and Homosporous conditions (Produce one kind of spore) found in pteris (fern).

10. (d) Williams, Goebel and Bower regard it as an intermediate structure between root and shoot hence an "Organ sui-genesis".

11. (b) Trabeculae endodermis : Endodermis having air chambers. The endodermis except in xerophytic species (*S. lepidophylla* and *S. rupestris*) is interrupted by large intercellular spaces. This is called the trabeculated endodermis.

12. (a) *Selaginella* is mainly found in damp shaded places. A few species are xerophytic (*e.g.*, *S. lepidophylla*, *S.pilifera*, *S. bryopteris*).

13. (c) In *Selaginella*, sporophytic and gametophytic generation are morphologically as well as genetically differ.

15. (a) Roots present in *Selaginella* and rhizoids present in *Funaria*.

16. (a) In male gametophyte the first division leads to formation of a small prothallial cell and a large antheridial cell.

18. (b) A flap like outgrowth is present at the base on adaxial side called ligule. It may be fan-shaped or tongue shaped or lobed. Such leaves are called ligulate.

19. (c) The microspores on germination forms the male gametophyte and the megaspore forms the female gametophyte.

22. (b) The main plant body of *selaginella* sp. is sporophyte which is diploid in condition.

23. (a) In dry conditions, the plant rolls up in to a compact ball and during the rainy conditions the ball on absorbing moisture becomes green again. Such plants are called resurrection plants.

24. (d) Reduction division or meiosis is called as sporic meiosis and is specific type met within pteridophytes.

Gymnosperms (General)

5. (d) Therophytes are those plants that survive in winter as a seed and complete their life cycle between the spring and autumn.

7. (c) Archegonia is found in bryophytes, pteridophytes and gymnosperms and antheridia occurs in bryophytes and pteridophytes.

8. (d) Gymnosperms are perennial trees and shurbs and woody large trees.

9. (b) Anemophily or wind pollination occurs in gymnosperms.

15. (a) Canada Balsam is used as a mounting for microscopic studies. The source is *Abies balsamea*.

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16. (c) The foliage leaves do not have lateral veins. Instead, transfusion tissue (hydrostereom) occurs internally for lateral transport.

19. (d) (a) Cycadophyta → Fossil *Williamsonia*.
(b) Coniferophyta → Fossil *cordites*.

20. (d) Main plant body sporophyte of gymnosperm and angiosperm are made up of root, stem and leaves.

21. (b) *Ginkgo biloba*, a gymnosperm, is at present confined to the eastern part of China and Japan.

22. (a) *Gnetum*, *Ephedra* (Jointed fir) and *Welwitschia*. This is the only order in gymnosperms, where vessels are present in xylem.

Pinus

3. (c) In *Pinus* annual ring consists of a zone of spring wood and autumn wood.

4. (d) Pollination in *Pinus* takes place when two prothallial cell, one generative cell and one tube cell are formed.

5. (d) Because pollen tube is present and dispersal of pollen grains by wind. So male gametes are not ciliate.

7. (c) Chilgoza is seed of *Pinus*.

10. (c) Male cones arise in place of dwarf shoots on long shoots and thus are equivalent to dwarf shoots.

11. (b) Because endosperm is haploid (n) and formed before fertilization and megaspore mother cell divides reductionally to form a linear tetrad of haploid megaspores and microspore (= pollengrain) is the first stage of the gametophyte (n).

12. (a) Tracheidal cell present in xylem, vessels are absent.

13. (b) In *Pinus*, as the seed matures a thin layer of ovuliferous scale fuses with testa of the seed in the form of a wing, this help in the dispersal of seeds.

14. (d) In *Pinus* seed there are many cotyledons (3–18 cotyledons).

15. (b) Male prothallus (gametophyte) in *Pinus* is having two prothallial cells and one tube cell.

16. (c) Vascular strand is unbranched and covered by pericycle. It has generally two conjoint and collateral vascular bundles separated by T-shaped sclerenchyma.

17. (a) In the embryo of Pinus rosette tier (4 cells) above the suspensor tier and mediates between the suspensor tier and nutritive tier.

18. (b) Resin is collected from the stem/wood of *Pinus*. It is distelled to produce *turpentine* and rosin.

19. (d) Winged pollen grains produced in microsporangium which represents the male gametophyte of *Pinus*.

20. (b) In *Pinus* embryo with 3 to 18 cotyledons.

21. (b) Brown membranous scale leaves (cataphylls) present on both long and dwarf shoots and serve to conserve water around the branches.

22. (c) Male gametophyte of *Pinus* is 4 celled (two prothallial cells, one generative cell and one tube cell).

23. (a) The wood of *Pinus* is pycnoxylic (more than one ring due to epimeral nature of cambium) and monoxylic (formed by the activity of single cambium).

25. (d) Because *Pinus* is gymnosperm plant.

