PLANT KINGDOM

Systems of Biological classification

1. Artificial classification systems

- Earliest systems of classification.
- They were based on vegetative characters or superficial morphological characters such as habit, colour, number and shape of leaves, etc.
- **Linnaeus's artificial system** of classification was based on the androecium structure.

Drawbacks:

- They separated the closely related species since they were based on a few characteristics.
- Equal weightage to vegetative and sexual characteristics. This is not acceptable since the vegetative characters are more easily affected by environment.

2. Natural classification systems

- These are based on natural affinities among organisms.
- It considers external features and internal features (ultrastructure, anatomy, embryology & phytochemistry).
- E.g. Classification for flowering plants given by **George Bentham & Joseph Dalton Hooker.**

3. Phylogenetic classification systems

- It is based on evolutionary relationships among organisms.
- This assumes that organisms in the same taxa have a common ancestor.

Other sources to resolve the problems in classification:

- **Numerical Taxonomy:** It is based on all observable characteristics. It is easily carried out using computers. Number & codes are assigned to all the characters and the data are processed. Thus, hundreds of characters can be equally considered.
- **Cytotaxonomy:** It is based on cytological information like chromosome number, structure, behaviour etc.
- **Chemotaxonomy:** It uses chemical constituents of plants.

ALGAE

- Algae are simple, thalloid, autotrophic, chlorophyll-bearing and aquatic (fresh water & marine) organisms.
- They also occur in moist stones, soils and wood.
- Some occur in association with fungi (lichen) and animals (e.g., on sloth bear).
- The form and size of algae is highly variable.
  - Microscopic unicellular forms: E.g. *Chlamydomonas.*
  - Colonial forms: E.g. *Volvox.*
  - Filamentous forms: E.g. *Ulothrix* and *Spirogyra.*

Reproduction:

- **Vegetative reproduction:** By fragmentation. Each fragment develops into a thallus.
- **Asexual reproduction:** By the production of spores. E.g. **zoospores** (most common). They are flagellated (motile) and on germination gives rise to new plants.
- **Sexual reproduction:** Through fusion of two gametes. It is many types:
  - **Isogamous:** Fusion of gametes similar in size. They may be flagellated (e.g. *Ulothrix*) or non-flagellated (non-motile, e.g. *Spirogyra*).
  - **Anisogamous:** Fusion of two gametes dissimilar in size. E.g. Some species of *Eudorina*.
  - **Oogamous:** Fusion between one large, non-motile (static) female gamete and a smaller, motile male gamete. E.g. *Volvox*, *Fucus.*

Benefits of algae:

☺ Through photosynthesis, they fix half of the total CO_2 on earth and increase the level of dissolved oxygen.

☺ They are primary producers and the basis of the food cycles of all aquatic animals.

☺ Many marine algae (70 species) are used as food. E.g. *Porphyra*, *Laminaria* and *Sargassum*.

☺ **Agar** (from *Gelidium* & *Gracilaria*) is used to grow microbes and in ice-creams and jellies.

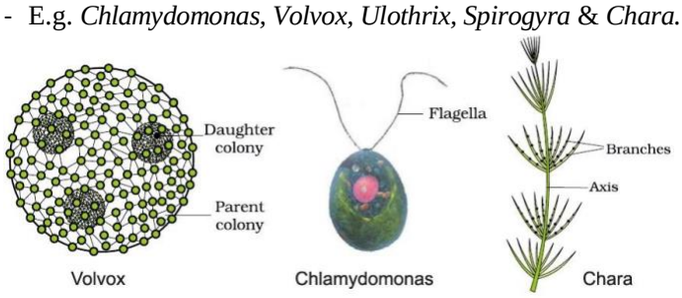
☺ Some marine brown & red algae produce **hydrocolloids** (water holding substances). E.g. **algin** (brown algae) and **carrageen** (red algae). These are used commercially.

☺ Protein-rich unicellular algae like *Chlorella* & *Spirullina* are used as food supplements by space travellers.

Algae include 3 classes: **Chlorophyceae, Phaeophyceae** and **Rhodophyceae**.

