

Plant Kingdom

INTRODUCTION

- Plant kingdom includes eukaryotic, multicellular (with few exceptions), non-motile and autotrophic organisms, that perform photosynthesis to manufacture food (primarily stored as starch) in different plant organs.
- The cells in plants have cellulosic cell walls.
- Plants are found on land, desert, hills, fresh water, marine water, brackish water and even on snow covered mountains.
- Plants found in water are called aquatic plants and those found on land are called terrestrial plants.
- Plants were frequently classified to make their study convenient on the basis of their use and structure.
- The earlier systems did classify the plants on the basis of their habitats into trees, shrubs, undershrubs and herbs. The bases were few morphological structures only, so the classification is termed as artificial system of classification.
- With the passage of time technical advancement happened that revealed structural details of cells. Later on, the concept of evolution helped scientists to understand the phylogeny of the organisms.
- Thus, artificial system of classification was replaced by natural system of classification and later on, the natural system of classification was replaced by phylogenetic classification.

CLASSIFICATION OF PLANTS

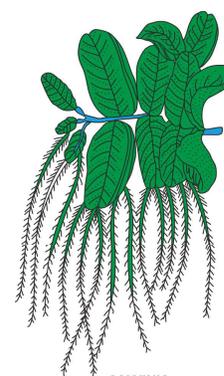
Aristotle divided the living world into two kingdoms – **plants** and **animals**.

ARTIFICIAL CLASSIFICATION

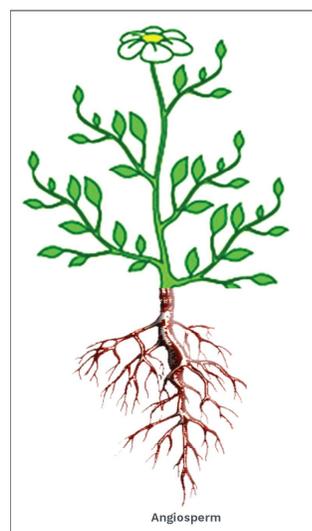
- Classification of plants based on only few morphological features.
- **Linnaeus** proposed a system of classification for plants based on floral characters, only i.e, the



VOLVOX



SALVINIA



Angiosperm

Rack your Brain



Who divided plants into trees, shrubs, undershrubs and herbs?



stamens and the carpels.

- This artificial system is also known as **sexual system** of classification.

Linnaeus divided the plants into 23 Classes, few of them are given below:

- Class Monandria: Plants with a single stamen, e.g., *Canna*
- Class Icosandia: Plants with twenty or more stamens
- Class Cryptogamia: All non-flowering plants viz. algae, fungi, lichens, mosses, and ferns were part of this class

DEMERITS OF ARTIFICIAL SYSTEM OF CLASSIFICATION

- This system did not consider the relationships among the plants.
- Unrelated families of monocotyledons and dicotyledons were placed in one class.

NATURAL SYSTEM OF CLASSIFICATION

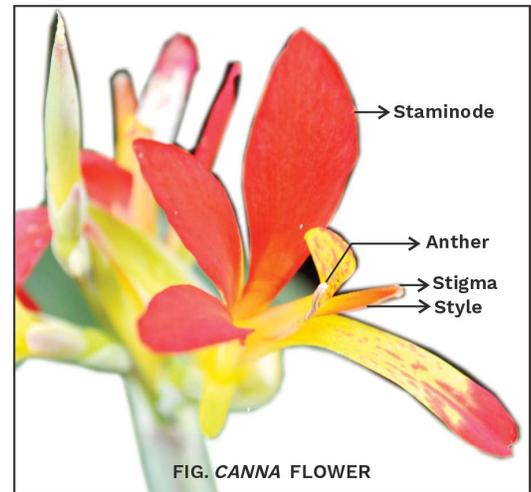
- In this type of classification importance is given to maximum possible characters.
- Reproductive characters (floral characters) are given preference for classification over vegetative characters.
- This system is more useful in placing the plants into the best-suited group in comparison to artificial system of classification.

TRADITIONAL SYSTEM OF CLASSIFICATION

This classification was proposed by **Eichler** in 1884.

Eichler divided Plant Kingdom into two sub-kingdoms:

- Sub-kingdom- *Cryptogamae*
- Sub-kingdom- *Phanerogamae*



Rack your Brain



Artificial system of classification given by Linnaeus is also known as sexual system of classification. Why?

Previous Year's Question



Classification given by Bentham and Hooker is

- (1) Artificial
- (2) Natural
- (3) Phylogenetic
- (4) Numerical



LATERAL SYSTEM OF CLASSIFICATION

- This system was proposed by George Bentham and Joseph Dalton Hooker for classifying seed plants.
- This taxonomic system was published in their book *Genera plantarum ad exemplaria imprimis in herbariis kewensibus servata definita* in three volumes (1862 and 1883).
- *Genera plantarum* contains classifications of 97,205 species.
- In this system, morphological features and detailed internal features (i.e., ultrastructure, anatomy, embryology and phytochemistry) were considered for classifying flowering plants.
- Natural affinities (natural similarities) among organisms were also considered for classification.

PHYLOGENETIC CLASSIFICATION SYSTEM

- Scientists who contributed to the phylogenetic classification system of plants are:
 - Adolf Engler
 - John Hutchinson
 - Armen Takhtajan
 - Arthur Cronquist
 - Rolf Dahlgren
 - Robert F. Thorne
- This system is based on evolutionary relationships between various plants along with other external and internal features.
- This system is useful in classifying those organisms which lack fossil record (i.e., no supporting fossil evidence).
- This system assumes that organisms that are placed in a taxon share common ancestor.

NUMERICAL TAXONOMY

- It is a part of biological systematics and was developed by Robert R. Sokal and Peter H. A. Sheath.
- Number codes are assigned to all the characters observed by the taxonomist.

- Data is processed by computers to categorize the organisms based on similarities.

CYTOTAXONOMY

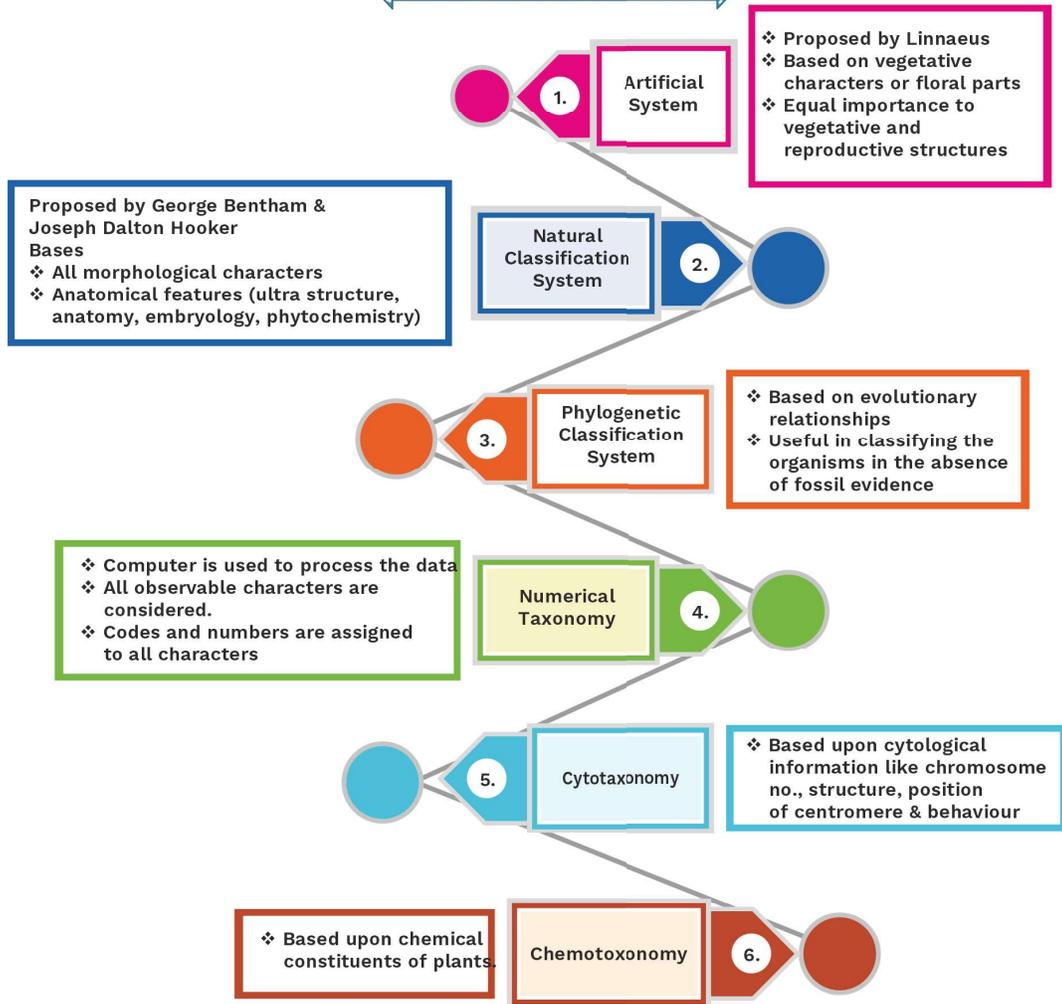
- It is a part of biological systematics where comparative study of chromosomes and their behaviour during mitosis are considered as well as due weightage is given to cellular structures.
- To infer relationships among organisms the widely used parameter is chromosome number, chromosome structure, position of centromere and behaviour.