26. (d) Dwarf shoot : In case of Pinus, actually in dwarf shoot the number of *Pinus* needles varies from one to six.

27. (b) Resin (Terpentine oil) : In *Pinus* roots, stem and needle, resin ducts are found having odorous oil known as resin. This resin is anticoagulant and do not allow to freeze water even upto – 30°C temperature in *Pinus* plants.

28. (c) The sporogenesis results in the formation of micro and megaspores representing the first gametophyte cells. They undergo gametogenesis so as to form the male and female gametophytes respectively.

29. (b) The 'endosperm' of *Pinus* is a haploid gametophytic tissue formed before fertilization.

30. (a) In gymnosperms and angiosperms gametophytes are dependent on sporophyte.

31. (b) As the seed matures, a thin layer of ovuliferous scale is fused with testa of seed in the form of wings.

32. (a) The seed of *Pinus* :
(1) Parent $2n$, sporophyte represented by wing, testa, tegmen and perisperm (nucellus).
(2) Female gametophyte (n) represented by enclosperm.
(3) Future sporophyte ($2n$) represented by embryo (Plumule, radicle, suspensor and cotyledons).

33. (a) Body cell divides into two daughter cells just before fertilization. These two cells are known as sperms.

34. (c) Seed of *Pinus* is endospermic, perispermic diploid ($2n$). The wing of seed is thin, membranous diploid ($2x$) and develops jointly from the basal upper surface (adaxial) of ovuliferous scale and outer layer of integument of the ovule.

35. (a) Monoecious

36. (b) In *Pinus* the pollination is anemophilous, (wind) *i.e.*, pollen grains are carried to the ovule through wind.

38. (b) Female cone are morphologically equivalent to long shoot because female cone is 1.8 to 3 *cm* in 1st and 2nd year and 45 *cm* in length and 10 *cm* wide in third year.

39. (d) Siphonogamous fertilization : The fertilization in which a long pollen tube carry two male sperms near to egg cell is called as siphonogamous fertilization. This is only found in gymnosperms and angiosperms.

40. (c) Four embryos are formed from a single fertilized egg in cleavage polyembryony simple polyembryony *i.e.*, When more than one embryos are developed as a result of fertilization of different archegonia.

41. (c) The microsporophylls of *Pinus* has 2 microsporangia on its abaxial surface.

Cycas

1. (c) Diploxylic vascular bundles : In *cycas* leaflet, in central V.B. two xylem and one phloem is found.

2. (a) The sperms of *cycas* are largest (300μ) in nature and visible to naked eye.

3. (c) Fern character in *cycas* is circinate venation in which younger leaf is coiled like a spring from apex downwards.

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4. (a) *Anabaena*, *Nostoc* and bacteria are found in coralloid roots hence it helps in fixation absorption of nitrogen.

5. (d) A starch called sago is obtained from the pith of *cycas*, that so *cycas* is called sago palm.

6. (a) In the female plant, the apical meristem remains unaffected. Hence, the growth pattern is monopodial.

7. (a) The terminal sterile portion of the sporophyll is called apophysis.

8. (a) In one young seed only one embryo remains at maturity and others perish are called potential true polyembryony.

10. (c) Secondary growth is carried by successive rings of cambia (as many as 22 rings of vascular tissues are observed).

11. (c) Living fossil is that organism whose relatives have become extinct (Fossilised) and has a restricted distribution, therefore, threatened to become extinct.

14. (d) The sperm of *Cycas* is remarkably large in the entire plant kingdom. It is top shaped with 4-5 spiral coils of cilia at anterior half.

15. (c) Vessels is a characteristic feature of angiosperms.

16. (d) Size of largest ovule – 6 *cm* (length) 4 *cm* (dia), size of largest – sperm – 300μ, size of largest egg – 0.5 *mm* in diameter.

17. (b) *Cycas* is dioecious in which male and female sex organs are present in a single plant.

18. (d) Sago palm rich in starch.

19. (b) Monoxylic and Polyxylic : The wood is loose, soft, nonporous commercially useless, parenchymatous tissue more, vascular tissue less pith and cortex broad, medullary rays wide *e.g.*, cycas wood.

20. (a) Stem pith of *cycas* having a number of mucilage canals.

21. (a) The pollination is anemophilous. The pollen grains of cycas are light in weight and easily blown away be wind.

22. (a) The megasporophylls is distinguishable in to a rachis part and a distal lamina in the upper part of the rachis are present to pairs of ovules, laterally.

25. (b) The 'endospoerm' in *cycas* is a haploid gametophytic tissue formed before fertilization.

26. (d) The male gametes of *cycas* are largest (300μ) in nature, broad and naked at posterian end and spirally coiled in the anterior half with thousands of small cilia.

27. (d) *Anabaena* with coralloid roots is an example of symbiosis. It helps in N_2 fixation.

29. (a) The pollen grains at this 3 celled stage fall directly on the pollination drop secreted by ovule as there is no stigma to receive pollen grains.