1. Chlorophyceae (green algae)

- Unicellular, colonial or filamentous.
- They are usually grass green due to the pigments **chlorophyll a** and **b** in chloroplasts.
- The chloroplasts may be discoid, plate-like, reticulate, cup-shaped, spiral or ribbon-shaped in different species.
- Most of them have one or more **pyrenoids** (storage bodies) located in the chloroplasts. Pyrenoids contain protein besides starch.
- Some algae store food as oil droplets.
- They have a rigid cell wall made of an inner layer of cellulose and an outer layer of pectose.
- E.g. *Chlamydomonas, Volvox, Ulothrix, Spirogyra* & *Chara.*

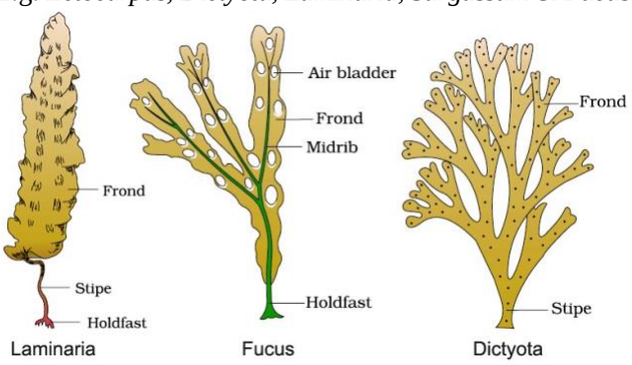


Reproduction:

- **Vegetative reproduction:** By fragmentation or by formation of different types of spores.
- **Asexual reproduction:** By flagellated zoospores produced in zoosporangia.
- **Sexual reproduction:** Isogamous, anisogamous or oogamous.

2. Phaeophyceae (brown algae)

- They are mostly marine forms.
- They show great variation in size & form. They range from simple branched, filamentous forms (E.g. *Ectocarpus*) to profusely branched forms (e.g. kelps- 100 m in height).
- They have chlorophyll *a, c*, carotenoids & xanthophylls.
- They vary in colour from olive green to brown depending upon the amount of a xanthophyll pigment, **fucoxanthin**.
- Food is stored as complex carbohydrates **(laminarin** or **mannitol).**
- The vegetative cells have a cellulosic wall covered by a gelatinous coating of **algin**.
- Protoplast contains plastids, central vacuole and nucleus.
- Plant body is attached to substratum by a **holdfast**, and has a stalk **(stipe)** and leaf like photosynthetic organ **(frond)**.
- E.g. *Ectocarpus, Dictyota, Laminaria, Sargassum* & *Fucus.*

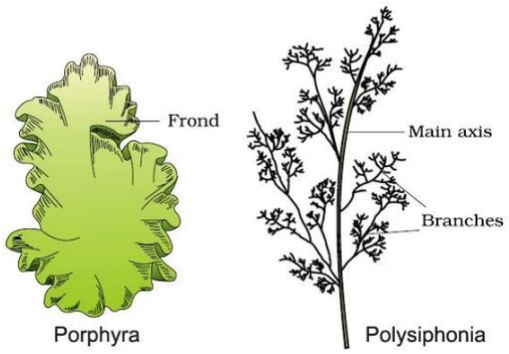


Reproduction:

- **Vegetative reproduction:** By **fragmentation.**
- **Asexual reproduction:** By pear-shaped **biflagellate zoospores** (have 2 unequal laterally attached flagella).
- **Sexual reproduction:** Isogamous, anisogamous or oogamous. Union of gametes occurs in water or within the oogonium (oogamous species). Gametes are pear-shaped (pyriform) bearing 2 laterally attached flagella.