CHEMOTAXONOMY (Also called chemosystematics)

- In this type of taxonomy comparative analysis of biochemical compounds is considered.
- Biochemical compounds which are considered more like proteins. Synthesis of proteins is controlled by genes and are least affected by natural selection (environmental factors).
- Other compounds used for this taxonomy are nucleic acids, amino acids etc.
- Used by plant taxonomists to resolve confusions regarding classification of certain plants.



TYPES OF CLASSIFICATION



SUB-KINGDOM CRYPTOGAMAE (Gk. *Cryptos* – hidden, *gamos* – marriage)

- The plants placed in this group do not bear flowers and seeds and possess hidden reproductive structures.
- All non-flowering plants such as, algae, fungi, lichens, mosses and ferns are part of this sub-kingdom.

Previous Year's Question



Plant reproducing by spores such as mosses and ferns are grouped under.

- (1) Thallophytes
- (2) Cryptogams
- (3) Bryophytes
- (4) Sporophytes

- Cryptogams do not bear flowers so are also known as **lower plants** or **non-flowering plants** or **seedless plants**.

Divisions of Sub-kingdom Cryptogamae

It is divided into three divisions

- Thallophyta
- Bryophyta
- Pteridophyta

Thallophyta (Gk. *thallos*–undifferentiated, *phyton* – plant)

- Plants placed in this group are the simplest plants and their body is not differentiated into roots, stem and leaves. Such a plant body is called thallus.
- Vascular system (xylem and phloem) is not found.
- Sub-divisions in Thallophyta are:
 - ◆ Algae
 - ◆ Fungi (**as per Eichler**)

Note: R. H. Whittaker placed fungi in a separate kingdom i.e., kingdom fungi as per five-kingdom classification.

ALGAE

- Photosynthetic pigment–chlorophyll is present, and mode of nutrition is autotrophic.
- Mostly aquatic or found in damp places, e.g., *Ulothrix*, *Sargassum*, *Gelidium*, etc.

BRYOPHYTA (Gk. *Bryon* – moss, *phyton* – plants)

- They are the simplest land plants with undifferentiated plant body.
- The vascular tissues are entirely absent.
- Sex organs are multicellular and jacketed (one cell in thickness).

Previous Year's Question



An alga that is highly rich in protein–

- (1) *Chlorella*
- (2) *Nostoc*
- (3) *Spirogyra*
- (4) *Ulothrix*

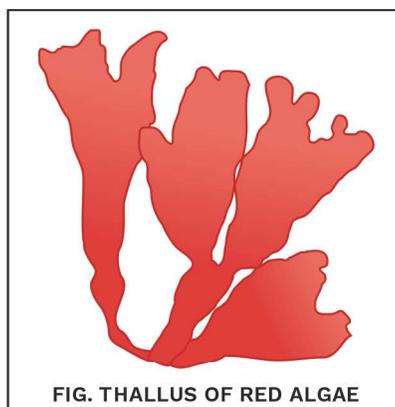


FIG. THALLUS OF RED ALGAE

Gray Matter Alert!!!

Thallus: An undifferentiated plant body.

Like in a thalloid plant body roots, stem and leaves are not differentiated. The whole plant body is green.



Classes in Division Bryophyta: This division has three classes–

- Class Hepaticae (liverworts e.g., *Riccia*, *Marchantia*)
- Class Anthocerotae (hornworts e.g., *Anthoceros*)
- Class Musci (mosses e.g., *Funaria*).

PTERIDOPHYTA (Gk. *Pteris* – fern, *phyton* – plant)

- These are also called **vascular cryptogams** due to the presence of vascular tissues in the plant body.
- These are the first land plants to have vascular tissues.
- The plant body is differentiated into roots, stem and leaves.

Division Pteridophyta is further divided into four classes:

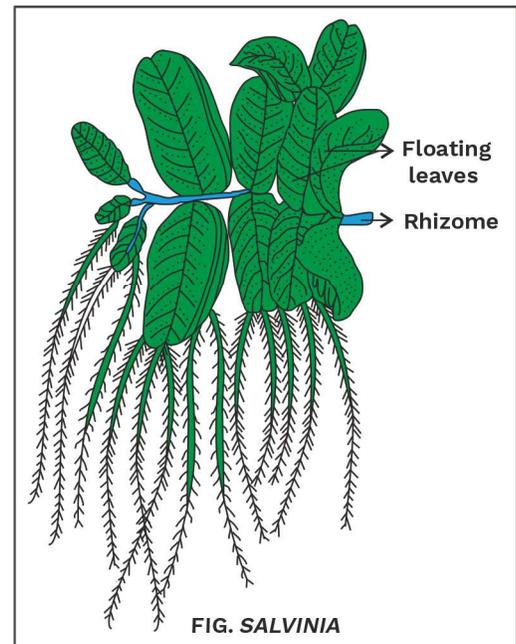
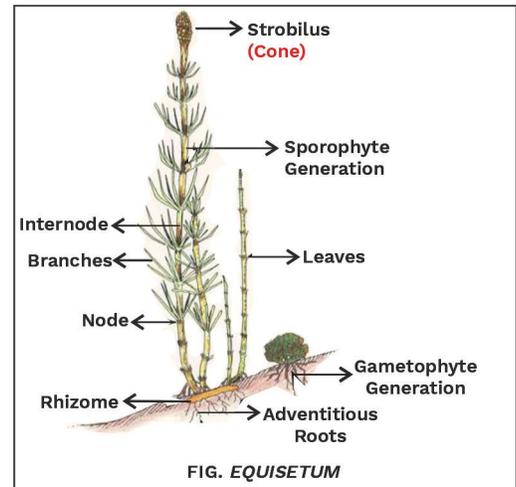
- Psilopsida (e.g., *Psilotum*)
- Lycopsidea (e.g., *Lycopodium*, *Selaginella*)
- Sphenopsida (e.g., *Equisetum*)
- Pteropsida (e.g., *Dryopteris*).

SUB-KINGDOM PHANEROGAMAE (Gk. *Phaneros-* visible, *gamos* -marriage).

- These plants possess reproductive organs called **flowers** and **seeds**.
- This sub-kingdom includes only a single division called Spermatophyta.

Spermatophyta (Gk. *Sperma*–seed, *phyton*– plants)

- These are seed bearing plants.
- Their plant body is differentiated into roots, stem and leaves.
- Vascular system is well developed.





Division spermatophyta is divided into two sub-divisions:

- Gymnospermae
- Angiospermae

Gymnospermae (Gk. *gymno* – naked, *sperma* – seed)

- Plants of this group do not bear flowers.
- Their seeds are not enclosed by a fruit.
- Reproductive structures develop on cones.

Sub division Gymnospermae is divided into three classes:

- Cycadopsida (e.g., *Cycas*)
- Coniferopsida (e.g., *Pinus*, *Cedrus*)
- Gnetopsida (e.g., *Gnetum*)

Angiospermae (Gk. *angion* – hidden, *sperma* – seed)

- These plants bear seeds that are enclosed by a fruit which is formed from ovary.
- All angiosperms possess flowers. Hence, are called **flowering plants**.

Sub-division Angiospermae is divided into two classes:

- Dicotyledonae (e.g., pea, gram)
- Monocotyledonae (e.g., cereals).

Note: The plants having vascular tissues, which resemble windpipe of animals, are called **tracheophytes** (*Trachea* – windpipe, *phyton* – plants)

Tracheophytes include bryophytes, pteridophytes and spermatophytes.