30. (b) Because sago is easily digestible with less starch (31%).

31. (a) Vessels are absent in gymnosperms.

32. (c) Bulbils (cresting adventitious buds), which are produced on the stem in the axil of scale leaves.

33. (a) Gynoecium is megasporophyll. Megasporophyll has stigma, style and ovary.

34. (d) In *Cycas* seeds are naked because it is not covered by ovary.

35. (d) Leaflet of cycas is diploxylic means 2 types of xylem – centripetal (exarch) and centrifugal (endarch).

36. (b) Microsporophyll bear sori of sporangia on the abaxial surface because the terminal portion is sterile.

38. (b) Motile sperms are found in both *Cycas* and *Adiantum*, Seeds, cambium are quite common in gymnosperms absent in pteridophytes.

39. (c) In young condition, young leaves show circinate ptyxis like fern leaves and are covered by ramenta.

40. (b) The zygote, which is the first sporophytic cell, undergoes free nuclear divisions.

Angiosperms

4. (b) In monocots vascular bundles are conjoint collateral, closed scattered are called Atactostele.

5. (c) In dicots tap roots and in monocots adventitious roots is present.

6. (d) Phanerogams means seed bearing plants. Gymnosperms and angiosperms both possess seeds.

9. (d) In Angiosperm seeds are enclosed within a hollow ovary.

10. (b) Dicots are considered primitive over monocots.

11. (d) Secondary growth takes place in angiosperms because cambium are present (except monocots).

13. (b) The tip of the root of *Rafflesia* makes haustorial contact with the root of host and absorbs food from the host.

15. (a) Male gametophyte is highly reduced in angiosperm and is known as pollen grain. It is 2 or 3-celled.

16. (d) Megaspore Mother Cell (MMC) undergoes meiosis to form megaspore.

Critical Thinking Questions

1. (b) *Adiantum* – *Maiden* Hair fern (because of shining, smooth and blackish hair like petioles).

2. (d) Seeds are formed after fertilization and consequent enlargement of the ovule. Two ovule or megasporangium are present on the adaxial side of ouvliferous scale. The ovuliferous scale and bracts constitute the megasporophyll.

6. (c) Because archegonia of *Pteris* secrete a chemical malic acid which attracts only sperms of *Pteris* chemotactically.

8. (d) **Equisetum** – Pteridophytes-Free living gametophyte – Prothallus.

Riccia – It is liverwort in which simplest sporophyte consists of capsule only while polytrichum is moss in which sporophyte consists of foot seta and capsule.

Volvox – oogamy is present.

Slime moulds – Spores bear cell wall.

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9. (a) Such a sporangium arises from a single superficial initial. It divides periclinally into outer and inner components. While the inner cell forms the stalk, the outer gives rise to sporangium proper. In *Marattia alata*, the sporangia in a sorus may fuse to form a synanjoi.

10. (a) Because endosperms of *Pinus* are always haploid and is formed before fertilization in ovules.

12. (d) The Microspores divides to form a 13 celled non-green, male gametophyte (one vegetative/prothallial cell + 8 jacket cell + 4 primary androgonial cells).

13. (d) Stigeoclonium shows heterotrichous habit which differentiated into prostrate and erect system.

15. (b) A – Mosses and lichen are pioneers on rocks

B – Selaginells is heterosporous

C – Coralloid roots of cycas has cyanobacteria – *Anabena cycadae*

D and E are correct.

16. (d) The male cones are borne in a cluster on a branch of unlimited growth behind the apical bud, in the axil of a scale leaf. A cone consists of a central axis bearing 60-135 microsporophylls in spiral manner. It is therefore, comparable female flower of angiosperm.

17. (a) Some red algae deposit calcium carbonate on their surface. They are called coralline algae *e.g.*, *Corallina*. They help to develop coral reefs alongwith corals.

18. (c) In ferns gametophytic generation is represented by heart shaped prothallus.

20. (b) Calyptra is a outermost protective covering of moss and liverwort.

21. (d) *Zea* is monocot, *Cycas* have two and *Pinus* have many cotyledons in their embryo

23. (c) Heterospory, seed formation and fertilization are found in gymnosperm.

24. (d) The male gametes of *Riccia* and *Dryopteris* have flagella while male gametes of *Cycas* have cilia.

25. (d) The fertilization takes place after about a year of pollination.

26. (b) Sporophytes and gametophytes are morphologically differ in *Funaria*, *Selaginella* and *Cycas*.

27. (c) (A) Cyanophyceae – The blue-green colour is due to presence of a phycobilin pigment c–phycocyanin (also c–phycoerythrin).

(B) Chlorophyceae – The green colour is due to presence of a chl. – a, chl. – b, xanthophylls and carotens.

(C) Phaeophyceae – Brown colour is due to presence of pigment 'fucoxanthin'.

(D) Rhodophyceae – Colour is red due to presence of a red pigment (r–phycocyanin) in the chromatophores.