3. Rhodophyceae (red algae)

- They have a red pigment, **r-phycoerythrin.**
- Majority are marine especially in the warmer areas.
- They occur in both well-lighted regions close to the surface of water and at great depths in oceans where relatively little light penetrates.
- The red thalli of most of the red algae are multicellular.
- Some of them have complex body organisation.
- The food is stored as **floridean starch** which is very similar to amylopectin and glycogen in structure.
- E.g. *Polysiphonia, Porphyra, Gracilaria* and *Gelidium.*



Reproduction:

- **Vegetative reproduction:** By **fragmentation.**
- **Asexual reproduction:** By non-motile spores.
- **Sexual reproduction:** Oogamous. By non-motile gametes. It has complex post fertilisation developments.

Classes	Chlorophyceae (Green algae)	Phaeophyceae (brown algae)	Rhodophyceae (Red algae)
Major pigments	Chlorophyll a, b	Chlorophyll a, c, Fucoxanthin	Chlorophyll a, d, Phycoerythrin
Stored food	Starch	Mannitol, laminarin	Floridean Starch
Cell wall	Cellulose	Cellulose and algin	Cellulose
Flagellar number & position of insertion	2-8, equal, apical	2, unequal, lateral	Absent
Habitat	Fresh water, salt water & brackish water	Fresh water (rare), salt water & brackish water	Fresh water (some), salt water (most) & brackish water

BRYOPHYTES

- They are called ***amphibians of the plant kingdom*** because they can live in soil but need water for sexual reproduction.
- They occur in damp, humid and shaded localities.
- Their body is more differentiated than that of algae. It is thallus-like and prostrate or erect, and attached to the substratum by unicellular or multicellular **rhizoids.**
- They lack true roots, stem or leaves. They may possess root-like, leaf-like or stem-like structures.
- The main plant body is haploid. It produces gametes, hence is called a **gametophyte**.
- The sex organs in bryophytes are multicellular.
- The male sex organ **(antheridium)** produces biflagellate **antherozoids**. The female sex organ **(archegonium)** is flask-shaped and produces a single **egg.**
- Antherozoids are released to water and meet archegonium. An antherozoid fuses with the egg to form **zygote.**
- Zygotes do not undergo meiosis immediately. They produce a multicellular body called a **sporophyte**.
- Sporophyte is not free-living but attached to the photosynthetic gametophyte and derives nourishment from it. Some cells of the sporophyte undergo meiosis to form haploid spores. They germinate to form gametophyte.

Importance of Bryophytes:

☺ Some mosses provide food for herbaceous mammals, birds and other animals.

☺ Species of *Sphagnum* (a moss) provide peat. It is used as fuel. It has water holding capacity so that used as packing material for trans-shipment of living material.

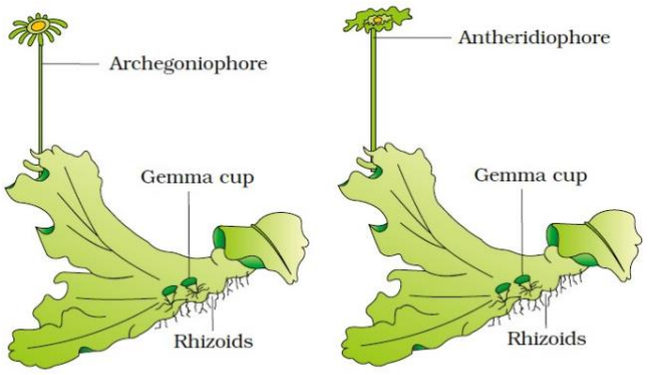
☺ They are ecologically important because of their role in **plant succession** on bare rocks/soil. Mosses along with lichens decompose rocks making the substrate suitable for the growth of higher plants.

☺ Since mosses form dense mats on the soil, they can prevent soil erosion.

The bryophytes are divided into **liverworts** and **mosses**.

