PLANT KINGDOM

INTRODUCTION

Plant kingdom : Algae, Bryophytes, Pteridophytes, Gymnosperms and **Angiosperms**.

Algae (= sea weed):

- The term **'Algae'** coined by **Linnaeus.**
- Study of Algae is called **Phycology or Algology**. **F. E. Fristch** is known as **'Father of phycology**'.
- Father of Indian phycology - **M.O.P. Iyenger.**
- It involves those organisms that have **thallus like plant body, chlorophyll, accessory spores for asexual multiplication nonjacketed gametangia, absence of embryo stage.**

Characters of Algae:

(i) They are usually found in water (either marine or fresh water). Some algae are found on moist stones, soils, wood, some of them also occur in association with fungi (lichen) and animals (e.g. on sloth bear)

(ii) Its plant body is covered by mucilage that provides protection from water currents and epiphytic growth.

(iii) Plant body is thallus that can be unicellular (*Chlamydomonas*), filamentous (*Spirogyra* & *Ulothrix*), colonial (*Volvox*) and composed of true parenchyma (e.g.

(iv) Cell wall consists of **cellulose, galactans, mannans and calcium carbonate.**

(v) Pigment - Chlorophyll-a and β-carotene are universal pigments (similar to higher plants).

(vi) Reserve food is mainly **starch.**

(vii)Reproduction:

(1) Vegetative : By **Fragmentation** (Each fragment develops into a thallus) and by formation of different type of **spores** (hypnospores, akinete etc.).

(2) Asexual : By different type of spores. The most common asexual spore is zoospore (Flagellated / Motile and produced new algal plant on germination).

(3) Sexual : Sexual reproduction take place through fusion of two gametes.

Sex organs - unicellular and non-jacketed gametangia.

Male sex organ - antheridium

Female sex organ - oogonium.

Type of sexual reproduction:

(a) Isogamy : Fusion of gametes of Similar size.

Flagelated isogametes - **Ulothrix**.

Non-flagelated isogametes e.g. **Spirogyra.**

(b) Anisogamy : Fusion of gametes of dissimilar size.

e.g. *Udorina.*

(c) Oogamy : Fusion between one large, non-motile (static) female gamete and smaller, motile male gamete.

e.g. *Volvox, Fucus.*

(viii) Fusion of gamete produce zygote which immediately undergoes meiosis (**zygotic meiosis**).

(ix) Lifecycle type in algae can be

Haplontic - Volvox, Spirogyra, some spp. of chlamydomonas;

Diplontic - Sargassum and Fucus;

Haplodiplontic - Polysiphonia, Ectocarpus, Kelps.

(x) Embryo stage is absent.

- **Whittaker** classified Algae **on the basis of photosynthetic pigments** into three classes – **Red algae, brown algae and green algae.**

(I) Class Chlorophyceae (Green Algae):

(i) Green algae are cosmopolitan **(Mostly fresh water).** Some species are marine **e.g.** *Caulerpa, Acetabularia, Codium.*

(ii) Thallus may be in various forms

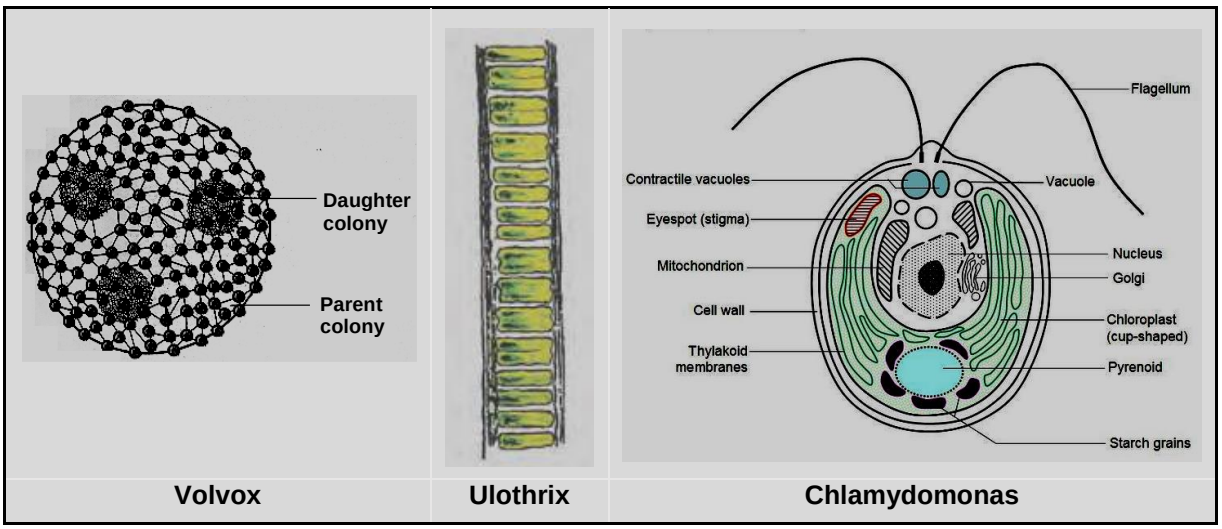
Unicellular - Acetabularia (largest unicellular algae/ umbrella plant), chlorela (non-motile), chlamydomonas (motile).

Collonial- Volvox (motile), Hydrodictyon (water net; non-motile)**.**

Multicellular Filamementous- Ulothrix (pond wool, attached to substratum), Spirogyra (pond silk, free floating).

Multicellular thalloid - Ulva (sea lettuce).

(iii) Shape of chloroplast in algae: Discoidal-Chara; **Plate like** - Chlorella; **Reticullate**- Oedogonium, Cladophora, Hydrodictyon; **Stellate** - Zygnema; **Girdle shaped**-Ulothrix; **Cup shaped**-chlamydomonas, Volvox; **Spiral or ribbon shaped**- Spirogyra.



Volvox **Ulothrix** **Chlamydomonas**

(iv) Pigments : chl a, b, carotenes(α, β and γ type), xanthophyll like lutein.

Note: Green algae are usually grass green due to dominance of pigment chl-a and chl-b.

(v) Stored food: Starch is reserve food material and stored in one or many storage bodies called **pyrenoids** located in the chloroplast. Pyrenoid contain protein in centre and starch in periphery.

(vi) Cell wall: Consists of **cellulose** (inner layer) and also have **pectose** (outer layer) & xylan.

(vii) Reproduction:

Vegetative reproduction-fragmentation or by formation of different type of spores.

Asexual reproduction - Flagellated zoospores produced in zoosporangia.

Sexual reproduction takes place through **isogamy, anisogamy and oogamy**.

(viii) e.g. *Chlamydomonas, Volvox, Ulothrix, Spirogyra* and *Chara.*

Note:

(a) *Acetabularia* **(umbrella alga)** is **largest unicellular marine alga** that was used by **Hammerling** for grafting experiment to prove the **role of nucleus in heredity**.

(b) **Calvin** used *Chlorella* **and Scenedesmus for studying photosynthesis**.

(c) **Ordovician period of palaeozoic era** is called the **age of algae**.

Economic importance:

(i) **Food :** *Chlorella pyrenoidosa* **(called space algae)** is used by **exobiologists** for food, O_2**,** disposal of CO_2 in prolonged space flight. *Chlorella* has proteins (upto 50%), fats (20%), carboydrates (20%), vit A, B_1, B_2 B_{12}, C and E. It is used as **SCP (single cell protein)** and its nutritional value is equal to soybean and spinach. Ulva (see lettuce) and *Codium* are used as salad.

(ii) **Sewage oxidation :** *Chlamydomonas, Scenedesmus* **and** *Chlorella* are found in sewage oxidation tanks where they produce O_2. The latter helps aerobic bacteria to decompose sewage.

(iii) **Antibiotic : Chlorellin** is extracted from *Chlorella*. It is effective against bacteria.

(iv) **Larvicidal property :** *Chara, Nitella* show larvicidal property. They kill mosquito larvae.

(v) **Parasitism :** Exceptionally ***Cephaleuros virescence*** is a parasite. It cause **red rust disease of tea**.

Resonate the Concept

Volvox : Commonly called **Rolling ball alga**

1. It is a colonial form consisting of 500–60000 **Chlamydomonas** like individuals (cells) joined by cytoplasmic strands.

2. Its colony is a **coenobium (a colony with fixed number of cells).**

3. Asexual reproduction occur by **Gonidia**, which occur in the posteri or part. Gonidium undergoes divisions first to form a **plakea stage** (plate like), Then inversion takes place, leads to formation of a pore called **phialopore**, after inversion phialopore closes.

4. Sexual reporduction is **oogamous type**. Colonies may be monoecious or dioecious

5. Each zygote forms a single colony.

Chara : Commonly called stone wort

1. Sex organs are exceptionally multicellular and jacketed.

2. The male sex organ of ***Chara*** is known as **globule** and female is known as **nucule.**

3. Chara shows larvicidal property as it kills mosquito larvae.

4. Chara is considered as ancestor of angiosperms.

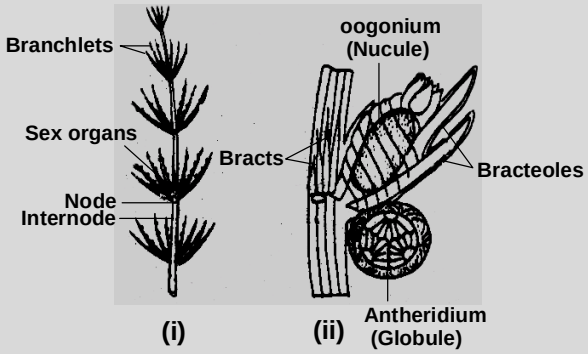


Fig.- Chara (i) Thallus (ii) Sex organs (TB)

Chlamydomonas:

1. **Structure:** Cup shaped chloroplast, pyrenoid, eye spot or stigma present non-cellulosic cell wall (cell wall made up of glycoprotein), two contractile vacuole, two apical isokont flagella present.
2. **Non-motile spores -** Applanospore (Thin walled) and Hyponospores (Thick walled)**.**
3. **Chlamydomonas** exhibits complete evolution of sexual reproduction.

e.g. *Chlamydomonas debaryanum* - isogamy (Flagellated isogametes)

Chlamydomonas braunii - Anisogamy

Chlamydomonas coccifera - Oogamy

(II) Class – Phaeophyceae (Brown Algae):

General characters:

(i) They are found primarily in marine habitat.