28. (b) Endosperm in gymnosperms is formed before fertilization and is always haploid.

29. (b) In *Pteris* antheridum is having (about 32) multiflagellated, coiled (2 – 3 coils) antherozoids or spermatozoids.

30. (c) Apospory is the formation of gametophyte directly from sporophyte without the meiotic formation of spores.

31. (d) At the base of ligule there is present a sheath of elongated cells called glossopodium (secretory). This ligule is secretory as well as protective. It secrets water/mucilage to keep growing point of stem and young leaves moist. It also protests young leaves.

34. (d)

(1) Moss of Bryophytes bears protonemal and leafy stage.

(2) Gymnosperm female gametophyte is not free living.

(3) They are present in Marchantia of Bryophyte.

(4) Origin of seed habit started in *Selaginella*.

Assertion and Reason

1. (b) Biennial plants live for two favourable seasons. During the first season, the plants grow in size and store food. In the second season, they bear flowers that form fruits.

2. (b) Bryophytes and tracheophytes possess an embryo stage. They are collectively called embryophyta. Bryophytes and tracheophytes are terrestrial plants. Bryophytes are nonvascular while tracheophytes possess vascular tissue.

3. (b) Stamens are specialized microsporophylls. Each stamen has a narrow stalk or filament and a knob-like broader tip called anther. Anther develops four microsporangia or pollen grains. Carpels are specialized megasporophylls. Each carpel has a swollen base named ovary. The interior of ovary contains one or more placentae for bearing ovules.

4. (a) On the basis of

(i) Thallus like non-vascular plant body,

(ii) Simple, unicellular non-jacketed sex organs and

(iii) No embryo development after gametic union, the algae and fungi have long been grouped together in thallophyta. The algae and fungi are the result of parallel development and do not indicate any phylogenetic relationship.

5. (a) The colour of the algal thallus which varies in different classes of algae is due to the presence of definite chemical compounds in their cells. These are called the pigments. Each pigment has its own characteristic colour. The particular colour that an alga has is due to the predominance of one pigment in a combination of several others. Each group of algae has its own particular combination of pigments and a characteristic colour which is not found in other algal groups.

6. (a) The red algae flourish and occur in abundance at great depths of sea where other plants do not occur in abundance. The sunlight as it penetrates water, portions of spectrum such as red, orange, yellow and green light rays which are of short wavelengths are filtered out. Only the blue and violet rays of great wavelength remain and penetrate to great depths. The green pigment chlorophyll cannot trap these light rays of great wavelength and the green plants are thus unable to carry on photosynthesis at these depth. On the other hand the red pigment $r-$phycoerythrin and a blue pigment $\gamma-$phycocyanin which are characteristic pigments of all the red algae, can utilize wavelengths of light (blue and violet rays) not absorbed by chlorophyll.

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7. (e) The carpogonium (female sex organ) in *Nemalion*, one of the simplest red alga, consists of a swollen basal part containing the female nucleus and an elongated terminal hair-like structure called the trichogyne. During fertilization the spermatium (male gamete) discharges its contents into the latter. The spermatium nucleus migrates downwards to fuse with the egg nucleus in the basal swollen part of the carpogonium. Soon after fertilization the trichogyne shrivels.

8. (a) In *Spirogyra*, the outermost portion of pectose changes into pectin. The latter dissolves in water to form the so called gelatinous sheath which is slimy. It envelopes the entire filament. This makes filament slippery in touch.

9. (c) The fusing gametes in the lower forms of algae are alike in size, structure and behaviour. They are indistinguishable as to sex. Such gametes are called the isogametes. Sexual reproduction which involves the fusion of isogametes is termed isogamous. It is a primitive type of sexual reproduction.

10. (a) Angiosperms is the highly evolved group of plant kingdom. It is adapted for terrestrial habitats. Swimming habit of sperms is completely lacking in angiosperm. The pollen grains reached to the stigma by an external agency and delivered the male nucleus in the ovule through pollen tube.

11. (b) Fertilized ovules ripen into seeds. The seeds are covered by fruits. A fruit is technically a ripened ovary. Gymnosperms contain ovules but they lack ovary, therefore, seeds are formed but fruits are not formed. Angiosperms contain both ovule and ovary and therefore, are seed bearing fruit forming plants.

12. (b) The chloroplasts of green algae contain one or more distinct, rounded, proteinaceous bodies called the pyrenoids. Pyrenoids diminish in size and ultimately disappear if the plant is under conditions of starvation. They reappear when the conditions become favourable.

13. (c) In green algae the eye spot is usually associated with the chloroplast. Eye-spot is considered as a photoreceptive organ.

14. (b) *Chlorella* could be utilised to keep the air in space vehicles pure and supply food in space stations and prolonged space flight trips. The space travellers could feed on *Chlorella* soup. It is nourishing but not appetizing food.