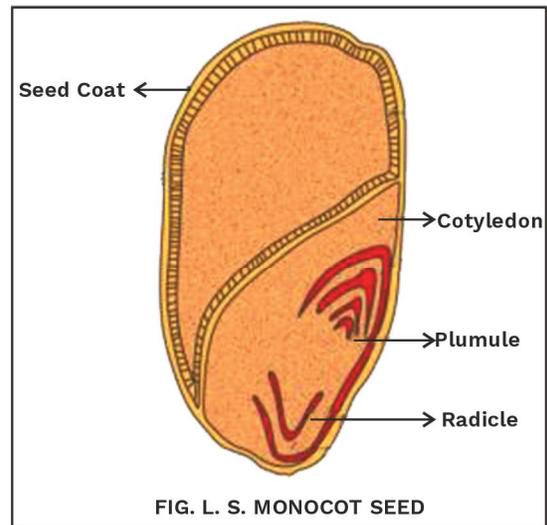


FIG. L. S. MONOCOT SEED

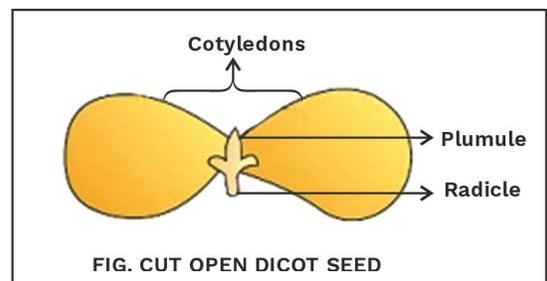


FIG. CUT OPEN DICOT SEED

DIFFERENCES BETWEEN CRYPTOGRAMAE AND PHANEROGAMAE

Cryptogamae	Phanerogamae
1. Plants with unexposed reproductive structures and are also seedless plants.	1. Plants with exposed reproductive structures and are also seed producing plants.
2. It includes three divisions – thallophyta, bryophyta and pteridophyta.	2. It includes only one division – spermatophyta.
3. Ovule is not found.	3. Ovule is present.
4. A process of transfer of male spore to vicinity.	4. Process of pollination is present.
5. Water is required for Fertilisation.	5. Fertilisation occurs through pollen tube hence, water is not required.

SUB-DIVISION THALLOPHYTA (ALGAE)

- Algae are eukaryotic, multicellular (except *Chlamydomonas*: unicellular alga) chlorophyll containing photosynthetic, non-vascular thalloid aquatic plants either marine or freshwater or a few are found on moist soils or any other moist surface.
- Algae usually live in well lighted areas.
- Thallus of multicellular algae can be microscopic, colonial, aggregates of cells, fine filaments of flattened sheets of cells.
- Some algae are complex and can attain length of 60 metre e.g., *Macrocystis*.
- Algal cell walls are cellulosic and reserve

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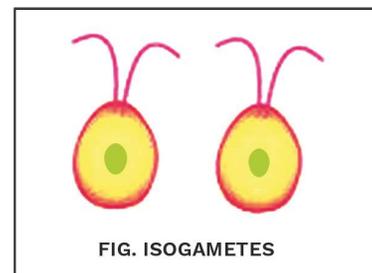
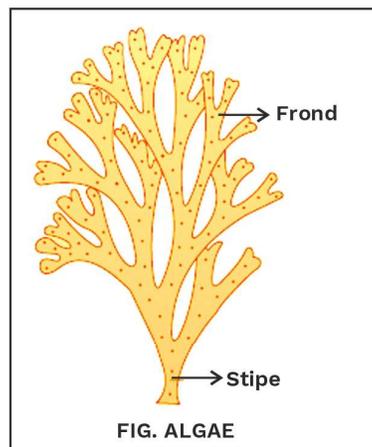
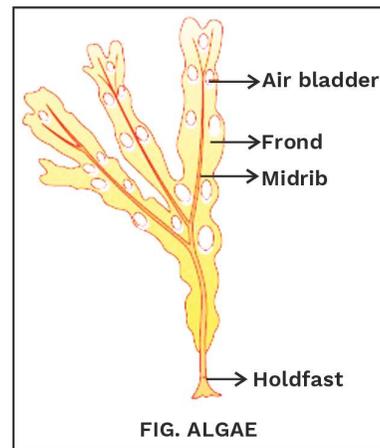
Photosynthetic producers are found up to 200 metres of depth of sea, also called **photic region**. Below this depth, no photosynthetic organisms can live due to lack of sufficient light, only consumers and decomposers are found.

food material is starch or any other related polysaccharide and oil globules.

- The filaments and sheets are not free-floating these are attached to the substratum by means of an anchoring structure called **holdfast**.
- Some algae are complex and very large up to 60 metre in length (e.g., *Macrocystis*).
- Thallus of massive algal forms show distinction of **lamina** (leaf-like blades) with photosynthetic tissues, **stipe** (stem-like stalk) and **holdfast**.
- Algae have simplest body structure and lack vascular tissues, as these are submerged in water, and water conduction is not required even in giant forms.
- Mechanical tissues are absent and buoyancy keeps them erect in water.
- Flexible bodies facilitate them to bend along with the sea water currents without being harmed or injured.
- Algal thallus is covered with mucilage that protects them from epiphytic growth and decaying effects of water. It also prevents desiccation of the algae.
- Most algae multiply by vegetative and asexual modes of reproduction. Asexual spores are of two types – **mitospores** and **meiospores** which are mostly motile or non-motile as well.
- Sex organs (gametangia) are **non-jacketed** i.e, lack protective covering of sterile cells found in other cryptogams.
- In sexual reproduction fusion of gametes occurs.
- Depending upon the type of gametes that participate in sexual reproduction, this mode of reproduction is divided into three types–
 - **Isogamous**: Fusion of gametes that are similar in all respect viz. flagellated and morphologically similar as observed in *Chlamydomonas* or non-flagellated (non-motile) but similar in size (as in *Spirogyra*).
 - **Anisogamous**: Fusion of two gametes dissimilar

Definition

Algae: A group of chlorophyllous, thalloid plants.



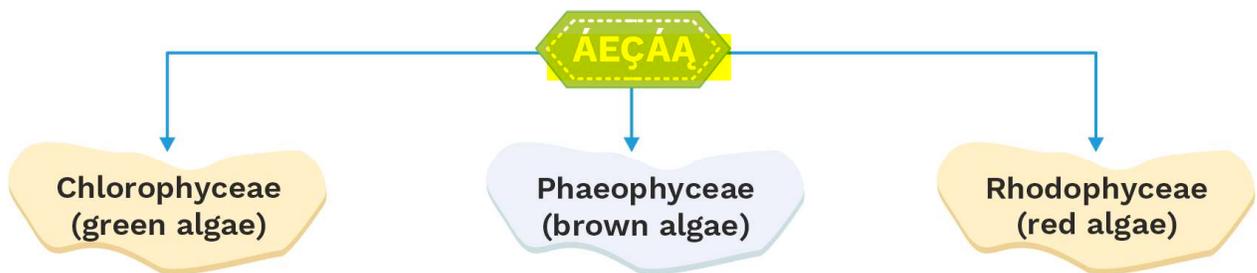
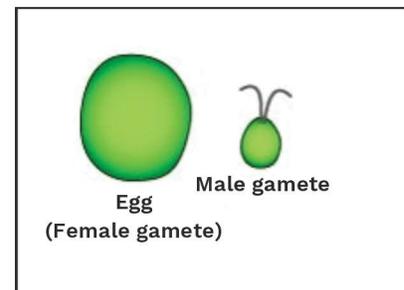
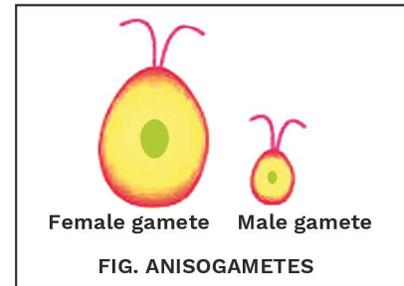
in size and vary in motility as in some species of *Chlamydomonas*.

- **Oogamous:** Fusion between one large, non-motile female gamete and a smaller, motile male gamete e.g., *Volvox*, *Fucus*.
- In algal life cycle, embryo stage is absent.

Classification of Algae:

On the basis of the nature of the photosynthetic pigments, storage material and complexity of structures. Algae are classified into three main classes

- Chlorophyceae
- Phaeophyceae
- Rhodophyceae



CHLOROPHYCEAE (Gk. *Chloros*-green; *phyton*-plant) (**Green Algae**)

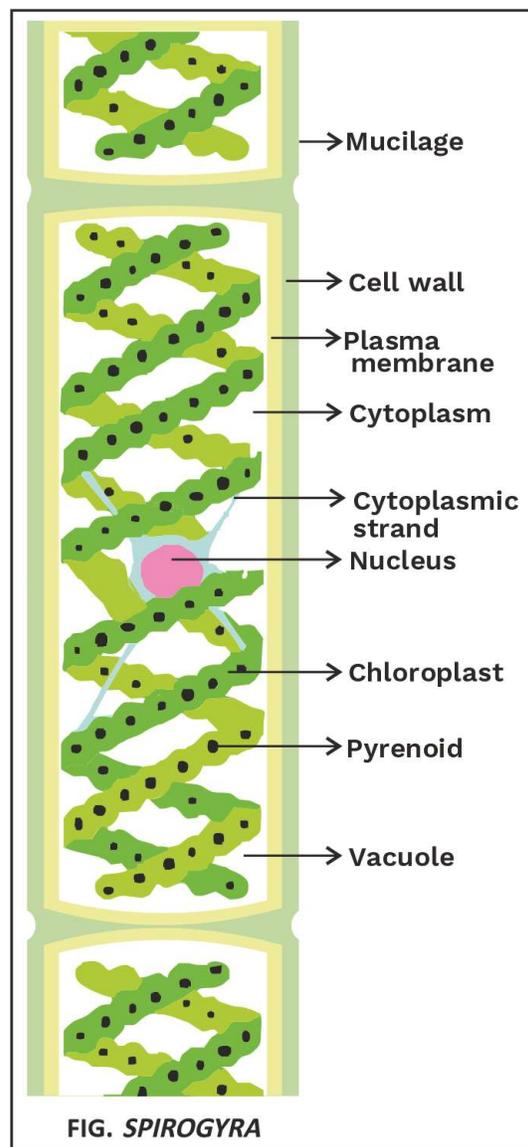
- **Habitat**
 - Most green algae are found thriving in freshwaters, while few are marine too.
 - These can also be terrestrial (on moist surfaces), epiphytic (living on other plants).
 - Some are even endozoic or epizole (growing in or on the bodies of animals) like *Zoochlorella* is found associated with sponges.
 - Certain green algae occur as one of the components of some lichens.