(ii) They show great **variation in size** and forms -

Simple branched filamentous form – Ectocarpus

Profusely branched (Parenchymatous structure) form – Kelp

(iii) Some **brown algae are giant** (large sized) that are called **kelps or sea weeds e.g. Macrocystis – length is 30–60 m,** *Nereocystis***–length is 20–30 m,** *Laminaria* **– Length is 2–12 m.**

(iv) Plant body is differentiated into **hold fast (for fixation with substratum), stipe (Stalk) and lamina (Leaf like for photosynthesis)**.

(v) Conducting tubes or **trumpet hyphae** are found in larger brown algae or kelps. It helps in food conduction (Analogus to sieve tubes of higher plants).

(vi) The vegetative cells have a cellulosic wall usually covered on the outside by a gelatinous coating of **algin**, fucin and fucoidin.

(vii) The protoplast contains, in addition to plastids, a centrally located vacuole and nucleus.

(viii) Pigments – Chl-a, Chl-c carotenoid (β-carotene) and xanthophyll (fucoxanthin).

Note: Colour of brown algae varies from **olive green to various shades of brown** due to different amount xanthophyll pigment.

(ix) Reserve food is laminarin or mannitol (complex carbohydrate) and oil.

(x) Reproduction -

Vegetative reproduction-fragmentation.

Asexual reproduction - Biflagellated zoospores in most of brown algae

Sexual reproduction takes place through **isogamy, anisogamy and oogamy**.

Note -

(a) Union of gametes may take place in water or within the oogonium (oogamous species).

(b) Both asexual biflagellated zoospores and sexual gametes are pear shaped (pyriform) and have two unequal, laterally attached heterokont flagella.

(c) Zygotic meiosis absent but **sporic meiosis occurs**.

(d) Life cycle is diplontic

eg. Ectocarpus, Dictyota, Laminaria (devil's apron), Sargassum and Fucus.

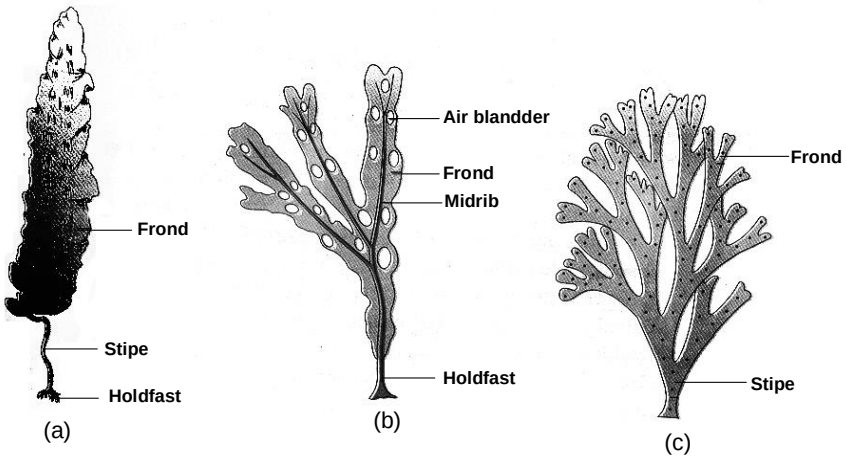


Fig : *Laminaria* (a), *Fucus* (b), *Dictyota* (c) (TB)

Economic importance:

- **(1) Algin:** It is **nonsulphated phycocolloid** and obtained from *Laminaria, Macrocystis, Fucus, Sargassum*. It is used in flame proof plastics, security glass, gauze and surgical threads, shaving creams, tooth paste, cosmetic creams, shampoos, sauces, sizing textiles, etc.
- **(2) Iodine :** It is extracted from *Laminaria* **and** *Fucus*.
- **(3) Mannitol :** It is used as food and added to inks, plastic, paints and varnishes. **It is half as sweet as sugar and is a good substitute of sugar for diabetic patients**.
- **(4) Food :** Some brown algae are used as food in some countries. **Kombu** is rich in carbohydrate and formed by *Laminaria. Alaria* yields a product called **sarumen** in japan.
- **(5) Potash :** It is extracted from *Macrocystis* **and** *Nereocystis* and used as fertilizer in germany.

Resonate the Concept

- *Sargassum* (gulf weed) is free floating and has air filled floats called vesicles that provide buoyancy. **North Atlantic sea** is called **sargasso sea** due to abundant occurrence of free floating *Sargassum fluitans*.
- In brown algae alternation of generation is **isomorphic (e.g.** *Ectocarpus, Dictyota***) or heteromorphic (e.g.** *Laminaria***).**

Laminaria:

1. A large algae (2-12 mt) found in littoral and sub-littoral regions of sea.
2. Plant body in differentiated into **holdfast, stipe and blade**. Holdfast have root like branches called haptera or crampons.
3. Stipe is unbranched and cylindrical which forms a new blade at the begining of a new growing season.
4. Blade also called **lamina or frond** is the photosynthetic part. In centre it have **trumpet hyphae**, which takes part in **food conduction**.
5. It shows **heteromorphic alternation of generation** with **dimorphic diplohaplontic life cycle.**
6. It is a **source of iodine, algin and potassium fertilizer**.

(III) Class – Rhodophyceae (Red Algae): Second most ancient algae.

General characters:

(i) Majority of the red algae are **marine** with greater concentrations found in the **warmer areas**.

(ii) The red **thalli of most of the red algae are multicellular**. Some of them have complex body organisation like unicellular thallus e.g. *Porphyridium*, ribbon like e.g. *Chondrus*, parenchymatous sheet e.g. *Porphyra*, multiaxial poysiphonous filaments e.g. *Polysiphonia*, uniaxial monosiphonous branched filaments e.g. *Batrachospermum*, graceful lace like e.g. *Gelidium*.

(iii) Flagellated cells are completely absent in life cycle.

(iv) Cell wall is mucilaginous and contains **cellulose, pectin and abundant sulphated phycocolloids (like agar, carrageenin, funori)**.

(v) Pigments – Chl-a, Chl-d carotenoid (β-carotene) and phycobilins (R-phycoerythrin - red colour and R - phycocyanin - Blue colour).

Red algae occur in both -

(a) Well lighted region / close to surface of water – Abundance of R - phycocyanin (Blue colour)

(b) Low lighted region / great depths in ocean - Abundance of R - phycoerythrin (Red colour).

(vi) Reserve food is floridean starch. It is highly branched as cyanophycian starch. Thus floridean starch and cyanophycian starch both are similar as amylopectin and **glycogen** in structure.

(vii) Reproduction:

(a) Vegetative reproduction – Usually by fragmentation.

(b) Asexual reproduction – By many types of **non-motile** spores like monospores, carpospores, tetraspores.

(c) Sexual reproduction – It is most advanced (Oogamous) type followed by complex post fertilisation development.

(viii) e.g. *Polysiphonia, Porphyra, Gracilaria* and *Gelidium.*

Note -

(a) Flagellated cells / motile gametes / motile spores are completely **absent** in life cycle.

(b) Batracospermum red algae - fresh water, blue coloured

(c) Harveyella red algae - pigment absent, colourless non-photosynthetic and parasite on other algae.

(d) Gaidukov's effect - colour of **red algae** and **blue green algae** changes according to depth in sea (Chromatid adaptation)

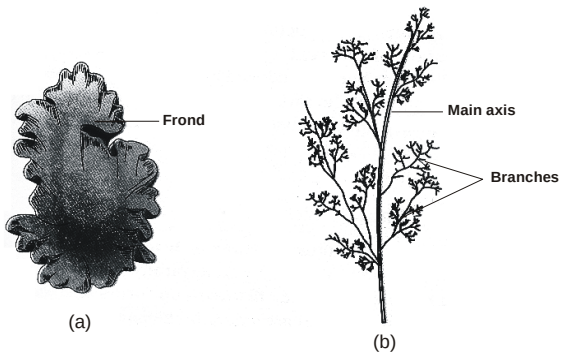


Fig. (a) Porphyra (b) Polysiphonia (TB)

Economic importance:

(i) Phycocolloids (Sulphated):

- **(a) Agar-agar** is obtained from *Gelidium, Gracilaria* etc (these algae are called agarophytes). It is used to solidify culture medium. It is also used as laxative stabilizer or thickener in preparing jams, jellies, creams, pudding, baby food, ice cream, bakery products.
- **(b) Carrageenin** is obtained from **cell wall of** *chondrus* **crispus and** *Gigartina*. It is used in confectionary, bakery, jelly, creams, as clearing agent in liquors (Beer) and leather finishing, as emulsifier in chocolates, icecreams, sauces, toothpastes paints and cosmetics.

(c) Funori is obtained from *Gloiopeltis*. It is a glue used as adhesive and in sizing textiles, papers etc.

(ii) Food:

Some red algae are edible **e.g. Laver (***Porphyra***), Dulse (***Rhodymenia***), Irish moss (***Chondrus***)**.