15. (b) In angiosperm, sporophylls are organised into flowers. Both microsporophylls and megasporophylls are specialised. A microsporophyll or stamen consists of a filament and an anther. A megasporophyll or carpel is rolled and partly sterilised to produce a stigma, style and ovary containing ovules.

16. (c) Many believed that *Chlorella* could serve as a potential source of food and energy because its photosynthetic efficiency can theoritically reach 8% comparable with other highly efficient crops nutrients. When dried, it has about 45% protein, 20% fat, 20% carbohydrate, 5% fibre and 10% minerals and vitamins.

17. (a) A life cycle characterized by a haploid thallus, and zygotic meiosis is called haplontic life cycle. It is also called as haplobiontic because only a single type of free living individual is involved in the life cycle. *Spirogyra* shows haplontic life cycle and therefore, it also shows zygotic nucleus.

18. (a) In some species of red algae called coralline algae, the cell walls become hardened with calcium carbonate. These algae hence important for the formation of coral reefs. Coral reefs are formed through the accumulation of calcareous exoskeletons of coral animals, calcareous red algae and molluscs. They form the foundation of reefs by secreting a calcium carbonate skeleton and provides protection for the coral polyps. Calcium carbonate is secreted continuously by the coral colony.

19. (a) Bryophytes are a group of non-vascular land plants. The sex organs in the bryophytes are multicellular and jacketed. The jacket of sterile cells around the sperms and eggs is an adaptation to a life on land. It protects the sex cells against the drying effects of air.

20. (e) Most of the bryophytes are land dwellers which inhabit damp, shaded and humid localities. A few of them live in or float on water. The bryophytes cannot carry on their reproductive activities without sufficient moisture. Presence of water is necessary.

21. (c) The bryophytes have evolved a life which comprises two phases-gametophyte and sporophytes. The gametophyte (haploid) is concerned with sexual reproduction and constitutes the most conspicuous, nutritionally independent phase in the life cycle. The sporophyte is dependent partly or wholly on the gametophyte for nutritional purpose.

22. (c) Thallophytes, *i.e.*, algae and fungi completely lack the formation of embryo. In bryophytes, the zygote, on germination, does not produce the gametophyte plant. It undergoes segmentation to form an embryo. The embryo (diploid) by further segmentation and differentiation gives rise to sporophyte. The sporophyll obtains its nourishment directly from the parent gaemtophyte to which it is organically attached.

23. (c) The female sex organ of the bryophytes is a remarkable structure. It appears for the first time in the liverworts and mosses and continues in the pteridophytes. Archegonium is absent in thallophytes (algae and fungi). Sex organs in them are male gametes and female gametes.

24. (d) In bryophytes, the zygote, on germination, does not produce the gametophyte plant. It undergoes segmentation to form an embryo. But the embryo formation and its development to sporogonium and sporophyte are dependent on gametophyte plant as the sporophyte is dependent on the gametophyte for nutrition. They remain attached organically to the gametophytic plant. In algae, the zygote is independent and it does not form the sporophyte.

25. (b) Fragmentation leads to increase in the number of plants in a locality but it does not permit spread of the plant to an entirely new locality. Being small and sufficiently buoyant, gemmae are easily carried. When detached, they spread by water and wind currents to new habitats, where each grows into a new individual immediately.

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26. (b) *Pinus* show alternation of generations. The sporophyte phase is of long duration and is represented by the huge pine tree, which bears the staminate and ovulate cones. Since meiotic divisions occur at the same time of the differentiation of the pollen grains and megaspores.

27. (e) In *Pinus*, the embryo is straight and consists of a short axis bearing a ring of about ten slender, yellow cotyledons at the end, away from the micropylar end. In *Pinus*, more than one embryo come from a single egg by the splitting of the product of a single fertilization, termed as cleavage polyembrony.

28. (b) The ovulate or female cones take three years to mature. The mature cones are hard, woody and very large in size. Many important changes take place in the female cone during the interval of about thirteen months between pollination and the actual act of fertilization.

29. (d) Female cones or ovulate cones are fewer in number and arise single or in a small cluster or two to four, each as a bud in the axial of a scale leaf towards the end of the new shoots of unlimited growth (long shoots) which do not bear the male cones.

30. (a) Each sperm of *Riccia* is a minute, slender curved structure. It is furnished with a pair of whiplash flagella at its anterior end. The sperms do not leave the antheridium until enough moisture is present to permit them to swim about. Several of the sperms may swim downward in the liquid in the neck.

31. (a) The sporogonium (capsule) of *Riccia* is the simplest among the liverworts. It lacks both the foot and the seta. There are no elater. Unlike other liverworts the embryo, sporogonium and spore mother cells in *Riccia* develop no chloroplasts. Thus no photosynthesis occurs there. The sporophyte remains totally dependent upon the gametophytic thallus.