Rack your Brain



Green algae are believed to be ancestors of terrestrial plants, how can it be justified?

- **Thallus form:** The thallus vary widely in shapes and sizes like:
 - Microscopic **unicellular and flagellated**, e.g., *Chlamydomonas*
 - Microscopic and non-flagellated e.g., *Chlorella*
 - Unicellular alga that grows several centimetres in length e.g., *Acetabularia* (umbrella plant)
 - Flagellated and colonial (e.g., *Volvox*)
 - Non-flagellated and colonial (e.g., *Scenedesmus*, *Hydrodictyon*)
 - Unbranched and filamentous (e.g., *Ulothrix* *Spirogyra*)
 - Branched and filamentous (e.g., *Cladophora*)
 - Two-layered sheets of cells (e.g., *Ulva* popularly known as sea lettuce)
 - Heterotrichous with prostrate and erect branches (e.g., *Draparnaldia*).
- **Photosynthetic pigments :** **Chlorophyll-a, chlorophyll-b, carotenes** and **xanthophylls** in grana in chloroplasts of the algae.
- **Reserve food material :** Starch found in the **pyrenoids**, these structures are located on chloroplasts.
- **Stigma or eye spot :** Flagellated green algae possess a photosensitive structure named **stigma** or **eye spot** in the chloroplast.
- **Reproduction in Green Algae–**
 - ◆ Vegetative reproduction
 - ◆ Asexual reproduction
 - ◆ Sexual reproduction
- Vegetative reproduction: By **fragmentation**.
- Asexual reproduction: By mitospores and meiospores.
The common asexual spores are–
Flagellated asexual spores : **Zoospores**
Non-flagellated asexual spores: **Aplanospores, hypnospores, akinetes** and **autospores**.



Definition

Zoospores: Flagellated, motile reproductive units produced by the algae.

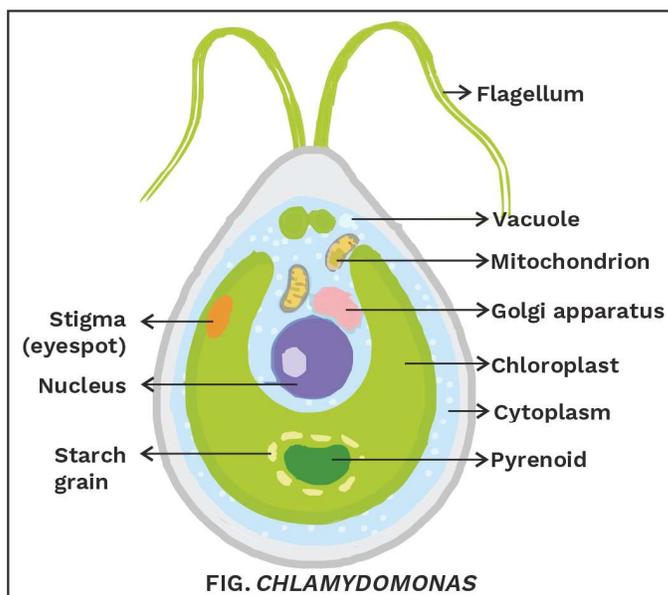


- Sexual reproduction can be of three types–
 - Isogamy
 - Anisogamy
 - Oogamy.

Isogamy : Two gametes that participate in the reproduction are morphologically and physiologically similar.
(The fusing gametes are similar in size, both gametes may either be flagellated or non-flagellated.)

Anisogamy: Participating gametes are structurally similar but different in size and behaviour.
(One of the two gametes is larger and is known as called **macrogamete** or **female gamete**. The other is smaller and motile, and is termed as **microgamete** or **male gamete**)

Oogamy: There is a large food-laden, non-flagellate female gamete called **egg** or **oosphere**.
(The other gamete is smaller and without any food reserve. It is called **male gamete** and is often motile)



Definition

Isogamous: It is a type of sexual reproduction where fusion between similar gametes takes place.

Gray Matter Alert!!!

Cephaleuros is a genus of parasitic algae that belongs to Thallophyta and is commonly known as red rust. It occurs as a parasite on tea and coffee plants.

Definition

Anisogamous: It is a type of sexual reproduction where fusion between dissimilar gametes occur.

Definition

Oogamous: It is a type of sexual reproduction where fusion between one large, non-motile female gamete and a small, motile male gamete occurs.

- **Life-Cycle: Members of thallophyta exhibit three types of life cycles:**

- Haplontic life cycle
- diplontic life cycle
- diplohaplontic life cycle

- **Haplontic Life Cycle**

- Dominant phase is haploid as the adult alga is haploid.
- Diploid stage is briefly represented by the zygote or zygospore.
- Zygote undergoes meiosis and forms four new haploid **alga** (zygotic meiosis) e.g., *Chlamydomonas*, *Ulothrix*, *Spirogyra*, *Chara*.

- **Diplontic Life Cycle**

- Dominant phase in the life cycle is diploid as the adult alga is diploid.
- Gametes are produced through meiosis (gametic meiosis).
- These gametes represent haploid phase.
- Fusion of gametes occurs that restores diploid phase (e.g., *Caulerpa*).

- **Diplohaplontic Life Cycle**

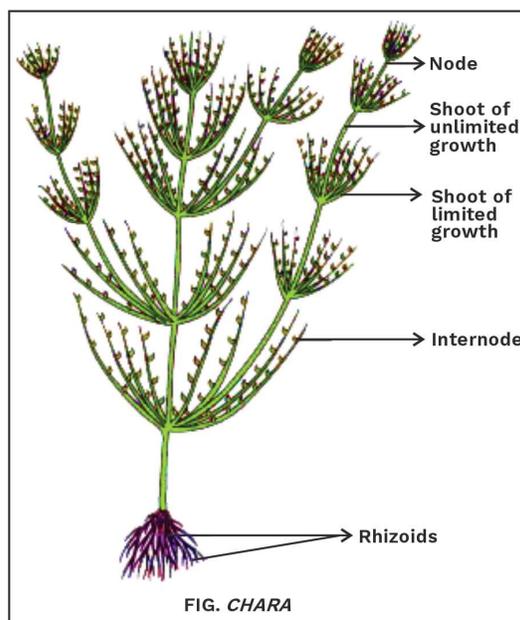
- Haploid and diploid phase are well developed and multicellular.
- They are respectively called **gametophyte** and **sporophyte**.
- The haploid gametophyte produces haploid gametes, which fuses into diploid zygote.
- The diploid zygote grows into a diploid sporophyte. The latter produce haploid spores or meiospores through meiosis (sporic meiosis) e.g., *Ulva*, *Cladophora*.
- New gametophytes are produced by the germination of meiospores. Diplohaplontic life cycle, thus, exhibits **alternation of generations** between haploid and diploid multicellular generations.