Resonate the Concept

- In some red algae it has deposition of **calcium carbonate** and appear coral like and called **coralline e.g.** *Corallina*.
- **Reproduction in red algae -** Male sex organ is called spermatangium that forms nonmotile spermatia. Female sex organ is a flask shaped carpogonium that contains basal swollen carpogyne & upper long neck like trichogyne which receives spermatia from water.
- **Red snow -** Found in polar region due to presence of **Cryophyte algae** like ***Haematococcus nivalus*** **(Red algae),** ***Chlamydomonas nivalus*** (green algae)

TABLE : Divisions of Algae and their Main Characteristics

Classes	Common name	Main pigment	Stored food	Cell wall	Flagellar Number and Position of Insertion	Habitat
Chlorophyceae	Green algae	Chlorophyll a, b	Starch	Cellulose	2-8, equal, apical	Fresh water, brackish water, salt water
Phaeophyceae	Brown algae	Chlorophyll a, c fucoxanthin	Mannitol, laminarin	Cellulose and algin	2, unequal lateral	Fresh water (rare) brackish water, salt water
Rhodophyceae	Red algae	Chlorophyll a, d phycoerythrin	Floridean starch	Cellulose, pectin and poly sulphate esters	Absent	Fresh water (some), brackish water, salt water (most)

Bryophytes (Bryon = moss; Phyton = Plant):

Introduction:

- The term **Bryophytes** coined by **Robert Braun (1864)**.
- **Study of Bryophytes is called Bryology.**
- **Hedwing is known as Father of Bryology while S.R. Kashyap is known as the Father of Indian Bryology**.
- These are the most primitive plants of the **kingdom embryophyta**.

General characters:

(i) These are **first land inhabiting or terrestrial plants**. Bryophytes are non-vascular, autotrophic, seedless, nonflowering plants. These are known as **amphibians of plant kingdom**.

(ii) Habitat: They usually occur in damp, humid and shaded localities.

(iii) Bryophytes include the various mosses and liverworts that are found commonly growing in moist shaded areas in the hills.

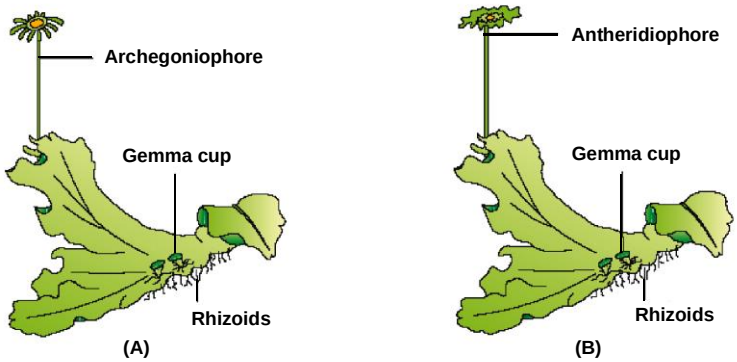


Fig. Marchantia (A) Female Thallus (B) Male Thallus

(iv) Body form:

- The plant body of bryophytes is more differentiated than that of algae.
- It is thallus-like (liverworts) and prostrate or erect (Mosses) and attached to the substratum by unicellular and unbranched rhizoids (Liverworts) or multicellular and branched rhizoids (Mosses).
- They lack true roots, stem or leaves. They may possess root-like (rhizoids), leaf-like (Phylloid) or stem-like (cauloid) structures.
- Thallus is multicellular, thick and **dichotomously branched.**
- The main plant body of the bryophyte is haploid. It produces gametes, hence is called a gametophyte.

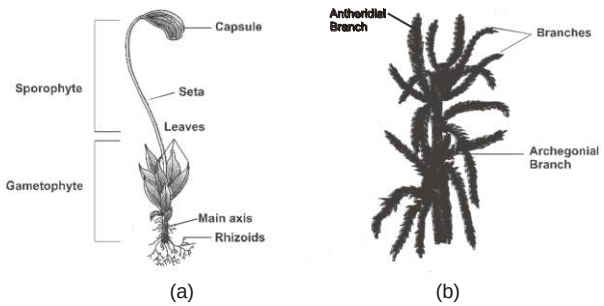


Fig. (a) Funaria (b) Sphagnum (TB)

(v) **Vascular tissues (xylem and phloem) are absent** in both gametophytic and sporophytic phases. The **conduction** takes place through **specialized parenchyma**.

(vi) **Reproduction:**

(a) **Asexual reproduction** – Vegetative propagation takes place in **liverworts by fragmentation, and gemmae** while in **mosses by fragmentation and budding in secondary protonema.**

(b) **Sexual reproduction** – **Oogamous type**

- Sex organs are multicellular and surrounded by **single layered sterile jacket**.
- **Male sex organ** is called **antheridium** which is globular or club shaped and forms **biflagellated antherozoids or sperms (motile male gamete)**.
- **Flask shaped female sex organ** is called **archegonium** that consists of **a swollen venter** and **a tubular neck**.
  - Neck is composed of **6 vertical rows of cells** and encloses **4–10 neck canal cells** while venter has **venter canal cell** and a **single egg cell or oosphere (nonmotile female gamete)**.
- **Water is essential for fertilization**. **Archegonia** secretes **mucilage** rich in **potassium salts / proteins / sucrose** for attracting antherozoids in water.
  - Fertilization is internal and takes place by **zoodiogamy**. Diploid zygote formed in the venter by the fusion of one antherozoid with egg cell.
  - After fertilization zygote immediately divides mitotically and form multicellular embryo.
- **Embryo gives rise to multicellular sporogonium or sporophyte. The latter differentiates into foot, seta and capsule**. **Sporophyte is completely (e.g.** *Riccia***) or partially (e.g.** *Funaria***) parasite on gametophyte**.
- **Some cells of the sporophyte capsule called as Spore mother cells or sporocytes** undergo **sporic meiosis** and form haploid **meiospores** which are alike or **homosporous**.
- On germination, **spore** forms **new gametophytic plant** either **directly (e.g. liverworts and hornworts)** or indirect by juvenile filamentous, green, multicellular **protonema stage (e.g. moss)**.

Economic importance:

- **(i)** Mosses form **dense mats** on the soil, they reduce the impact of falling rain and **prevent soil erosion.**
- **(ii)** Mosses along with lichens are the first organisms (pioneer species) to colonise rocks **(succession)** and hence, are of great ecological importance.
- **(iii)** Mosses provide food for herbaceous mammals, birds and other animals.
- **(iv)** Species of Sphagnum, a moss **(peat moss)**, provide peat that have long been used as fuel.
- **(v)** *Sphagnum* has **good water holding capacity** therefore it is widely used as packing material for trans-shipment of living material because of their capacity to hold water.

(vi) Dry clean, disinfected *Sphagnum* is used as a replacement of absorptive cotton for wound dressing.

(vii) **Sphagnol,** an **antibiotic** that is derived from distillation of peat tar which is effective against **skin diseases**.

(viii) *Polytrichum* has ability to dissolve stones in kidney and gall bladder.

Classification of Bryophyta:

- Bryophytes are classified into three classes - Hepaticopsida, Anthocerotopsida and Bryopsida.

(i) Hepaticopsida – (e.g. Liverworts)

- The liverworts grow usually in moist, shady habitats such as banks of streams, marshy ground, damp soil, bark of trees and deep in the woods.
- The thallus is dorsiventral and closely appressed to the substrate.
- The leafy members (like *Porella*) have tiny leaf-like appendages in two rows on the stem-like structures.
- **Gemmae:** Gemmae are green, multicellular, asexual buds, which develop in small receptacles called gemma cups located on the thalli. The gemmae become detached from the parent body and germinate to form new individuals.
- During sexual reproduction, male and female sex organs are produced either on the same (*Riccia*) or on different thallus (*Marchantia*).

(ii) Anthocerotopsida – (e.g. Hornworts)

(iii) Bryopsida – (e.g. Mosses)

- Gametophyte which consists of two stages - Protonema stage and Leafy stage.

Protonema stage:

- The first stage is the protonema stage (primary protonema), which develops directly from a spore. It is a creeping, green, branched and frequently filamentous stage.

Leafy stage:

- The second stage is the leafy stage, which **develops from the secondary protonema** as a lateral bud. They consist of upright, slender axes bearing spirally arranged leaves (sex organ present on tip of branches).

Note:

- In India, they are abundantly found in Himalayan region hence **Western Himalaya is known as gold mine of bryophytes**.
- **Life cycle of bryophyte is haplodiplontic** and **alternation of generation** is **heteromorphic**.
- Dominant phase is gametophyte (sexual generation) and sporophyte (asexual generation) is completely / partially parasite on gametophyte.
- **The sporophyte in mosses (like *Funaria*) is more elaborate than that in liverworts (like *Riccia*).**
- Mosses have an elaborate mechanism of spore dispersal (by peristome teeth).
- The presence of leaf like structure in gametophyte is the unique character of Moss because in plant kingdom any gametophyte do not have leaf like structure.
- **Elator :** Diploid, elongated cells present in sporangia along with haploid spores. It is **hygroscopic** in nature and when dried it **help in spore dispersal by air.** Elators found in liverwort but absent in mosses.
- Most of Bryophytes e.g. *Riccia* are monoecious and ***Marchantia* is dioecious.**

Resonate the Concept

- Some Bryophytes are **aquatic** like *Riccia flutians, Riccia abuensis, Ricciocarpus natans, Riella*, **some sp. of** *Sphagnum, Fontinalis* etc.
- Some Bryophytes are **saprophytes e.g.** *Cryptothallus mirabilis*, *Buxbaumia aphylla*.
- **Largest bryophyte is** *Dawsonia* **(moss - 70 cm) and smallest bryophyte is** *Zoopsis argentea* **(liver wort).**
- **Cell wall in liverworts** is composed of **cellulose and pectose** whereas in **mosses** it is of **hemicellulose and pentosan**. **Reserve food** is **starch**.
- In *Riccia* foot & seta are absent only capsule is present. In this plant elaters are also absent and they are replaced by **nurse cells** which are nutritive in function. Spore dispersal occur by **decay of capsule wall**.