32. (b) In young stems of *Funaria*, the cortical cells contain chloroplasts, hence, they are photosynthetic. The central cylinder forms the core of the stem. It consists of vertically elongated, thin-walled, narrow, compactly arranged cells without protoplasm. These thin walled, elongate, dead cells with nonlignified walls are commonly called the hydroids.

33. (c) *Pinus* is monoecious as it bears both types of cones on the same tree on separate branches. The male cone consists of a number of small spirally arranged microsporophylls. Each microsporophyll bears two microsporangia or pollen sacs as swelling on the lower surface of its horizontal position.

34. (c) The formation of small, underground resting, budlike structures called the tubers has also been reported in some mosses. Formerly these underground bud-like structures were called the bulbils. The tubers develop singly on stem, leaves and rhizoids as small, spherical storage organs containing starch. These serve as means of perennation and enable the plant to tide over periods unfavourable for vegetative growth.

35. (e) In *Funaria*, the gemmae develop on the stem and leaves of the gametophore at the onset of condition unfavourable of growth or during injury. These detached gemmae under conditions favourable for vegetative growth directly develop into new leafy gametophores.

36. (b) Morphologically *Funaria* looks dioecious, but it is monoecious.

The antheridia (male sex organ) are formed at the summit of a relatively small, main leafy shoot which develops first. It is in fact the parent plant.

The female branch arises later as a lateral outgrowth from the base of the parent male shoot. When the two kinds of the sex organs are borne in separate clusters on two distinct branches of the same plant the arrangement is called monoecious. *Funaria* is protandrous (male matures first). This ensures cross fertilization.

37. (e) In *Funaria*, the antheridia are not sunk in pits, but project from the surface of the receptacle and are aggregated to form a cluster. The leaves surrounding the antheridial cluster are known as the perigonial leaves. The antheridial cluster with the surrounding perigonial leaves is called the perigonium.

38. (b) The peristome teeth are present at the mouth of capsule. The teeth may be solid cellular tissue or composed only of the thickened portions of the cell walls of adjacent cells.

When the teeth of peristome are solid structures composed of bundles of dead cells, it is termed *nematodontous* peristome are solid structures composed of bundles of dead cells, it is termed *nematodontous* peristome. It is found in *polytrichum*, *Pogonatum* and *Tetraphis*. If peristome composed of thin, membranous, transversely barred teeth, each tooth is made up of the thickened portions of the cell walls of adjacent cells. Such a peristome is called *orthodontous*.

39. (b) Within the hypodermis of *Pinus* leaf is the parenchymatous mesophyll. It is compart and shows no differentiation into palisade and spongy tissues. It consists of thin walled cells which contain numerous chloroplasts and abundant starch. The mesophyll thus functions as the chlorophyll bearing tissue which manufactures food for plants.

40. (a) Secondary growth takes place in the manner similar to dicotyledonous stem. The secondary word shows well marked growth rings which are formed annually due to environmental fluctuations. Each annual ring possesses a zone of spring and an autumn wood. Spring wood is formed during season under availability of enough water and minerals. It possess large polygonal, thin walled and wide tracheids with large bordered pits. Autumn wood is formed during Autumn season. It possesses smaller, squrish, thick walled and narrow tracheids with small bordered pits. It is evident that the size of tracheids shows a marked variation with regard to amount of nature available in the respective season.

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41. (a) Rubling and Tyler (1979) showed that air dried mosses can absorb metals. The accumulation of heavy metal cations in mosses enables them to be used as pollution indicators.

42. (a) According to some Botanists, Mosses originated from algae. Protonema of mosses is similar to certain algae.

43. (c) In the sproangia of *Pteridium* are not grouped together in small separate sori, but the sorus is continuous along the under margin of the pinnules, often for considerable distances. This type of sorus is known as continuous linear sours (coenosorus).

44. (b) Indusium is an epidermal membranous outgrowth covering the sori in some ferns. The coenosorus is surrounded by two well formed indusial lips, between which lies the receptacle. The outer indusial lip is well-developed and is formed by the reflexed margin of the pinnule, which overlaps the coenosorus and its sporangia. This is commonly called the false indusium.

45. (b) In *Dryopteris*, young rhizome and leaves are covered with dry, brown, chaffy scales known as ramenta. In *Pteridium*, the rhizome and the leaves especially while young, are covered by a felt of simple hairs, and the scales are conspicuously absent.

46. (d) The scale leaves are present both on the long and dwarf branches. They fall off as the branches mature. The scale leaves on the dwarf shoots are called the cataphylls and possess a distinct midrib.

47. (d) In bryophytes, antheridia are well developed and often possess a stalk. In pteridophytes, antheridia are less developed and generally devoid of a stalk whereas pteridophytes has multiflagellate sperm formed from androcyte cell of antheridium. Bryophytes has biflagellate sperm.

48. (e) In fern, fertilization usually takes place if the prothalli are watered from above as they would be by rain in the ordinary course of nature. They possess flagella for swimming movement towards archegonia through water.