Previous Year's Question



Chloroplast in *Chlamydomonas* is

- (1) Stellate
- (2) Cup-shaped
- (3) Collar-shaped
- (4) Spiral

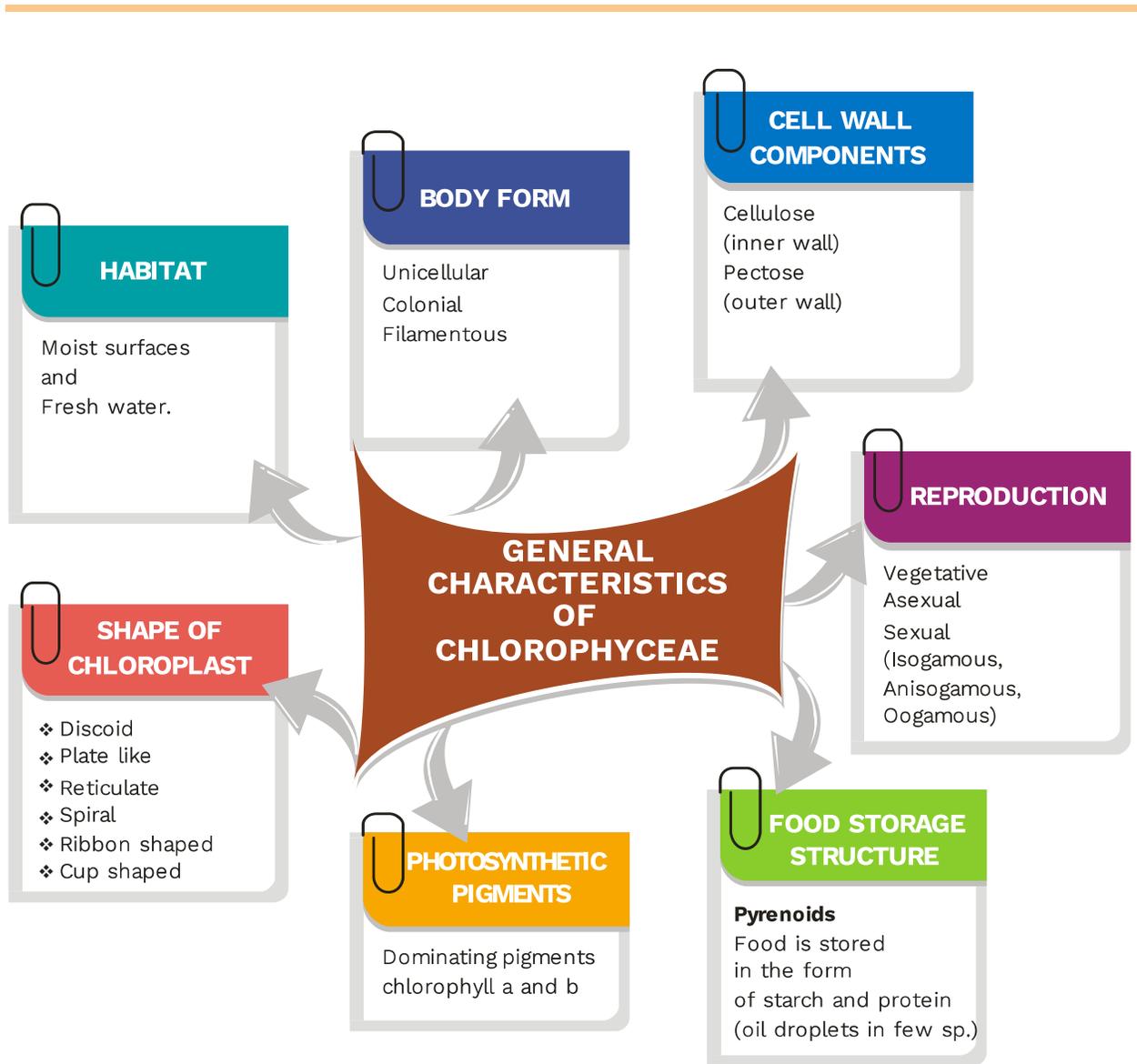


Rack your Brain



Which of the following algae shows best origin and evolution of sex?

- (1) Brown algae
- (2) Red algae
- (3) Blue-green algae
- (4) Green algae

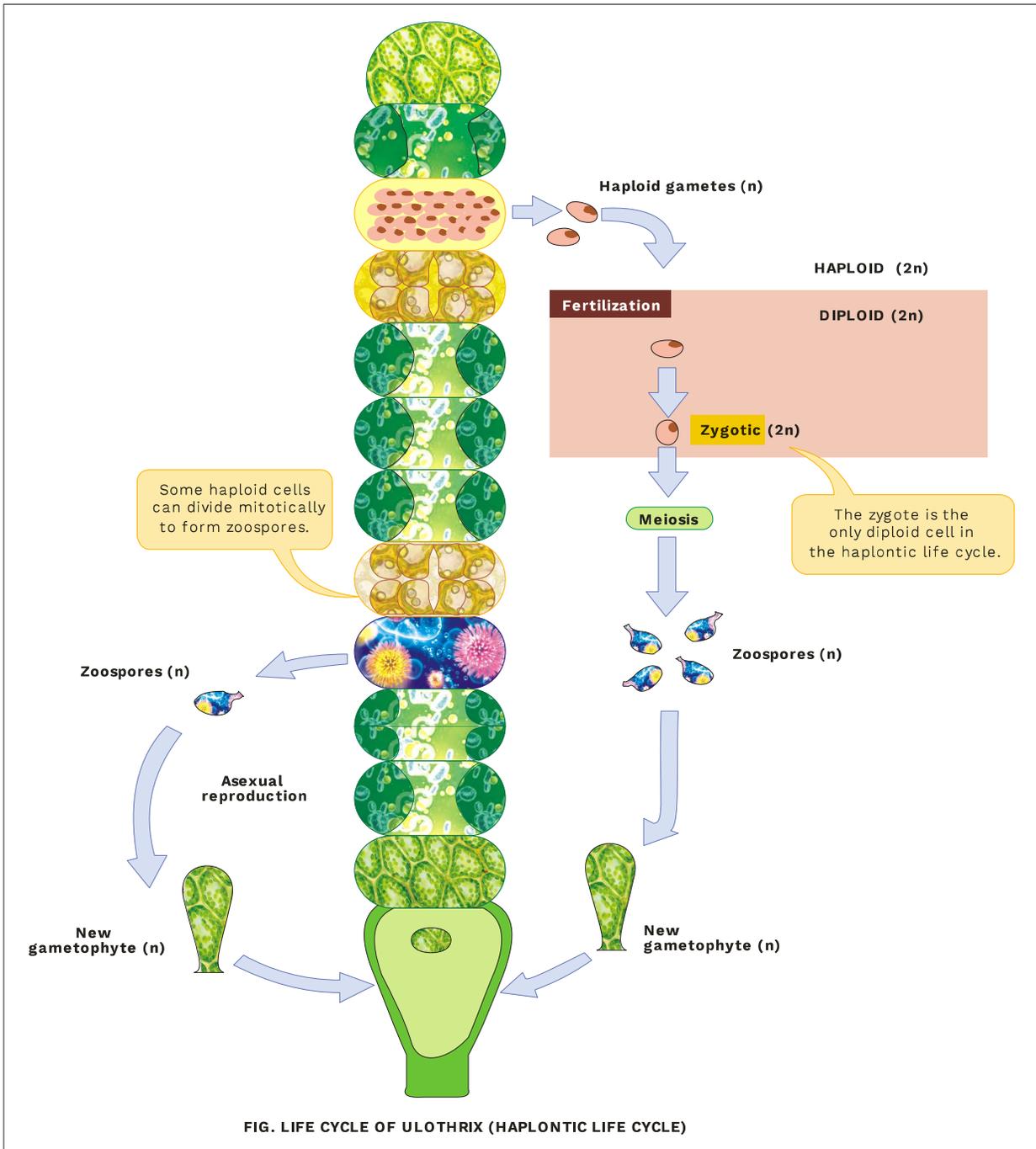


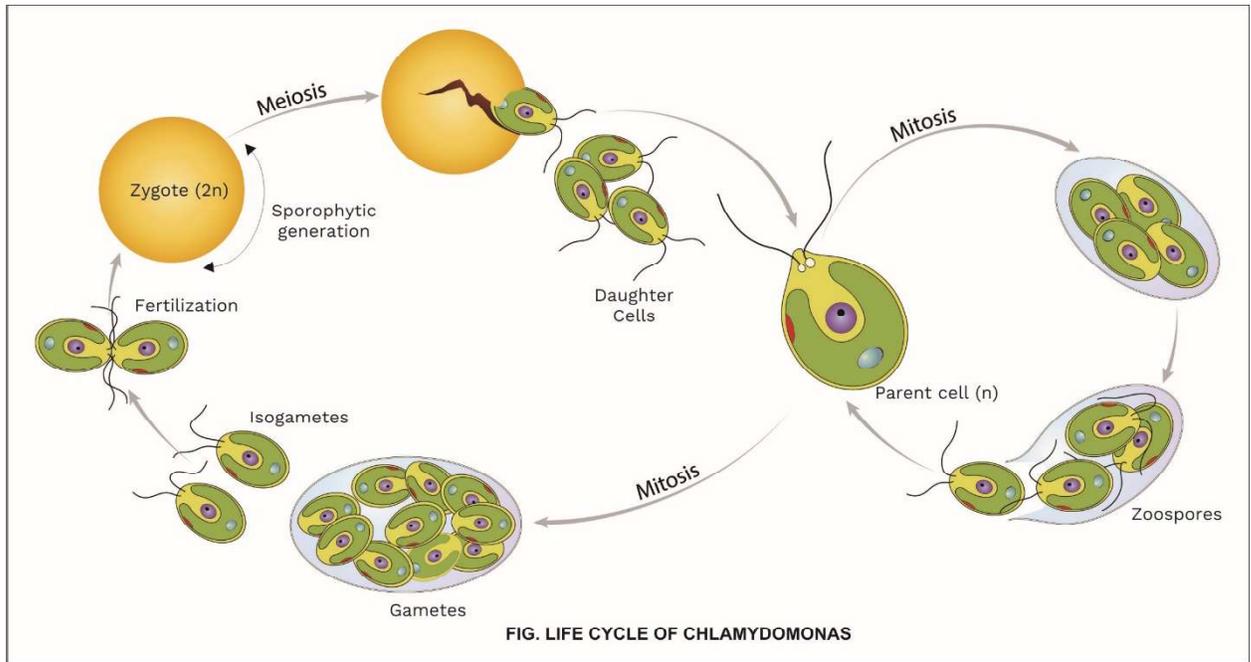
Rack your Brain



Which group of algae have pyrenoids?