Marchantia :

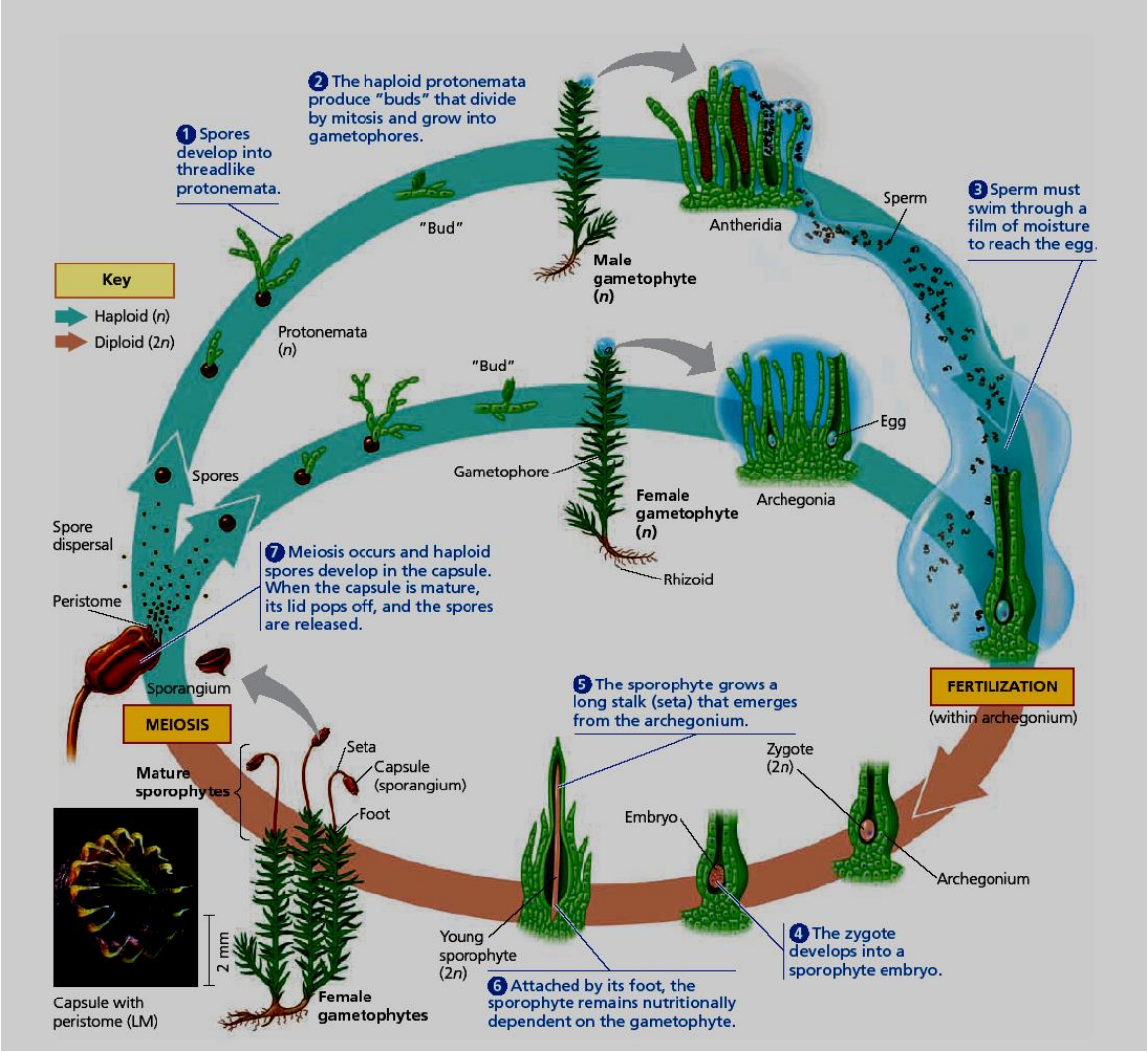
1. It is a thalloid liverwort, grow prostrately on the surface and show dichotomous branching.
2. The thallus have dorsal groove on the upper surface and **rhizoids and scales / amphigastria** on lower (ventral) surface (4-6 row).
3. Rhizoids are unicellular, arising from the middle raised portion and are of two types namely **smooth walled and tuberculate**. Tuberculate rhizoids have peg like ingrowths from the inner wall.
4. Vegetative reproduction occur by progressive death, regeneration, adventitious, branches.
5. **Gemmae** perform asexual reproduction and are formed inside small **gemma cups** developing middorsally on vegetative thalli. **Gemma cups** have eight shaped (8) gemmae and mucilagenous hairs.
6. In sporophyte capsule spore mother cell divide by meiosis, producing haploid spores while elater mother cells simply elongates and form diploid elaters. The elaters have sipral thickening bands with the help of which it show **xerochasy** and help in breaking capsule wall and ultimately release of spores.

Funaria

- The main axis of gametophyte act as male shoot while its branches act as female shoot branch.
- Funaria is **Monoecious and Autoicous plant** (male and female sex organs are on same plant but on different branches).
- Sporophyte is partially dependent on gametophyte.
- Mosses have radial symmetry.

Capsule of mosses:

- Basal part is photosynthetic called apophysis which bear primitive type of stomata.
- Capsule develops chlorenchyma for photosynthesis (partial parasite on gametophyte).
- Central part is called as columella (non-photosynthetic).
- Opening of capsule is surrounded by 32 acellular structure arranged in two whorls called peristome teeth.



Comparsion of Hepaticopsida, Anthoceratopsida and Bryopsida			
S. No.	**Hepaticopsida**	**Anthoceratopsida**	**Bryopsida**
1	Plant body is Thalloid/ Foliose.	Plant body is Thalloid.	Plant body is leafy and erect.
2	Rhizoids are Unicellular and unbranched.	Rhizoids are Unicellular and unbranched.	Rhizoids are multicellular and branched.
3	Scales present.	Scales absent.	Scales absent.
4	Columella Absent in capsule.	Columella present in capsule.	Columella present in capsule.
5	Elaters present, they help in dispersal of spores as well as dehiscence of capsule.	Pseudoelators present, function of former is similar as elaters.	Elaters absent but peristome teeth are present that help in dispersal of spores.
6	Sporogonium is completely parasite on gametophyte	Sporogonium is partially parasite on gametophyte.	Sporogonium is partially parasite on gametophyte.
7	Eg:- *Riccia, Marchantia Pellia, Porella.*	Eg:- *Anthoceros, Notothallus*.	Eg: *Funaria Sphagnum*, *Polytrichum.*

Resonate the Concept

True Mosses:

S.No.	Common name	Botanical name
1	Peat / Bog / Turf Moss	*Sphagnum*
2	Cord Moss / Green moss	*Funaria*
3	Hair Cap Moss	*Polytrichum*
4	Brook Moss	*Fontinalis*
5	Granite moss	*Andraea*
6	Maiden hair Moss	*Pogonatum*
7	Twisted Moss	*Tortula*
8	Black Moss	*Grimmia*

False Mosses:

S.No.	Common name	Botanical name
1	Reindeer moss	*Cladonia rangiferina* (Lichen)
2	Iceland moss	*Cetraria icelandica* (Lichen)
3	Wolf moss	*Letharia* (Lichen)
4	Irish moss	*Chondrus crispus* (Red algae)
5	Ceylon moss	*Gracilaria* (Red algae)
6	Spanish florida moss	*Tillandsia* (angiosperm)
7	Bird's nest moss	*Selaginella* rupestris (Pteridophyte)
8	Club moss	*Lycopodium* (Pteridophyte)

Pteridophytes (Pteris = feather, phyton = plant):

- The term **pteridophyta** coined by **Haeckel (1866)**.
- The study of pteridophytes is called pteridology**.**
- **F.O. Bowers** is called **'Father of pteridology'** while **S.S. Bir** is known as **'Father of Indian Pteridology'**.
- These are **seedless**, spore producing land plants which are popularly known as **botanical snakes** or **vascular cryptogams (vascular tissues xylem and phloem present)**.

General characters:

(i) Most of the plants are terrestrial but still require water fertilization so grows well in cool, damp and shady places.

(ii) Most of the pteridophytes are herbaceous except **tree ferns like** *Cyathaea, Alsophila*.

(iii) The main plant body is sporophyte that is differentiated into true root, stem and leaves.

(iv) The leaves in pteridophyta are small (microphylls) as in Selaginella or large (macrophylls) as in ferns.

(v) Primary root is short lived. Later on the former is replaced by adventitious roots developed from stem.

(vi) Vascular tissue first time developed in pteridophytes.

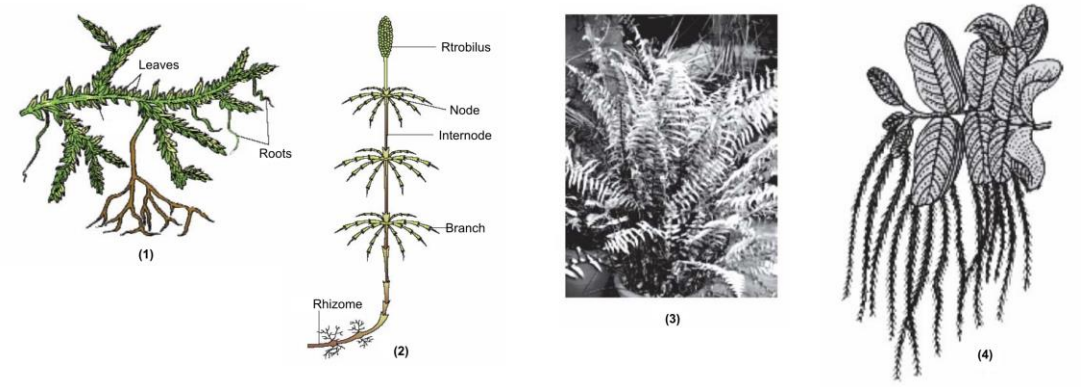


Fig. Pteridophytes : (a) Selaginella (b) Equisetum (c) Fern (d) Salvinia

Life cycle of Pteridophytes:

1. Main plant body is sporophyte (2N).

2. Sporophyte posses tropophylls (photosynthetic leaves) and sporophylls (Spore forming leaves)

3. Sporophyll posses spore forming structure (Sporangia) on abaxial surface (Ventral / lower surface) of leaf.

4. In most pteridophytes tropophylls and sporophyll are distinct while in others like ferns each leaf can perform both function.