The discharged matter at the mouth of the opened archegonial neck probably contains some chemical substance, e.g. malic acid, which by positive chemotaxis attracts the free swimming antherozoids, which penetrate the neck and reach the deeply seated ovum.

49. (c) In the pteridophytes, the sporophyte gains physiological independence and develops into the dominant, typically photosynthetic phase of the life cycle. It is organized into stem, leaves and roots. For the first time in the sporophyte of the pteridophytes true roots develops. Psilophyta (a pteridophyte division) lack true roots.

50. (e) In gymnosperms, xylem lacks true vessels and wood fibres. It consists of tracheids that are arranged in uniform radial rows and xylem parenchyma only. The phloem contains sieve tubes and parenchyma cells. There are no companion cells.

51. (d) In eusporangiate type of development, large sporangia develop from a group of initials. In leptosporangiate type of development, small sporangia develop from a single initial, the former builds the entire sporangium, its contents and stalk and the latter takes no part in the process.

52. (a) Leaf tips of *Adiantum caudatum*, develop adventitious buds for vegetative propagation. When leaf tip reaches the ground, it develops into new plant, therefore, it appears that the plant is walking.

53. (a) The gymnosperms have their ovules freely exposed before and after fertilization. They are not enclosed by any ovary wall. The seeds formed by them lack seed coat. Hence due to absence of every wall and seed coat their seeds are nacked.

54. (b) Long branches of *Pinus* become gradually shorter towards the apex. Hence the pine tree has a conical or pyramidal appearance. Long branches bear short branches and older portion of long branches show the scars of fallen short branches.

55. (c) In *Cycas* there is no true and compact or properly organised female cone. Megasporophylls are loosely arranged and thus form a loose female strobilus. The growing point of the stem is unaffected by their development and continues its growth through the loose strobilus.

56. (c) All living species of *Cycas* are dioecious as the male and female structures occurs on separate plants. The microsporophylls are aggregated into large compact male strobili or cones. The megasporophylls are loosely arranged. They do not form a true cone.

57. (b) When the microspores reach maturity, the male cone elongates considerably and rapidly. The scales separate from one another so that sporangia are exposed. The sporangia lose water and with the loss of water from its cells the exothecium shrinks. The sporangia thus open by a slit on its outer face. The spores fall out. The liberated spores are dispersed by wind.

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Plant Kingdom

SET Self Evaluation Test

1. In ferns, xylem is
   (a) Exarch (b) Mesarch
   (c) Endarch (d) Polyarch

2. Tracheophyte includes **[Odisha JEE 2009]**
   (a) Pteridophyte, gymnosperm and angiosperm
   (b) Bryophytes and spermatophytes
   (c) Only spermatophytes
   (d) Thalophytes and bryophytes

3. Heterospory and seed habit are often exhibited by a plant possessing **[CBSE PMT 1997; BVP 2009]**
   (a) Bract (b) Spathe
   (c) Petiole (d) Ligule

4. Match items in Column I with those in Column II

Column I	Column II
(A) Peritrichous flagellation	(J) *Ginkgo*
(B) Living fossil	(K) *Macrocystes*
(C) Rhizophore	(L) *Escherichia coli*
(D) Smallest flowering plant	(M) *Selaginella*
(E) Largest perennial alga	(N) *Wolffia*

   Select the correct answer from the following **[CBSE PMT 2005]**
   (a) A – L; B – J; C – M; D – N; E – K
   (b) A – K; B – J; C – L; D – M; E – N
   (c) A – N; B – L; C – K; D – N; E – J
   (d) A – J; B – K; C – N; D – L; E – K

5. A female gametangium of bryophyte differs from that of fungus in possessing
   (a) Large neck
   (b) A venter
   (c) Jacket layer with sterile cells
   (d) A single egg cell

6. Annulus of moss capsule separates **[CMC Vellore 1993]**
   (a) Operculum and columella (b) Theca and columella
   (c) Theca from operculum (d) Columella from apophysis

7. The microspore of *Selaginella* may be as small as **[MP PMT 2011]**
   (a) 5μ (b) 15μ
   (c) 1.5μ (d) $S\mu$

8. The major role in the dehiscence of a fern sporangium is played by its **[AIIMS 1999]**
   (a) Annulus (b) Indusium
   (c) Tapetum (d) Sorus

9. Leaf gap in the vascular cylinder in ferns is
   (a) Air space (b) Parenchymatous zone
   (c) Collenchymatous zone (d) Area exclusively of phloem

10. The female sex organ in *Riccia* and *Funaria* is **[AIIMS 1992; BHU 1994]**
   (a) Archegonium (b) Antheridium
   (c) Oospore (d) Paraphyses

11. The sclerenchyma of the hypodermis in the *Pinus* needle helps in **[AIIMS 1992]**
   (a) Checking transpiration
   (b) Mechanical support
   (c) Photosynthesis
   (d) Increasing the absorptive surface of the cell