LIFE CYCLE OF REPRESENTATIVE MEMBERS OF CHLOROPHYCEAE





GREEN ALGAE AS ANCESTORS OF LAND PLANTS

Green algae are considered to be the ancestors of all land plants (bryophytes and tracheophytes). A biochemical study of the cell indicates that there is no land plant, which has descended from the ancestral red or brown algae. On the other hand, all land plants have similarities with green algae in the following features:

- Both green algae and land plants possess the same type of photosynthetic pigments i.e., chlorophyll a , chlorophyll b , carotenes and xanthophylls.
- Both the groups contain cellulose and pectic compounds in the cell wall.
- Starch is the common storage carbohydrate in the two groups.

Therefore, green algae are regarded as the parent group from which the ancestors of land plants have evolved.

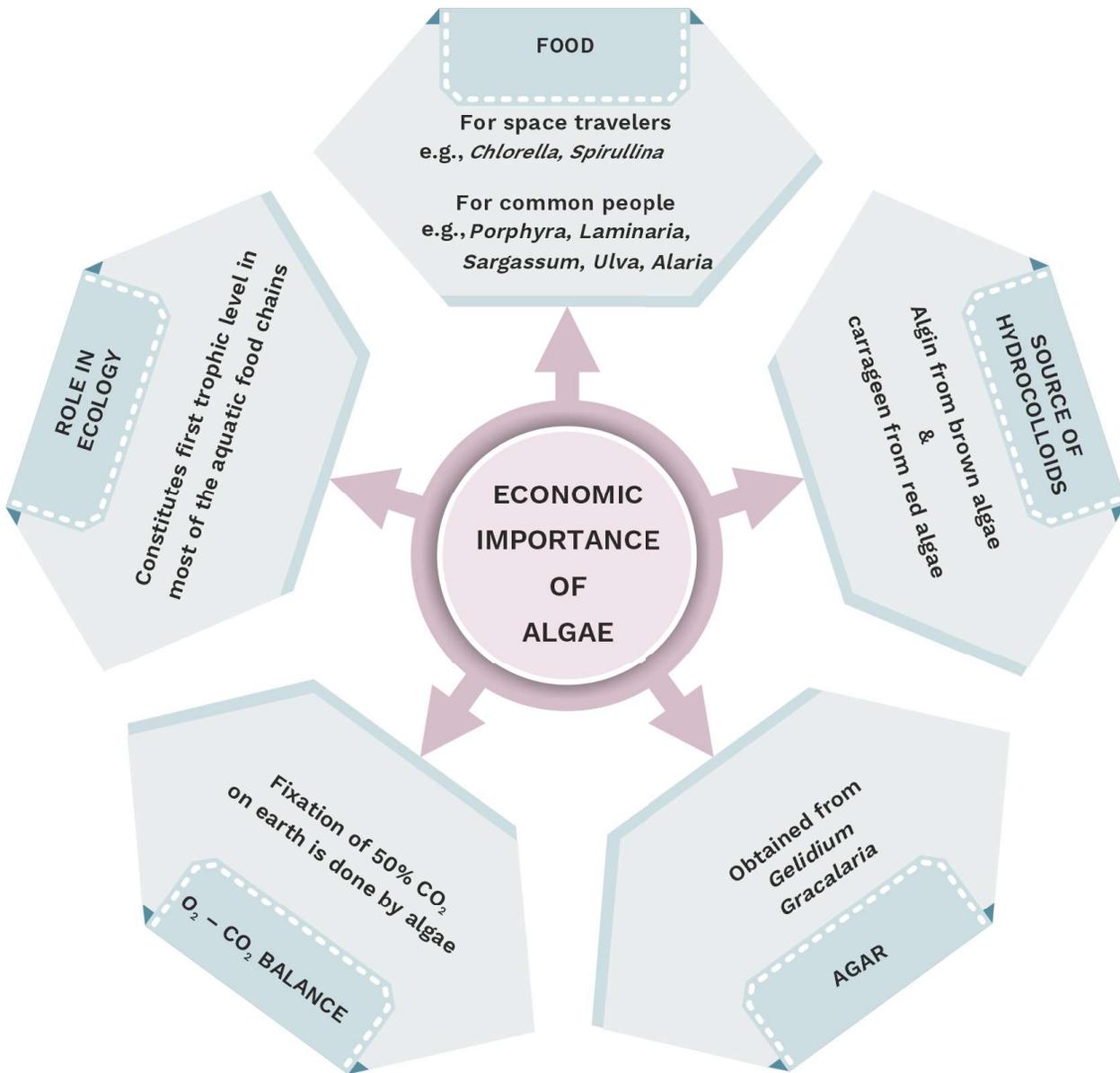
Economic importance of green algae

1. A number of green algae is used as food, e.g., *Chlorella*, *Ulva* (sea lettuce), *Caulerpa*, *Enteromorpha* etc.
2. Some green algae such as, *Chlamydomonas*, *Chlorella* help in sewage disposal.
3. Parasitic green algae *Cephaleuros* attacks on tea and coffee and reduces their yields.
4. An antibiotic **chlorellin** is extracted out from *Chlorella*.

Rack your Brain



Name a parasitic member of the division Chlorophyta.



PHAEOPHYCEAE (Gk. *Phaios*-brown; *phyton*-plant) (Brown Algae)

CHARACTERISTIC FEATURES OF BROWN ALGAE

- **Habitat:** Mostly marine, found thriving in cooler seas.
Exception – *Sargassum* thrives in warm seas.

Rack your Brain



State the biochemical similarity between green algae and terrestrial plants.



- **Structure:** Branched, filamentous (e.g., *Ectocarpus*) or flat ribbon-shaped (e.g., *Sargassum*, *Laminaria*, *Fucus* etc.). Some brown algae reach 40–60 metres in length e.g., *Macrocystis*. The giant brown algae are called **kelps**.

The plant body of large algal forms is differentiated into–

- Holdfast
- Stipe
- Lamina
- **Air vesicles:** These may also be present for providing buoyancy.
- **Sieve septa:** The larger algal forms possess sieve septa to carry food from the blade to the holdfasts. These can be termed as analogous to phloem of higher vascular plants.
- **Free-floating or sedentary:** Brown algae are commonly found attached by their holdfast. While a few such as *Sargassum* and *Fucus* are free-floating.
- **Cell wall composition:** Cellulosic cell wall, a colloidal covering consisting of a mixture of polysaccharides collectively called phycocolloids that are non-sulphated in brown algae. The common phycocolloids are **alginic acid** (algin), **fucoïdin** and **fucin**. Phycocolloids prevent drying or freezing (in water). When the algae are exposed to air during low tides and protect cells when waves beat them against the rocks.
- **Photosynthetic pigments:** A brown pigment – **fucoxanthin**, along with **chlorophyll-a**, **chlorophyll-c** and **carotenes**.

- Fucoxanthin masks the green colour of the chlorophyll.
- Fucosan is in retractile vesicles called **fucosan vesicles** found in the cells. Fucosan is colourless in water but becomes brown or black on exposure to air.