Liverworts

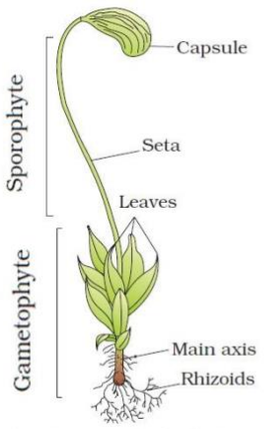
- They grow usually in moist, shady habitats such as banks of streams, marshy ground, damp soil, bark of trees and deep in the woods.
- Their plant body is thalloid. E.g. *Marchantia*. Thallus is dorsi-ventral and closely appressed to the substrate. The leafy members have tiny leaf-like appendages in two rows on the stem-like structures.
- **Asexual reproduction:** By **fragmentation** of thalli, or by the formation of **gemmae** (sing. gemma). Gemmae are green, multicellular, asexual buds that develop in small receptacles **(gemma cups)** on the thalli. Gemmae are detached from the parent body and germinate to form new individuals.
- **Sexual reproduction:** Male and female sex organs are produced on the same or different thalli. Sporophyte is differentiated into a **foot, seta** and **capsule.** After meiosis, spores are produced within the capsule. These spores germinate to form free-living gametophytes.



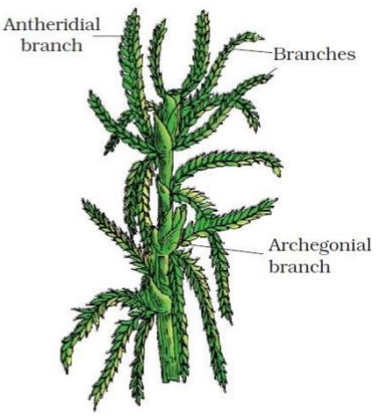
A liverwort – *Marchantia:* Female thallus & Male thallus

Mosses

- The predominant stage of the life cycle of a moss is the **gametophyte.** It consists of two stages.
  - **Protonema stage**: The first stage which develops directly from a spore. It is a creeping, green, branched and frequently filamentous stage.
  - **Leafy stage:** The second stage which develops from the secondary protonema as a lateral bud. They consist of upright, slender axes bearing spirally arranged leaves. They are attached to soil through multicellular and branched rhizoids. This stage bears the sex organs.
- **Vegetative reproduction:** By **fragmentation** and **budding** in the secondary protonema.
- **Sexual reproduction:** The **antheridia** & **archegonia** are produced at the apex of leafy shoots. After fertilisation, zygote develops into a sporophyte, consisting of a foot, seta and capsule. The sporophyte in mosses is more elaborate than that in liverworts. The capsule contains spores. Spores are formed after meiosis. Mosses have an elaborate mechanism of spore dispersal.
- E.g. *Funaria, Polytrichum* and *Sphagnum.*



Funaria, gametophyte & sporophyte



Sphagnum gametophyte

PTERIDOPHYTES

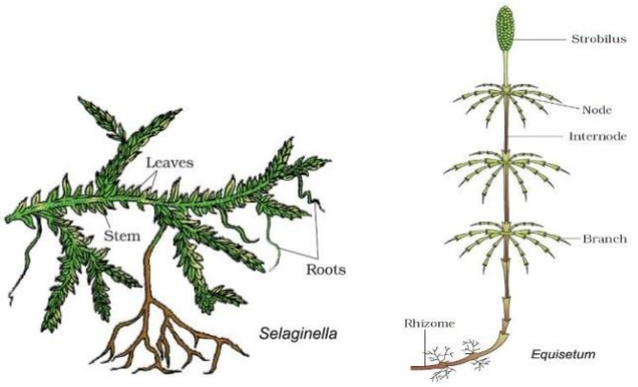
- They include **horsetails** and **ferns.**
- They are found in cool, damp, shady places. Some flourish well in sandy-soil conditions.
- Evolutionarily, they are the first terrestrial plants to possess vascular tissues (xylem & phloem).
- In bryophytes, the dominant phase in the life cycle is the gametophyte. In pteridophytes, the dominant phase (main plant body) is a **sporophyte.** It is differentiated to **true root, stem** & **leaves.** These organs have well-differentiated vascular tissues.
- The leaves in pteridophyta are small **(microphylls)** as in *Selaginella* or large **(macrophylls)** as in ferns.
- **Economic importance:** They are used for medicinal purposes and as soil-binders and ornamentals.