12. Which one of the following characters in not shown by *Selaginella*
   (a) Circinate venation (b) Precocious germination
   (c) Microphyllous leaves (d) Protostele

13. Match the following

A.	Red Algae	1.	Marchantia
B.	Liver wort	2.	Pinus
C.	Walking fern	3.	Polysiphonia
D.	Gymnosperm	4.	Adiantum

   [Kerala PMT 2006]
   (a) A – 1, B – 2, C – 4, D – 3 (b) A – 2, B – 4, C – 3, D – 1
   (c) A – 2, B – 3, C – 1, D – 4 (d) A – 3, B – 1, C – 4, D –2

14. Select the correct statement **[Kerala PMT 2011]**
   (a) Absorption of water by seeds and dry wood are examples of facilitated diffusion
   (b) The apoplast is the system of interconnected protoplasts
   (c) Pinus seeds cannot germinate and establish without the presence of mycorrhizae
   (d) The translocation phloem is unidirectional whereas in the xylem it is bidirectional

15. In bryophytes an operculum a cap like structure develops from **[CPMT 1993]**
   (a) Antheridium (b) Archegonium
   (c) Both (a) and (b) (d) None of these

16. Number of flagella in male gametes of fern is **[RPMT 1995]**
   (a) Zero (b) One
   (c) Two (d) Infinite

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17. Well developed archegonium with neck consisting of 4–6 rows of neck cells characterises **[CBSE PMT 1995]**

(a) Gymnosperms and flowering plants

(b) Bryophytes and pteridophytes

(c) Gymnosperms only

(d) Pteridophytes and gymnosperms

18. Meiosis (reduction division) in pteridophytes takes place at the time of **[MP PMT 2003; AFMC 2004]**

(a) Spore formation (b) Sexual organ formation

(c) Germination of spores (d) Gamete formation

19. Which organism lacks archegonium **[MP PMT 2011]**

(a) *Funaria* (b) *Pteris*

(c) *Cycas* (d) *Spirogyra*

20. *Laminaria* (kelp) and *Fucus* (rock weed) are the examples of **[AFMC 2000; CBSE PMT 2001; BVP 2002; AMU (Med.) 2009; Kerala PMT 2012]**

(a) Green algae

(b) Brown algae (Phaeophyceae)

(c) Red algae (Rhodophyceae)

(d) Golden brown algae

21. Rhizoids in *Funaria* arise from **[CPMT 1998; MHCET 2003]**

(a) Basal region (b) Ventral region

(c) Dorsal region (d) None of these

22. The walking fern is so named because **[CBSE PMT 1998]**

(a) Its spores are able to walk

(b) It is dispersed through the agency of walking animals

(c) It propagates vegetatively by its leaf tips

(d) It known how to walk by itself

Answers and Solutions

1	b	2	a	3	d	4	a	5	c
6	c	7	b	8	a	9	b	10	a
11	b	12	a	13	d	14	c	15	b
16	d	17	b	18	a	19	d	20	b
21	a	22	c						

1. (b) *Mesarch* : When in xylem, protoxylem and metaxylem are mixed then in ferns xylem becomes mesarch.

3. (d) Heterospory meant for the production of two different sizes of spores *i.e.*, microspore and megaspore. It is found in *Selaginella*. In *Selaginella*, there is a small membranous ligule found at the basal portion of the leaf.

5. (c) A female gametangium of bryophyte differ from fungus multicellular sex organs surround by a single layered jacket of sterile cells.

6. (c) Capsule has three parts – lower assimilatory apophysis, middle spore containing theca (with central sterile columella) and upper part having an operculum, peristome and annulus.

9. (b) The parenchymatous region left behind in the main stele after the departure of the leaf trace is called 'leaf gap'.

11. (b) Because sclerenchyma are thick wall cells.

12. (a) Circinate vernation is characteristic feature of division filicophyta (*e.g.*, *Dryopteris*) while *Selaginella* include in division lycophyta.

15. (b) The upper region of capsule is slightly oblique having upper cap-like portion called operculum.

16. (d) Male gametes of fern is multiflagellated.

18. (a) In pteridophytes, spore mother cell undergo meiosis to form tetrahedral tetrads of spores.

20. (b) The large (giant) parenchymatous forms of brown algae are called kelps or sea weed or trees of seas or forest of sea. (*e.g.*, *Maccrocystic* 30–60*m*; *Nereocystis* 20–30*m*, *Laminaria* 2–12*m*). Both contain fucoxanthin, which is brown in colour. Due to which both are grouped under brown algae.

21. (a) On the lower portion of the leafy gametophore, there are present branched, multicellular rhizoids with oblique septa.

22. (c) *Adiantum caudatum* walking fern because its leaf tips when come in contact with soil, form new plants as adventitious buds develop at leaf tips. This helps in the spread of fern over a large soil surface and thus derives the name walking fern.

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