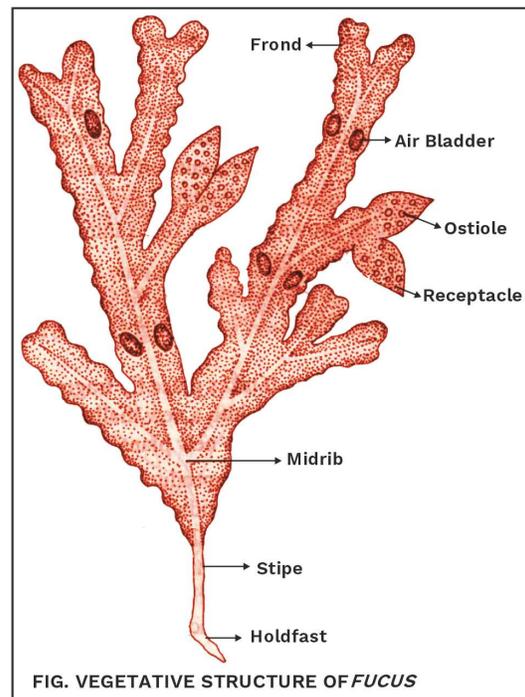
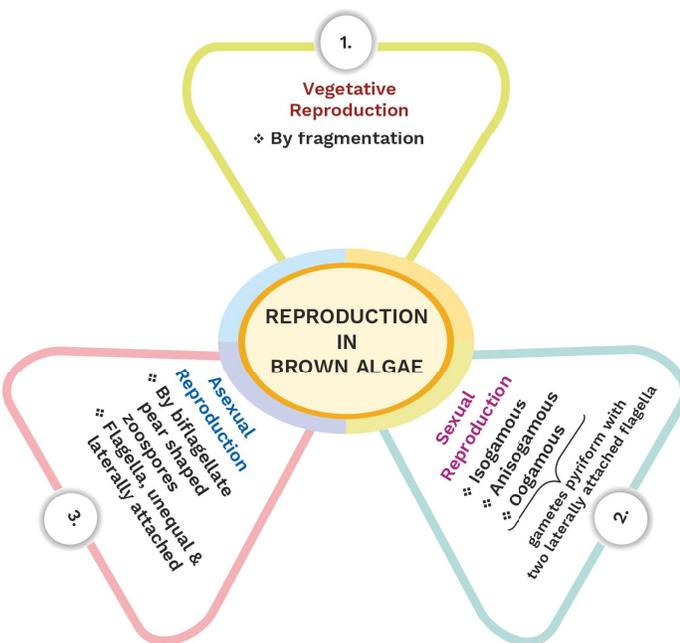
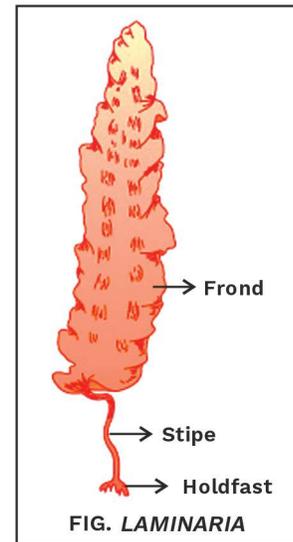
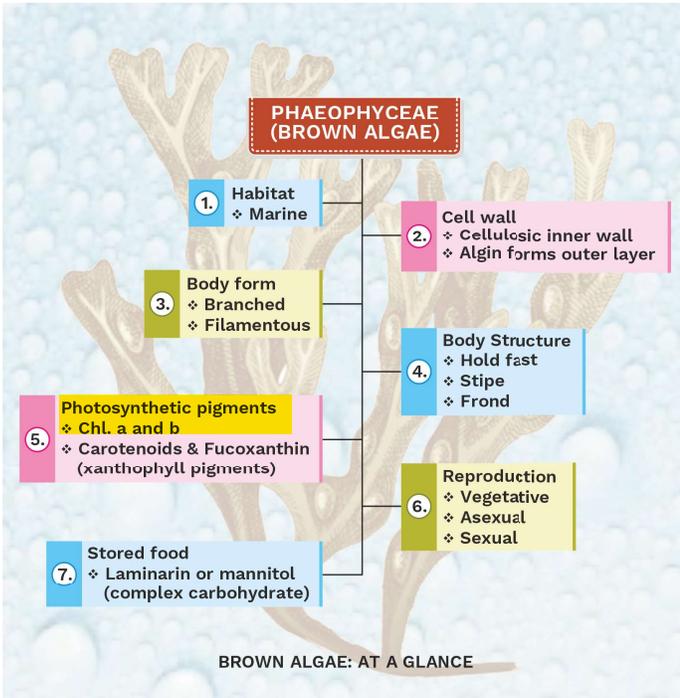
- **Reserve food material:** Laminarin (a form of carbohydrate) and lipid.
- **Reproduction in brown algae:**
 - Vegetative reproduction: By fragmentation
 - By specialized propagules called nests of cells.
 - Asexual reproduction: By both motile and non-motile spores. Motile spores or zoospores possess lateral heterokont flagellation (2 flagella, one is whiplash-type and the other is tinsel type).
 - Sexual reproduction varies from isogamy, anisogamy to oogamy.
- **Alternation of generation:** It occurs in some algae during their life cycles.
 - In few algae, the two generations are similar in structure which is termed as **isomorphic alternation of generation** e.g., *Ectocarpus*, *Dictyota*.
 - In few cases diploid phase is dominant and the haploid phase is represented by gametes, e.g., *Fucus*.

Rack your Brain



The giants among the following algae are :

- (1) *Laminaria*
- (2) *Dictyota*
- (3) *Microcystis*
- (4) *Macrocystis*





Economic Importance of Brown Algae

- **Iodine** is obtained commercially from *Fucus* and *Laminaria*.
- **Alginic acid or algin**
 - It is a phycocolloid that is extracted from several brown algae which also includes the giant forms.
 - It is used as an emulsifier in ice creams, toothpastes, cosmetics, ointments etc.,
 - It is also used in textiles sizing and making flame-proof plastics, security glass, artificial silk (seaweed rayon) and surgical threads.
- Food and fodder : *Laminaria*, *Alaria*, *Macrocystis*, *Sargassum* etc., are used as food in many countries while some of the algae are used as fodder too.
- Medicinal value : *Laminaria* and *Ascophyllum* have antibiotic property, while *Durvillaea* possesses worm expelling properties (vermifuge properties).

RHODOPHYCEAE (Gk. *rhodo*-red; *phyton*-plant) (Red Algae)

Red algae are an ancient group of algae consisting of about 5,000 living species. They possess chlorophyll α , phycobilins, floridean starch as reserve food, abundant phycocolloids but lack flagellated cells. They are characterised by the following features:

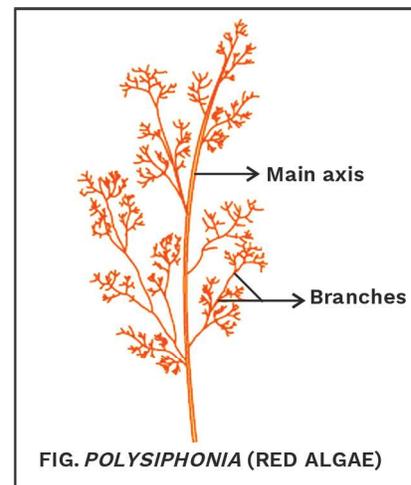
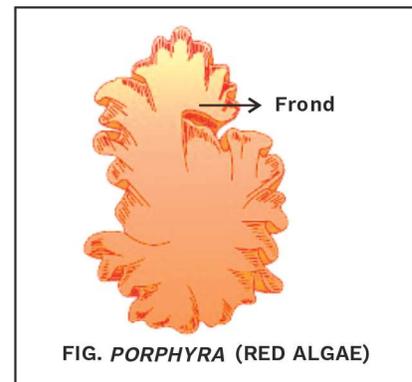
- Habitate
 - Mostly marine and include several seaweeds.
 - Few are found in fresh water also (e.g., *Batrachospermum*).
- Size: Microscopic to about half a metre in length. Their plant body may be—
 - Unicellular (e.g., *Porphyridium*)
 - Filamentous (e.g., *Steriocystis*)
 - Sheet like (e.g., *Porphyra*, *Chondrus*)
 - Lace like (e.g., *Gelidium*)
- Cell wall: It consists of sulphated mucopolysaccharides called **phycocolloids**,

Rack your Brain



Which of the following is an example of agarophyte?

- (1) *Dictyota*
- (2) *Nostoc*
- (3) *Gelidium*
- (4) *Fucus*





beside **cellulose** and pectic substances. The important phycocolloids of red algae are **agar**, **carageen** and **porphyrin**.

Some red algae appear coral-like and are called **coralline algae** (e.g., *Corallina*). Due to the accumulation of calcium carbonate from sea water and its deposition on the cell walls.

- Photosynthetic pigments: **Chlorophyll a**, **carotenoids** and **phycobilins**.

Phycobilins are water soluble pigments that are of two types –

- Red coloured phycoerythrin
- Blue coloured phycocyanin.

The phycobilin pigments of red algae are the same as found in *Cyanobacteria*.

In deep waters, red algae are more red, due to abundant formation of phycoerythrin, while in shallow waters red algae appear greenish, violet, or purplish due to lesser synthesis of phycoerythrin.

Note:

Blue-green waves of the spectrum, being shorter, can reach the greatest depth in water. The red pigment phycoerythrin captures the blue-green part of the spectrum more effectively. This is the reason for the red algae to be found growing in the deepest seas, where normally other photosynthetic forms cannot live.

- Stored food reserve: **Floridean starch** (somewhat similar to glycogen).
- Flagellated or motile cells are absent in red algae.
- Reproduction:
 - Vegetative reproduction
 - ◆ By fragmentation
 - ◆ By regeneration of several holdfast.
 - Asexual reproduction
 - ◆ Neutral spores
 - ◆ Monospores
 - ◆ Carpospores
 - ◆ Tetraspores, etc.