REPRODUCTION:

- The sporophytes bear **sporangia** that are subtended by leaf-like appendages called **sporophylls**. In some cases, sporophylls may form distinct compact structures called **strobili or cones** (E.g. *Selaginella, Equisetum*).
- Sporangia produce spores by meiosis in spore mother cells.
- The spores germinate to give inconspicuous, small, multicellular, free-living, mostly photosynthetic thalloid gametophytes called **prothallus**.
- Prothallus requires cool, damp, shady places to grow. Also, it needs water for fertilization. So, the spread of pteridophytes is limited and restricted to narrow geographical regions.
- The gametophytes (prothallus) bear male and female sex organs called **antheridia** and **archegonia,** respectively.
- Water is needed for transfer of **antherozoids** (male gametes from antheridia) to the mouth of archegonium.
- Antherozoid fuses with the egg in the archegonium to form zygote. Zygote develops to a multicellular well-differentiated **sporophyte.**
- Most of the pteridophytes produce similar kinds of spores **(homosporous plants).** Others produce two kinds of spores, **macro (mega)** & **micro spores.** They are **heterosporous**. E.g. *Selaginella* & *Salvinia.*
- The **megaspores** & **microspores** germinate and give rise to female and male gametophytes, respectively. The

female gametophytes are retained on the parent sporophytes for variable periods.

- Within female gametophytes, zygotes develop into young embryos. This event is a precursor to the **seed habit.** It is considered as an important step in evolution.
- The pteridophytes have 4 classes:
  1. **Psilopsida:** E.g. *Psilotum*
  2. **Lycopsida:** E.g. *Selaginella, Lycopodium*
  3. **Sphenopsida:** E.g. *Equisetum*
  4. **Pteropsida:** E.g. *Dryopteris, Pteris, Adiantum*



GYMNOSPERMS

- Gymnosperms (*gymnos:* naked, *sperma:* seeds) are plants in which the **ovules are not enclosed by ovary wall** and remain exposed before and after fertilization. **Seeds** that develop post-fertilization are **not covered (naked).**
- They include medium-sized trees or tall trees and shrubs. **Sequoia** (giant redwood) is the tallest tree species.
- The roots are generally **tap roots.**
- Roots in some genera have fungal association in the form of **mycorrhiza** *(E.g. Pinus).*
- In plants like *Cycas,* small specialized roots **(coralloid roots)** are associated with N_2- fixing cyanobacteria.
- Stems are unbranched (*Cycas*) or branched (*Pinus, Cedrus*).
- Leaves are simple or compound. They are well-adapted to withstand extreme temperature, humidity and wind.
- In *Cycas*, the pinnate leaves persist for a few years.
- In conifers (*Pinus, Cedrus* etc.), the needle-like leaves reduce the surface area. Their thick cuticle and sunken stomata also help to reduce water loss.

REPRODUCTION:

- Gymnosperms are **heterosporous.** They produce haploid **microspores** and **megaspores.**
- Some leaves are modified into **sporophylls.** They are compactly and spirally arranged along an axis to form **lax** or **strobili** or **cones**.
- Sporophylls bear **sporangia** in which spores are produced.
- Sporophylls are 2 types:
  - **Microsporophylls:** They are arranged to **male strobili (microsporangiate).** They bear **microsporangia.** The microspores develop into male gametophytes. It is highly reduced and confined to only a limited number of cells. This gametophyte is called a **pollen grain**. The pollen grains are developed within the microsporangia.
  - **Megasporophylls:** They are arranged to female strobili **(macrosporangiate).** They bear **megasporangia** (ovules). Megasporangium mainly consists of a body called **nucellus.** It is protected by envelopes. The megaspore mother cell is differentiated from a cell of the nucellus. Megaspore mother cell undergoes meiosis to form four megaspores. One of the megaspores enclosed within the **Megasporangium (nucellus)** develops into a multicellular female gametophyte that bears two or more **archegonia.** The multicellular female gametophyte is also retained within megasporangium.
- The male or female cones may be borne on the same tree (*Pinus*) or on different trees (*Cycas*).
- 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 pollen grain released from the microsporangium are carried in air currents and meet the opening of the ovules. The pollen tube carrying the male gametes grows towards archegonia in the ovules and discharges their contents near the mouth of the archegonia.
- After fertilization, zygote develops into an embryo and the ovules into seeds.