5. Presence of photosynthetic sporophyll is unique feature of pteridophyte.

6. Sporangia may present in groups on sporophylls called as Sori.

7. Sporangia contain spore mother cell (2N) which undergoes sporic meiosis to form spores (N)

8. Spores (N) released from sporangia and reach the soil and germinate to develop into gametophyte (Prothallus).

9. **Prothallus is small, inconspicuous, multicellular, independent, free living, monoceious, mostly photosynthetic (sometimes saprophytic), non-vascular and thalloid gametophyte.**

10. Prothallus require cool, damp, shady place to grow.

11. In most of **homosporus pteridophytes (e.g. Pteris, Equisetum, Adiantum, Dryopteris and Lycopodium)** prothallus is monoecious (male and female sex organ present on same prothallus).

12. Male sex organ (antheridia) and female sex organ (archegonia) develop on protoallus.

13. Antheridia form Bi-flagellated (Selaginella) or multiflagellated (Most of pteridophytes like *Dryopteris*) male gamete / Antherozoids by mitosis.

14. Archegonia form egg in venter and have neck of 4 rows.

15. Male gametes swim in water (Zoodiogamy) and reach upto mouth of archegonia where fertilization take place to form zygote (2N).

16. Zygote develops into embryo and form main sporophytic plant.

Heterosporus pteridophytes

1. Some of the pteridophytes are **heteroporus (e.g. *Azolla, Isoetes, Marsilia, selaginella* and *salvinia*)** in which two type of spores are formed, microspore (in microsporangia) and megaspore (in megasporangia).

2. Microspore produce male gametophyte and megaspore form female gametophyte **(Dioecious prothallus)**.

3. The female gametophyte in these plants are retained on parent sporophyte for variable periods (Prococious development).

4. Male gametophyte form male gametes (antherozoids) which move through water to reach the neck of archegonia (female gametophyte).

5. Fertilization and embryonic development take place within the female gametophyte. This event is precursor to seed habit and considered important step in evolution.

Seed habit in pteridophytes:

- Seed habit originated in extinct plant - Seed ferns / Pteridosperms / Cycadofilicales (intermediate between cycads and ferns)
- The important requirements of the seed habit are –
  (a) Development of heterospory
  (b) Functioning of only one megaspore mother cell.
  (c) Degeneration of three megaspores and formation of female gametophyte inside the megasporangium.
  (d) Embryo develop for some time inside the megasporangium.

Economic importance:

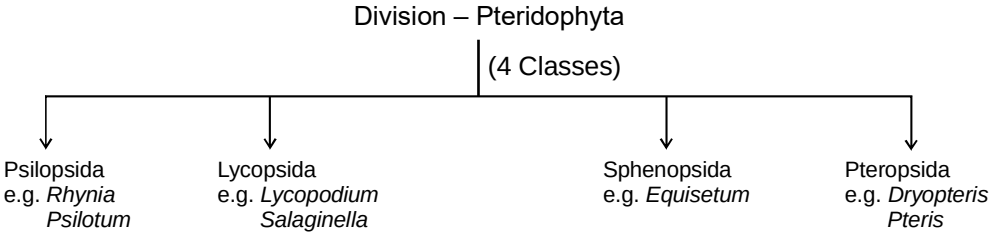
(i) Pteridophytes are used for medicinal purposes and as soil-binders.
e.g. (a) An antihelminthic drug is obtained from rhizomes of *Dryopteris*.
(b) Homeopathic medicine is obtained from *Lycopodium*.
(c) *Selaginella* is helpful in soil conservation.

(ii) They are also frequently grown as ornamentals. e.g. Ferns.

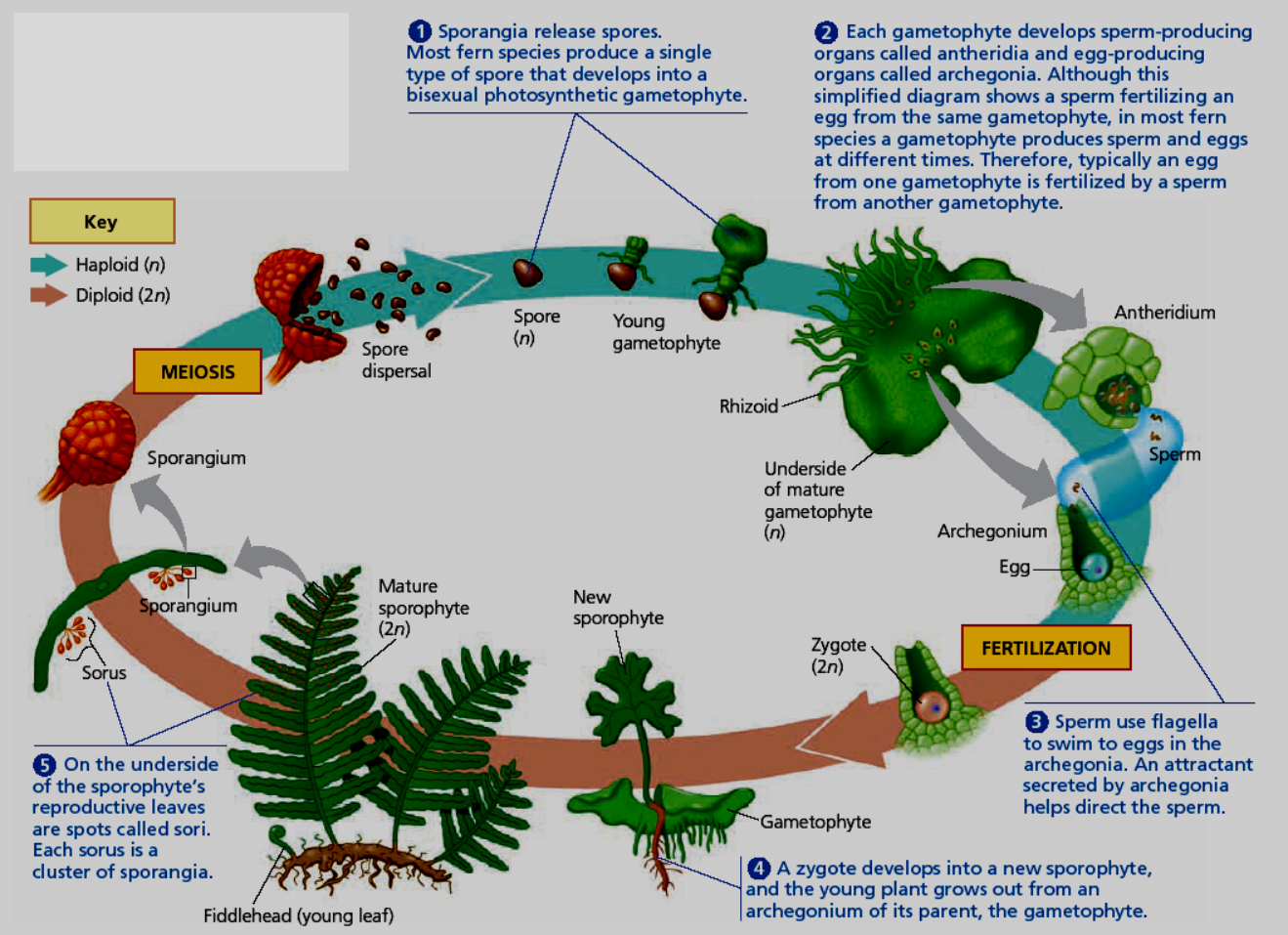
(iii) Food : Sporocarps of ***Marsilea*** **(a water fern) contains starch** and are used as food article by certain tribes.

Classification of Pteridophytes:

Pteridophytes are classified in to 4 classes.



- **Psilotum – Living fossil**
- **Rhynia – Primitive vascular extinct / fossil pteridophyte.**
- **Lycopodium –** Club moss
- **Selaginella –** Ressurrection plant. Scaly / Ligulate leaves present.
  Selaginella bryopteris – Sanjeevani booti.
- **Equisetum** contain silica which causes forest fire.
- Most of pteridophytes are **pteropsida,** commonly called as "ferns". e.g. Azolla, Adiantum (walking fern), Pteris and Dryopteris.



Note:

(a) Homosporus pteridophytes are monoecious while heterosporus pteridophyte are dioecious.

(b) Independent or most distinct or heteromorphic or heterologus alternation or generation found in pteridophyte.

(c) Cone / strobili found in lycopsida (*Lycopodium, Selaginella*) and sphenopsida (*Equisetum*).

(d) Pteridophytes have vascular tissue even then their distribution is limited because (i) gametophyte (prothallus) do not have differentiated body and roots for water absorption. (ii) They require water for fertilisation (Zoodiogamy).

(e) Life cycle - Diplo-haplontic.

(f) Sexual reproduction - Oogamous type.

(g) **Sporocarp -** In aquatic pteridophyte (Marsilia, Azolla, Salvinia) sporangia are formed in sporocarp (Sporangia bearing body).

1. Some pteridophytes are found in **xerophytic** conditions **e.g.** *Selaginella lepidophylla***,** *S. rupestis***,** *Equisetum arvense*. Some are **epiphytic e.g.** *Lycopodium phlegmaria, Pleopeltis, Ophioglossum*. Some are **aquatic e.g.** *Marsilea, Azolla, Salvinia, Isoetes.*
2. Pteridophytes stems may be underground or aerial. The branching of stem may be **dichotomous e.g.** *Marsilea***,** *Lygodium* or **monopodial e.g.** *Lycopodium, Selaginella*.
3. All the vegetative parts bear vascular tissues that form different types of steles. Vessels are usually absent in xylem similarly companion cells, sieve tubes and fibres are absent in Phloem but sieve cells are present.
4. In microphyllous types, Leaves are small and unveined while stem is comparatively longer and leaf traces do not leave leaf gaps in the stele **e.g.** *Lycopodium, Selaginella, Equisetum* while in megaphyllous types stems are short and leaves are large (called frond) with branched venation. Leaf gaps are found in stele **e.g. ferns (***Pteridium, Dryopteris, Pteris***)**.
5. Development of sporangia is of two types.
   (i) Eusporangiate type : Sporangium is developed by a group of sporangial initials **e.g.** *Lycopodium, Selaginella, Equisetum***.**
   (ii) Leptosporangiate type : Sporangium is developed by single initial cell. **e.g. ferns.**
6. *Azolla* **:** It is **smallest pteridophyte**. It is **aquatic fern** that is used as **biofertilizer** due to presence of **nitrogen fixing cyanobacteria-** *Anabaena* **in its leaves**.
7. *Rhynia* **and** *Cooksonia* of Psilopsida are **oldest known fossil vascular pteridophytes** on land.
8. *Isoetes* **(Quillwort) : Secondary growth** is found in its stem.
9. **Synangium :** A compound fruiting body formed by the lateral fusion of individual sporangia **e.g.** *Psilotum***.**
10. **Circinate Ptyxis –** Young leaves of ferns coiled like dog tail this is called circinate ptyxis or vernation
11. **Aquatic ferns– e.g.** *Marsilea, Salvinia, Azolla***.**
12. *Ophioglossium* **has maximum number of chromosomes in plant kingdom (2n = 1262).**

Equisetum (Horse tail) : *Scouring rushes*.

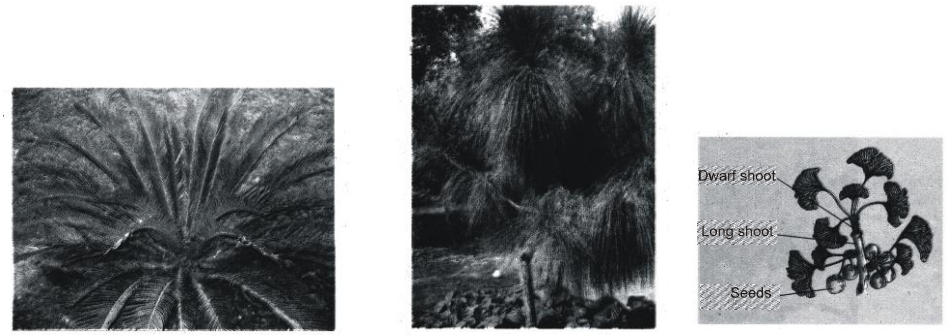
- It is the only living member of its group **sphenopsida**.
- Stem has two parts - branched, underground **rhizome** which is nonphotosynthetic and less branched upright, aerial branches which are photosynthetic.
- The **epidermis is impregnated with silica** on the outer side which makes the outer surface rough.
- **Plant is homosporous and spores have elaters**. The **elaters in this case are haploid** because they are formed by outer spore wall.

S.No.	Common name	Botanical name
1	Walking fern, Maiden hair fern.	*Adiantum caudatum*
2	Bracken fern or sun fern	*Pteridium*
3	Male shield fern	*Dryopteris*
4	Spike moss, little club moss	*Selaginella*
5	Club moss, trailing evergreen	*Lycopodium*
6	Horse tail, Scouring rushes	*Equisetum*

Differences between Bryophytes and Pteridophytes		
S. No.	**Bryophytes**	**Pteridophytes**
1	Plant body is gametophyte.	Plant body is sporophyte.
2	Plant body is thalloid that does not differentiate into roots, stem and leaves.	Plant body is differentiated into roots, stem and leaves.
3	Vascular tissue is absent.	Vascular tissue is present.
4	Sporophyte is parasite over gametophyte.	Total independent sporophyte.
5	Antherozoids are biflagellate.	Antherozoids are multiflagellate.
6	Gametophyte is well developed.	Gametophyte is reduced, independent and short lived.

Gymnosperms (gymnos–naked, sperm–seed) :

- The term **Gymnosperm** coined by **Theophrastus.**
- **The study** of **Gymnosperm** is called **Gymnospermology**.
- These are **perennial woody plants or ancient seed bearing phanerogamic sporophytic plants without flowers, ovary and fruits**. They are popularly called **naked seeded vascular plants**.



(a) (b) (c)

Fig. Gymnosperms: (a) Cycas (b) Pinus (c) Ginkgo

General characters:

(i) Habit and Habitat :

- Gymnosperms include medium-sized trees or tall trees (Sequoia) and shrubs (Ephedra).
- The giant redwood tree **Sequoia** is one of the tallest tree species.
- These are found **mainly** in cold temperate climates but cycads occur in warmer areas.
- In India Gymnosperms are found on Himalayan mountains.

(ii) Morphological character :

- **Root :** The roots are generally tap roots.
- Roots in some genera have fungal association in the form of **mycorrhiza (Pinus),** while in some others **(Cycas)** small specialised roots called **coralloid roots** are associated with N_2-fixing cyanobacteria.
- **Stem :** The stems are unbranched (Cycas) or branched (Pinus, Cedrus / Deodar).
- **Leaf :** The leaves may be simple or compound.
- In Cycas the **pinnate leaves** persist for a few years **(Perrenial leaves)**.

- The leaves in gymnosperms are well-adapted to withstand extremes of temperature, humidity and wind (Xerophytic adaptation).
- In conifers (e.g. pinus), the **needle-like leaves** reduce the surface area and their thick cuticle and sunken stomata also help to reduce water loss.

(iii) Anatomical character :

- **Stem** bears **eustelic condition**.
- **Vessels are absent in xylem of gymnosperms except gnetales (e.g. Welwitschia, Ephedra, Gnetum)**.
- Phloem has **sieve cells and albuminous** cells and sieve tubes and companion cells are absent.
- Xylem has trachied but vessels absent.
- Secondary growth occurs in stem and root.
- Bordered pits are present.
- **Wood of gymnosperms** is **homoxylous, nonporous and soft.**

Life cycle of gymnosperms

(1) The gymnosperms are **heterosporous**; they produce haploid microspores and megaspores.

(2) The two kinds of spores are produced within sporangia that are borne on sporophylls which are **arranged spirally** along an axis to form **lax** (loosely packed) or compact **strobili or cones**.

(3) The male or female cones or strobili may be borne on the same tree (Pinus- Monoecious) and in *cycas* and *ginkgo* (Dioecious) male cones and megasporophylls are borne on different trees.

(4) Male cone -

- The strobili bearing microsporophylls and microsporangia are called microsporangiate or male strobili.
- The microspores develop into a male gametophytic generation which is highly reduced and is confined to only a limited number of cells (Cycas - 5 cells and Pinus - 6 cells).
- This reduced gametophyte is called a pollen grain.
- The development of pollen grains take place within the microsporangia.

(5) Female cone -

- The cones bearing megasporophylls with ovules or megasporangia are called macrosporangiate or female strobili.
- The ovules are borne on megasporophylls which may be clustered to form the female cones.
- The nucellus (2N) is protected by envelopes / integument (unitegmic) and the composite structure is called an ovule or integumented megasporangium.
- The megaspore mother cell (2N) is differentiated from one of the cells of the nucellus.
- The megaspore mother cell divides meiotically to form four megaspores (N) out of which 3 megaspore degenerated.
- One of the megaspores (functional) enclosed within the megasporangium develops into a multicellular female gametophyte (also known as endosperm) that bears **two or more archegonia** or female sex organs.
- The multicellular female gametophyte is also retained within megasporangium / ovule.

NOTE :

- Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. They remain within the sporangia retained on the sporophytes.
- The development of male gametophyte and female gametophyte take place within microsporangia and megasporangia respectively.

(6) Pollination and Fertilization -

- The pollen grain is released from the microsporangium.
- They are carried in air currents (Anemophily) and come in contact with the opening of the ovules borne on megasporophylls.
- Pollen grain is released in 3 celled stage in *Cycas* and 4 celled in *Pinus.*
- The pollen tube carrying the male gametes (two) grows towards archegonia in the ovules and discharge their contents (two male gametes) near the mouth of the archegonia.
- One male gamete fuses with female gamete and another male gamete degenerates. The fertilisation is performed which results in zygote an then embryo formation within the ovule.
- After fertilisation, zygote develops into an embryo and the ovules into seeds.
- These seeds are not covered by ovary (naked seed).

NOTE:

- Archegonia is without neck in gymnosperm.
- Polyembryony is common in seeds of gymnosperms.
- Antheridia is observed upto pteridophytes only and archegonia observed upto gymnosperm.
- Gymnosperm are classified into Cycadophyta and Coniferophyta (Higher gymnosperm).
- Cycadophyta include lower gymnosperm in which male gamete is motile e.g. Cycas.
- Coniferophyta include higher gymnosperm like Ginkgo, Pinus, Cedrus, Abies, Sequoia and Gnetales (Gnetum, Welwetschia and Ephedra).
- **Transfusion tissue -** Found in Gymnosperm leaves around vascular bundle. It include tracheid (dead cell), Parenchyma and albuminous cell.

Economic Importance:

(1) Source of Wood - e.g. *Cedrus deodara* (deodar, strongest of all soft wood), *Sequoia* (red wood tree), *Pseudosuga* (Douglos fir), *Taxodium*, *Taxus* (Yew).

(2) Food - Sago a kind of **starch** is obtained from **cortex and pith of stem and seeds of Cycas**.

The **Roasted seeds of** *Pinus gerardiana* **(Chilgoza)** are used as dry fruit.