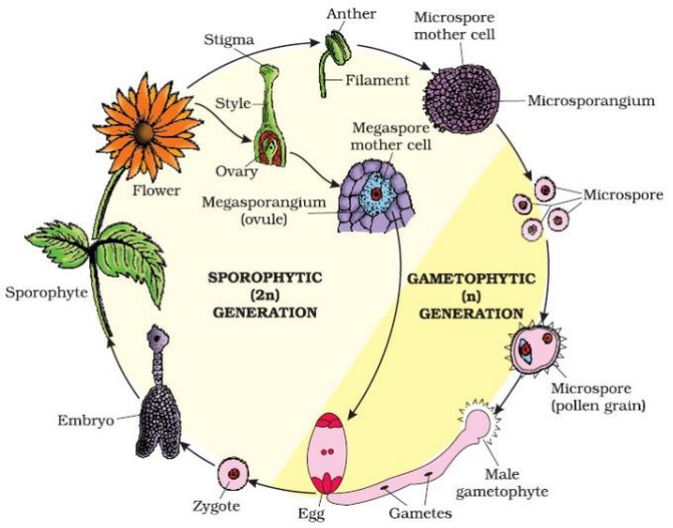
ANGIOSPERMS (FLOWERING PLANTS)

- They are an exceptionally large group of plants.
- They range in size from tiny, almost microscopic *Wolffia* to tall trees of *Eucalyptus* (over 100 metres).
- They include 2 classes: Dicotyledons & Monocotyledons.
  - **Dicotyledons:** Have 2 cotyledons in seeds, reticulate venations in leaves and tetramerous or pentamerous flowers (4 or 5 members in each floral whorl).
  - **Monocotyledons:** Have only one cotyledon, parallel venation in leaves and trimerous flowers (3 members in each floral whorl).

REPRODUCTION:

- **Flower** is the reproductive structure.
- Male sex organ in a flower is the **stamen.** Each stamen consists of a **filament** with an **anther** at the tip. Within the anthers, the **pollen mother cell** divides by meiosis to produce **microspores** which matures into **pollen grains.**
- Female sex organ in a flower is the **pistil.** It consists of a swollen **ovary** at its base, a long slender **style** & **stigma.** Ovary contains **ovules.** An ovule has a **megaspore mother cell** that undergoes meiosis to form 4 haploid **megaspores.** 3 of them degenerate and one divides to form **embryo sac.**
- Each embryo-sac has a 3-celled **egg apparatus** (one **egg cell** & two **synergids)**, 3 **antipodal** cells & 2 **polar nuclei**. The polar nuclei eventually fuse to produce a **diploid secondary nucleus.**

- Pollen grains dispersed from anthers are carried by wind or other agencies to the stigma of pistil. It is called **pollination.**
- Pollen grains germinate on the stigma and the resulting **pollen tubes** grow through the tissues of stigma and style and reach the ovule.
- Pollen tubes enter the embryo-sac where 2 male gametes are discharged. One male gamete fuses with egg cell to form **zygote (syngamy).** The other male gamete fuses with diploid secondary nucleus to produce triploid **primary endosperm nucleus (PEN).** Because of the involvement of two fusions, this event is called **double fertilisation.** It is an event unique to angiosperms.
- The zygote develops into an **embryo** (with one or two cotyledons). The PEN develops into **endosperm** which provides nourishment to the developing embryo.
- Synergids & antipodals degenerate after fertilization.
- During these events, the **ovules** develop into **seeds** andthe **ovaries** develop into **fruit.**
- The seeds are enclosed by fruits.

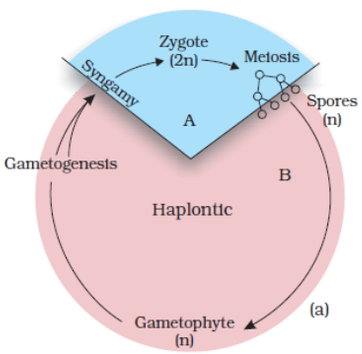


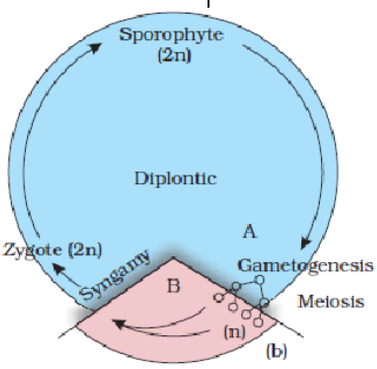
PLANT LIFE CYCLES AND ALTERNATION OF GENERATIONS

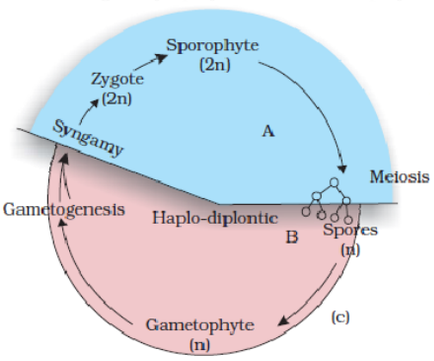
- In plants, both haploid and diploid cells can divide by mitosis. This forms haploid and diploid plant bodies.
- Haploid plant body **(gametophyte)** produces gametes by mitosis.
- After fertilization, the zygote also divides by mitosis to produce a diploid plant body **(sporophyte).** This produces haploid **spores** by meiosis.
- Spores divide by mitosis to form a haploid plant body.
- Thus, during the life cycle of any sexually reproducing plant, there is an alternation of generations between gametophyte (n) and sporophyte (2n).

Patterns of Plant life cycles

1. **Haplontic:** In this, sporophytic generation is represented only by the zygote. There are no free-living sporophytes. Zygote undergoes meiosis to form haploid spores. They divide mitotically to form gametophyte. The dominant, photosynthetic phase is the free-living gametophyte. E.g. Algae such as *Volvox, Spirogyra* and some species of *Chlamydomonas*.
2. **Diplontic:** In this, diploid sporophyte is the dominant, photosynthetic, independent phase. Gametophytic phase is represented by the single to few-celled haploid gametophyte. E.g. An alga, *Fucus* sp., all seed-bearing plants (gymnosperms & angiosperms - the gametophytic phase is few to multi-celled).
3. **Haplo-diplontic:** It is the intermediate condition between haplontic & diplontic. Both gametophyte & sporophyte are multicellular and often free-living. But they have different dominant phases. E.g. Bryophytes & Pteridophytes.







MODEL QUESTIONS

1. Match the names given in column I with the items in column II

	Column I	Column II
a)	Adiantum	Bryophyte
b)	Sargassum	Angiosperm
c)	Sunflower	Algae
d)	Riccia	Pteridophyte

2. Bryophytes are called 'amphibians of the plant kingdom'. Justify the statement.
3. Match the following.

	A	B
a.	Algae	Naked seeded plants.
b.	Pteridophytes	Amphibians of plant kingdom
c.	Gymnosperms	Flowering plants
d.	Angiosperms	Thalloid body, photosynthetic and mainly aquatic
e.	Bryophytes	Independent sporophytic and gametophytic phase. Commonly called ferns.

4. The most characteristic feature of angiosperms is double fertilization.
   a. What is double fertilization? b. Why is it called triple fusion?
5. Identify the plant group from the given data.
   a. Plant body is not differentiated into root, stem and leaf.
   b. Reproductive structures are strobili.
6. Some Pteridophytes produce two types of spores.
   a. Name the phenomenon. b. This event is an important step in evolution. Explain.
7. Some features of Haplontic and Diplontic life cycles are given below. Arrange them correctly in a table.
   - Sporophyte is a single celled zygote
   - Meiosis occurs in Zygote
   - Sporophyte dominant
   - No free-living Sporophyte
   - Gametophyte dominant
   - Meiosis occurs before zygote formation