Seeds of *Ginkgo* biloba are eaten in china and japan.

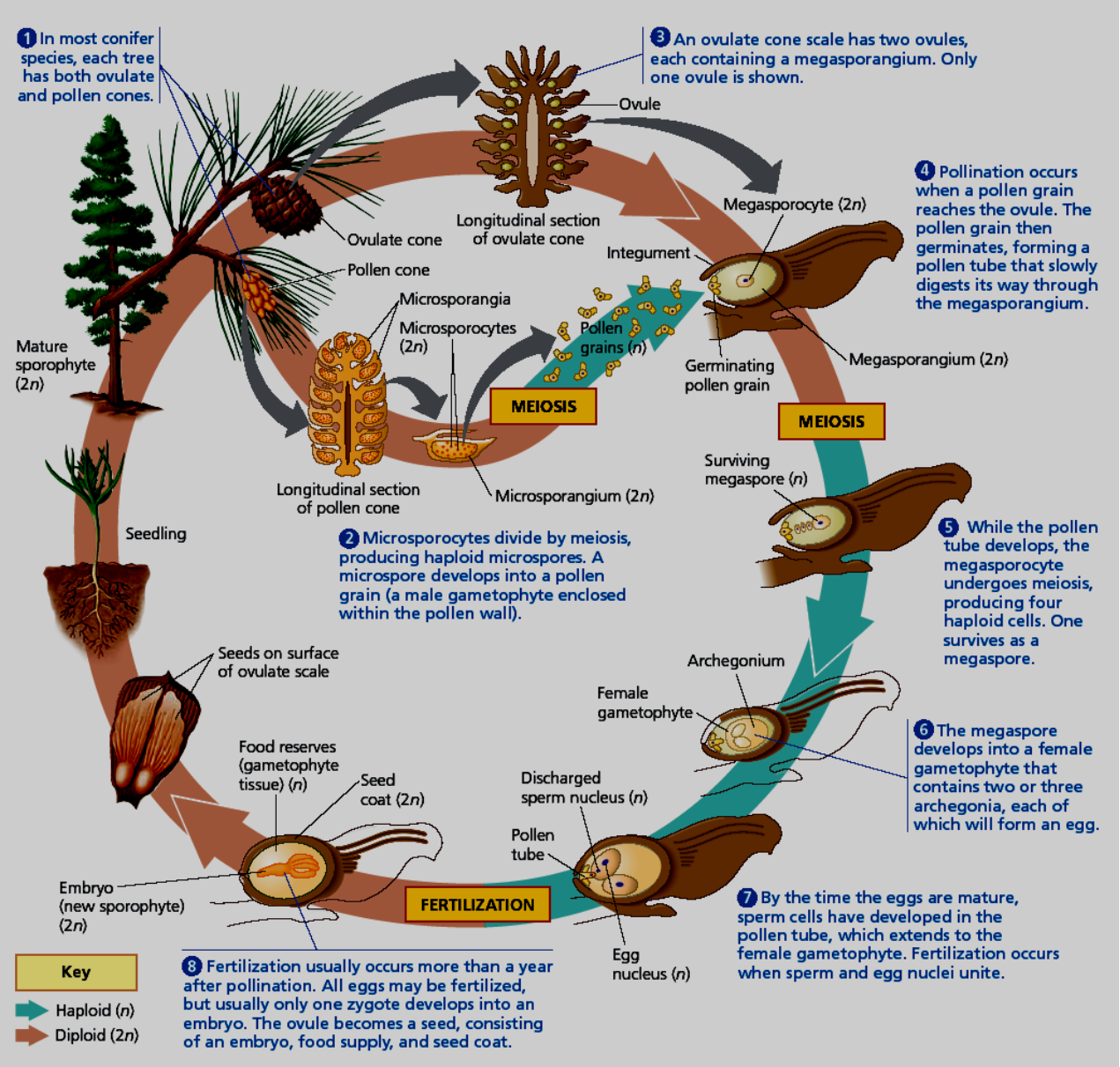
(3) Cedar wood oil is obtained from **stem of** *Juniperus virginiana* **(Red cedar)** and used as **immersion oil** in **oil immersion lens**.

(4) Medicinal use - Ephedrine is obtained from **stem branches of** *Ephedra* and used to cure **cough, cold, bronchitis, asthma and fever**.

Taxol is extracted from **Taxus baccata (yew)** and used in the treatment of **cancer**.

(5) *Canada balsam* is a **turpentine** extracted from *Abies balsamea* used in **mounting of permanent slides**.

(6) Many Gymnosperms are grown in the gardens as ornamental plants **e.g.** *Cycas, Taxus, Thuja,* **(Morpankh),** *Araucaria excelsa* **(x-mas /christmas tree),** *Ephedra, Cupressus, Ginkgo* **(Pagoda tree / Maiden hair tree),** *Araucaria imbricata* **(Monkey's puzzle)**.



Differences between Cycas and Pinus		
S.No.	**Cycas**	**Pinus**
1.	Unbranched stem	Branched stem
2.	Dioecious	Monoecious
3.	Pinnate, spirally arranged leaves	Needle like scally leaves
4.	Coralloid root present	Mycorrhizal roots present
5.	Male gamete motile (Zooido-siphonogamy)	Male gamete non-motile (Siphonogamy)
6.	Manoxylic wood	Pycnoxylic wood
7.	Male gametophyte - 5 cells only	Male gametophyte - 6 cells only
8.	Pollination at 3 cell stage.	Pollination at 4 cell stage.
9.	Megasporophyll contains 1-5 ovule	Megasporophyll contains 2 ovule
10.	Male cone present and Female cone absent	Male cone and female cone present
11.	Pollen grain are without wings.	Seed and pollen grain are winged.
12.	Pollen grain contain 1 prothalial cell.	Pollen grain contain 2 prothalial cell.

Differences between Pteridophytes and Gymnosperm		
S.No.	**Pteridopohytes**	**Gymnosperms**
1	**These are found in moist and shady places.**	**They are xerophytic.**
2	**Secondary growth is absent.**	**Secondary growth is quite common.**
3	**Ovules absent.**	**Ovules present.**
4	**Pollen tube is not formed.**	**Pollen tube is formed.**
5	**Neck canal cell is found in the archegonium.**	**It is absent in archegonium.**
6	**Seed formation does not take place.**	**Seed formation takes place.**

Resonate the Concept

1. *Ephedra foliata* is naturally occurring **gymnosperm in Rajasthan**.
2. *Sequoia sempervirens* **is tallest Gymnosperm** while *Zamia pygmia* **is smallest gymnosperm.**
3. **Double Fertilization** is usually **absent in Gymnosperms** but found in *Ephedra*.
4. ***Ginkgo biloba*-**
   - Common name - **Maiden hair fern**.
   - **Dioecious** and contains 3 - layer integumented ovule. Edible endosperm (seed).
   - It belong to higher gymnosperm but exceptionally it have motile male gamete.
   - Bears **root nodules** formed by **a Nitrogen fixing actinomycete bacteria -** *Frankia***.**
5. *Cycas, Ginkgo* **and** *Sequoia* **are considered as 'living fossils'**. *Ginkgo* is extinct in wild.
6. **Triassic and jurassic period of mesozoic era was age of Gymnosperms. At that time they cover 1/3rd part of the world's forests**.
7. **Endosporic germination -** For the formation of male & female gametophytes microspore and functional megaspore germinate within microsporangia and megasporangia. This germination of spore is called as endosporic germination.
8. In Pteridophyte and Gymnosperm **seed contain three generation** locked one within another -
   (a) Parent sporophyte in the form of seed coat and persistent nucellus.
   (b) Female gametophyte which store food.
   (c) Future sporophyte in the form of embryo.
9. In angiosperm seed do not contain gametophytic but it contain two generation -
   (a) Parent sporophyte in the form of seed coat and persistent nucellus.
   (b) Future sporophyte in the form of embryo.
10. **Gnetales -** e.g. Gnetum, Welwetschia and Ephedra.
    - They are most advanced gymnosperm.
    - Archegonia absent and vessels in xylem present.
    - ***Gnetum*** - *Gnetum* show many similarities with angiosperms like reticulate venation in their leaves, presence of vessels in xylem absence of archegonia and presence of two cotyledons. But still it is gymonosperm because ovules are naked.
11. Ovule, male gamete, egg and male cone of cycas are largest in plant kingdom.

Angiosperms (angeion = vessel, sperma = seed) -

- Angiosperms are most advanced plants, that have flowers, covered ovules / seeds.
- They are most dominant and highest evolved plants on this earth. **Tertiary period of coenozoic era** is called **Age of angiosperms**.
- Angiosperms have been reported in every habitat. All types of plants are found in angiosperms– annuals/biennials/perennials; autotrophs/parasites/epiphytes/insectivorous/saprophytes.

General characters:

(i) The main plant body is sporophyte that is differentiated into roots, stem and leaves.

(ii) The characteristic features is **presence of vessels in xylem** and **presence of companion cells in phloem**.

(iii) Wood is hard, porous, monoxylic. Secondary growth is found in dicots.

(iv) **Antheridia and archegonia are absent. Presence of flowers is most important feature. Sex organs enclosed in the flower**.

(v) Flower consists of 4 whorls – **Calyx, Corolla, Androecium, and Gynoecium. Androecium (stamen)** is **microsporophyll** and **Gynoecium (carpel)** is **megasporophyll**.

(vi) Megasporophyll or carpel contains ovary, style and stigma.

(vii) **Ovules are enclosed within ovary**. **Pollen grains** are shed at **2-3 celled stage** and fall on stigma.

(viii) **Double fertilization (syngamy and triple fusion) is characteristic feature that is found only in angiosperms.**

(ix) **Endosperm is triploid (3n) and formed after double fertilization.**

(x) **Ovules & ovary** are converted into **seeds and fruits** respectively after fertilization.

(xi) Seed has two generations–a parent sporophyte and future sporophyte but gametophytic generation is absent in seeds.

(xii) **Embryo has 1–2 cotyledons**.

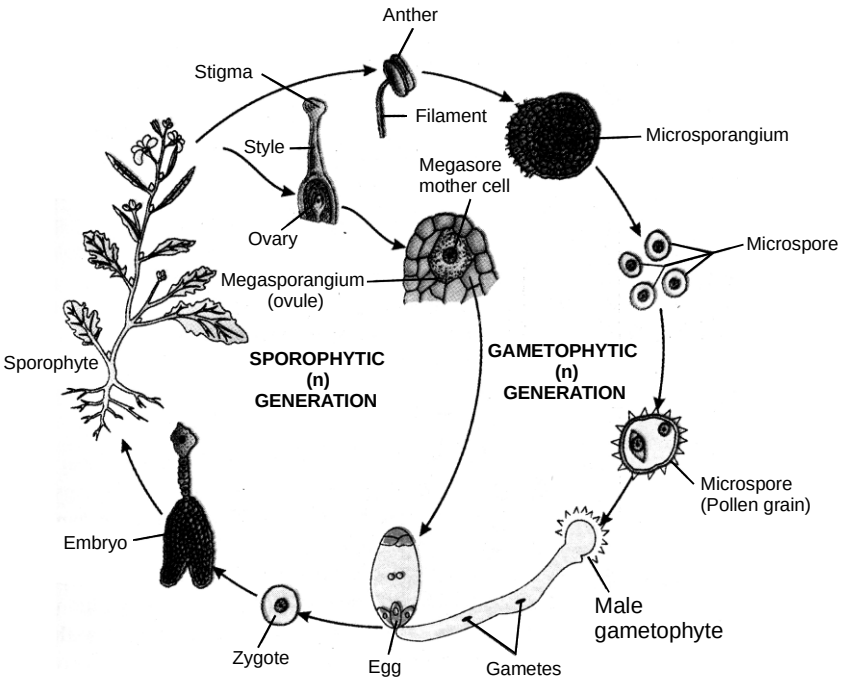


Fig: Life of cycle of an angiospermic plant

(TB)

Differences Between Gymnosperms and Angiosperms		
S.No.	**Gymnosperms**	**Angiosperms**
1	Flowers and fruits are absent.	Flowers and fruits are found.
2	Seeds are naked & exposed directly on the surface of megasporophylls.	Seeds lie inside ovary/fruit.
3	Seeds are sessile & unitegmic.	Seed is borne on a stalk (funiculus) & uni / bitegmic.
4	Archegonia present.	Archegonia absent.
5	Double fertilization is absent.	Double fertilization is present.
6	Endosperm is haploid (n) and formed before fertilization.	Endosperm is triploid (3n) and formed after double fertilization.
7	Seed bears three generations (parent-sporophyte, gametophyte and future sporophyte).	Seed bears two generations (parent-sporophyte and future sporophyte).
8	Pollination is direct and by wind only.	Pollination is indirect and by many agencies.
9	Vessels in xylem, sieve tubes and companion cells in phloem are absent.	Vessels in xylem, sieve tubes and companion cells in phloem are present.

Resonate the Concept

1. **Smallest angiospermic plant** is *Wolffia microscopica* **(1 mm)** while **largest angiospermic plant** is *Eucalyptus regnans* **(114 mt or 375 feet– tallest angiospermic tree)**.
2. **Rootless Angiosperms:** *Utricularia, Ceratophyllum, Myriophyllum***.**
3. Four types of Parasitic Angiosperms are found in nature.
   - **(i) Total root parasite : e.g.** *Orobanche* **on roots of crucifers,** *Rafflesia arnoldi* **(largest flower, Queen of Parasites) and** *Balanophora* **on roots of forest trees,** *Striga* **(witch weed) on Sugarcane and** *sorghum*.
   - **(ii) Total stem parasite – e.g.** *Cuscuta reflexa* **(dodder, Amarbel),** *Arceuthobium* **(smallest parasite)**
   - **(iii) Partial root parasite – e.g.** *Santalum album* **(Sandal wood tree)**.
   - **(iv) Partial stem parasite – e.g.** *Viscum* **(Mistletoe),** *Loranthus*.
4. **Monocarpic and polycarpic plants :** Monocarpic plants are annual/perennial and they form fruits and seeds only once in their life time **e.g. Bamboo, Wheat, Rice, Banana,** *Agave***.**
   Polycarpic plants form flowers and fruits every year after maturity **e.g. Mango,** *Eucalyptus***, Apple**.

Differences between Dicots and Monocots		
S.N.	**Dicots**	**Monocots**
1	Number of Cotyledons is 2 in the embryo of seed.	Number of Cotyledons is 1 in the embryo of seed.
2	Flower is mostly pentamerous	Flower is mostly trimerous.
3	Tap root system is present.	Adventitious root system is common.
4	Leaves are dorsiventral, bifacial & bear reticulate venation.	Leaves are isobilateral, unifacial and have parallel venation.
5	Vascular bundles of stem are arranged in a ring & they are conjoint, collateral, open (cambium present).	Vascular bundles of stem are scattered in the ground tissue & they are conjoint, collateral, closed (cambium absent).
6	Secondary growth is common in stem and roots.	Secondary growth is usually absent.

PLANT LIFE CYCLES AND ALTERNATION OF GENERATIONS

- In plants, both haploid and diploid cells can divide by mitosis. This ability leads to the formation of different plant bodies - haploid and diploid.
- The haploid plant body / gametophyte produces gametes by mitosis. This plant body represents a gametophyte.
- Following fertilisation, the zygote also divides by mitosis to produce a diploid sporophytic plant body.
- Haploid spores are produced by this sporophytic plant body by meiosis.
- Spore 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.

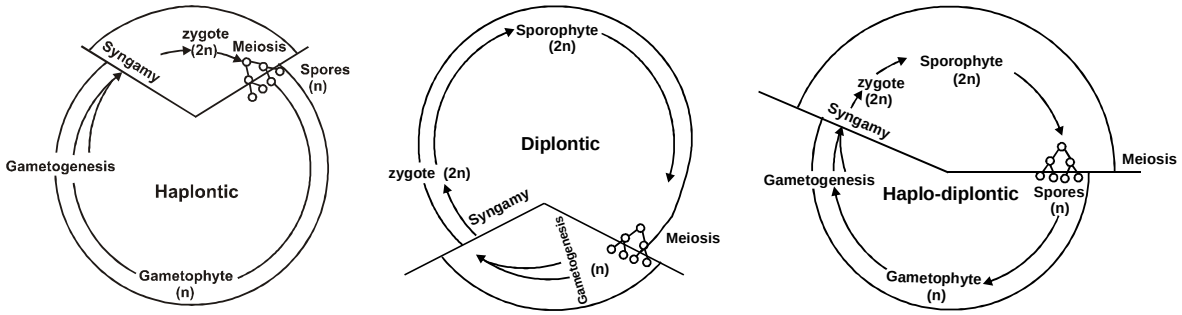
  However, different plant groups, as well as individuals representing them, differ in the following patterns:

  (a) Haplontic:
  - The main plant body is haploid gametophyte.
  - The dominant, photosynthetic phase in such plants is the free-living gametophyte.
  - Gametophyte divide mitotically to form haploid gamete.
  - Fertilization of gamete leads to formation of zygote (2N)
  - Sporophytic generation is represented only by the one-celled zygote.
  - There are no free-living sporophytes.
  - Meiosis in the zygote **(zygotic meiosis)** results in the formation of haploid spores.
  - The haploid spores divide mitotically and form the gametophyte.
  - This kind of life cycle is termed as **haplontic.**
    e.g. ***Ulothrix, Chlamydomonas, Spirogyra*** and ***Volvox.***

  (b) Diplontic:
  - Diploid sporophyte is the dominant, photosynthetic, independent phase of the plant.
  - Sporophyte undergo meiosis for gamete formation (**gametic meiosis**) or spore formation (Sporic meiosis).
  - The gametophytic phase is represented by the single to few-celled haploid gametophyte.
  - This kind of life cycle is termed as **diplontic**.
    e.g. **Gymnosperm and angiosperm. Some green algae- (***Caulerpa***), Some brown algae –** (*Fucus*, *Sargassum*)

(c) Haplodiplontic:

- **Bryophytes and pteridophytes, interestingly, exhibit an intermediate condition (Haplo-diplontic)**; both phases are multicellular and often free-living.
- e.g. Algae - Ectocarpus, Polysiphonia and Kelps
  Bryophyte - Dominant gametophyte
  Pteridophyte - Dominant sporophyte



Haplontic **Diplontic** **Haplo-diplontic**

Test your Resonance with concept

1. The leaves in pteridophytes are small (microphylls) as in _____(i)_____ & large (macrophylls) as in _____(ii)_____ i & ii are respectively.

(1) (i) Fern, (ii) *Selaginella*
(2) (i) *Selaginella* (ii) fern
(3) (i) *Pteridium* (ii) *Equisetum*
(4) (i) *Lycopodium* (ii) *Equisetum*

2. In Gymnosperm the male or female cones or strobili may be borne on the same tree ____(i)____ or on different tree ____(ii)_____. In this question.
(i) & (ii) are.

(1) (i) *Pinus* ; (ii) *Cycas*
(2) (i) *Cycas* ; (ii) *Pinus*
(3) (i) *Pinus* ; (ii) *Pinus*
(4) (i) *Cycas* ; (ii) *Cycas*.

3. Algae which shows haplo - diplontic alternation of generation?

(i) *Laminaria* (ii) *Ectocarpus* (iii) *Polysiphonia* (iv) *Batrachospermum*
(1) (i) and (ii) (2) (ii) and (iii) (3) (iii) & (iv) (4) (ii) and (iv)

Answers

1. (2) **2.** (1) **3.** (2)