Gray Matter Alert!!!

Harveyella is a parasitic red alga that draws its food from other red algae.

Rack your Brain



What are the similarities between blue - green algae and green algae ?



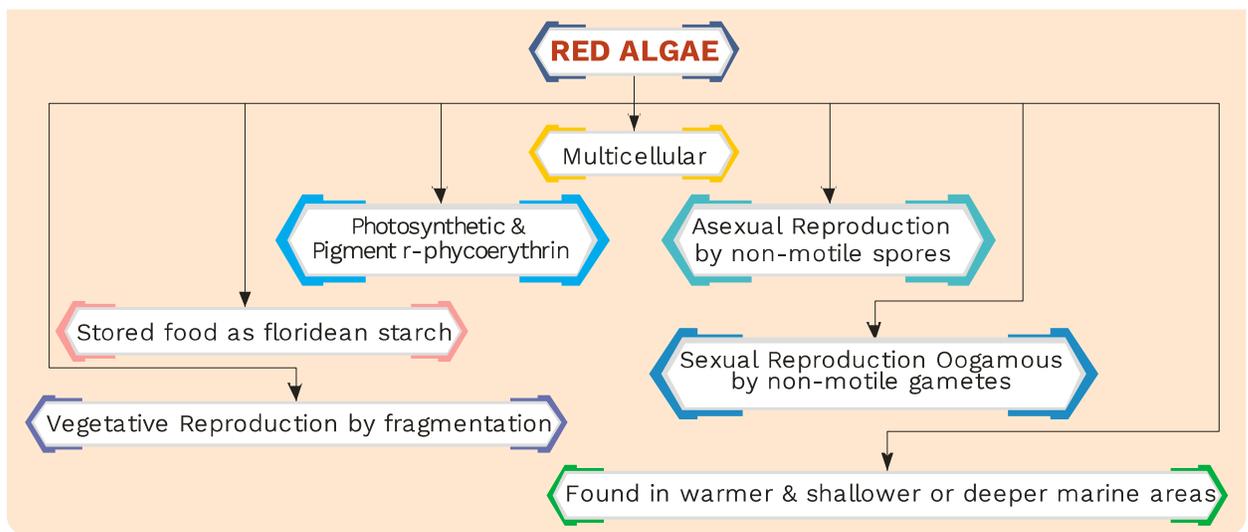
These all are non-motile spores of different kinds.

- Sexual reproduction: By the fusion between non-motile male gamete and female gamete.

The male gamete called **spermatium** which is produced in male sex organ **antheridium** or **spermatangium**, water

carries spermatium to the **trichogyne** of the flask shaped female sex organ called **carpogonium**. The fertilised carpogonium remains attached to the parent plant and forms a diploid structure called **carposporophyte**.

- Alternation of generation: It is observed in some red algae during the life cycle.



Economic Importance of Red Algae

- **Agar** is obtained commercially from *Gelidium* and *Gracilaria* commonly called **agarophytes**. Agar is widely used to solidify culture media in microbiological studies. It is also used as stabiliser or thickener in the preparation of jellies, puddings, ice creams, bakery, etc.
- **Carrageen** extracted from *Chondrus*, is used as clearing agent in liquors and as emulsifier in chocolates, ice creams, toothpaste.
- Funori obtained from *Gloiopeltis* is a glue. It is used as adhesive in textiles sizing and papers.
- Some red algae like *Chondrus* (Irish moss), *Porphyra* (Laver), *Rhodomenia* (Dulse), etc., are used as food. *Rhodomenia* (also called sheep's weed) is used as fodder.
- Some red algae have medicinal value, e.g., *Corallina* is used for worm infection. Agar is used as laxative and carrageen as blood coagulant.
- **Bromine** is obtained from *Rhodomela*.



CHARACTERISTICS OF ALGAE AT A GLANCE

Classes	Major Pigments	Stored Food	Cell Wall	Reproduction	Habitat	Examples
Chlorophyceae (Green algae)	Chlorophyll a, b	Starch	Cellulose	Vegetative – Fragmentation Asexual – Flagellated zoospores Sexual – Isogamous/ Anisogamous/ oogamous	Fresh water, brackish water, salt water	<i>Chlamydomonas</i> <i>Volvox</i> <i>Ulothrix</i> <i>Spirogyra</i> <i>Chara</i> <i>Chlorella</i>
Phaeophyceae (Brown algae)	Chlorophyll a, c, fucoxanthin	Mannitol, laminarin	Cellulose and algin	Vegetative – Fragmentation Asexual – Biflagellated (uneven in length), pear shaped zoospores Sexual – Isogamous/ Anisogamous/ oogamous Gametes – Pyriiform, biflagellated	Fresh water (rare) brackish water, salt water	<i>Ectocarpus</i> <i>Dictyota</i> <i>Laminaria</i> <i>Sargassum</i> <i>Fucus</i>
Rhodophyceae (Red algae)	Chlorophyll a, d, phycoerythrin	Floridean starch	Cellulose, pectin and polysulphate esters	Vegetative – Fragmentation Asexual – Non-motile spores Sexual – Oogamous (non-motile gametes)	Fresh water (few), brackish water, marine (most), warm sea water (shallow as well as marine)	<i>Polysiphonia</i> <i>Porphyra</i> <i>Gracilaria</i> <i>Gelidium</i>

**BRYOPHYTES** (Gk. *bryan*-moss; *phyton*-plant)

Bryophytes are non-vascular land plants of moist habitat. Their characteristic features are:

- Habitat: Found growing in damp and shady places. Generally, grow densely and form green carpets or mats like structures on damp soils, rocks, walls, tree trunks, etc., especially during the rainy season.
- Size: Generally small plants and seldom grow more than 15 cm in height.
- Body form: The dominant phase or main plant body of bryophytes is a gametophyte i.e., haploid. Gametophyte is not differentiated into true root, stem and leaves. Hence, the plant body is called **thallus**.
- Rhizoids: Thalloid body is fixed to the substratum by means of fine hair like structures called rhizoids.
- Water absorption: In the absence of roots, thallus absorbs water and minerals directly from ground or even from the atmosphere. Hence, can thrive only on moist places.
- Absence of vascular tissues: These tissues are not found in bryophytes, so conduction of water and food takes place by diffusion.
- Reproduction
 - Vegetative reproduction– Commonly observed in bryophytes and occurs by:
 - ◆ Fragmentation
 - ◆ Tubers
 - ◆ Gemmae
 - ◆ Adventitious buds
 - Asexual reproduction – Not observed
 - Sexual Reproduction– It occurs by the fusion between motile male gametes and non-motile female gametes.

The sex organs are **multicellular and jacketed**

Male Sex Organ: **Antheridium**

It produces numerous **biflagellate male gametes** or antherozoids. Being motile these can be termed as sperms too.

Gray Matter Alert!!!

The tallest moss is *Dawsonia*. It measures 60 cm in height and occurs in New Zealand.

Definition

Thallus: Undifferentiated body, i.e., not differentiated into distinct parts: Stems, leaves etc., of plants.

Definition

Gametophyte: Body or structure that produces gametes.

Definition

Archegonium: Female sex organ that encloses egg cell.

Definition

Antheridium: Male sex organ that produces antherozoids (male gametes).

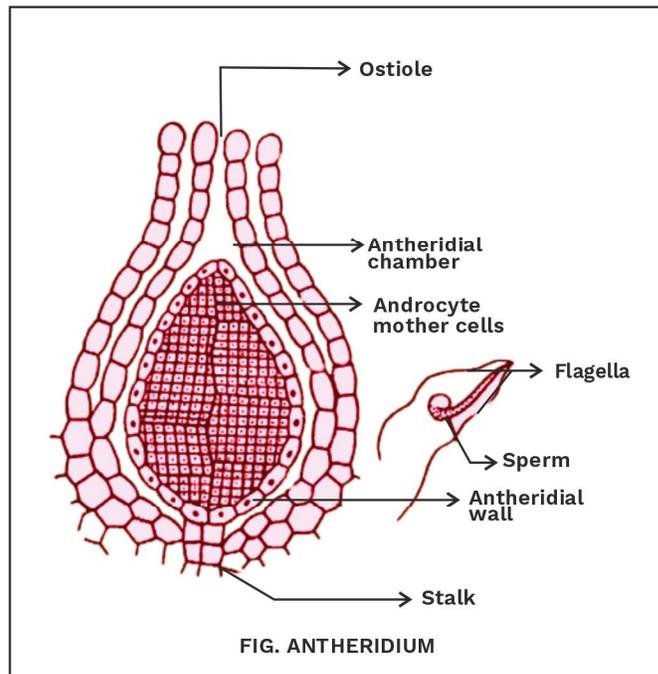
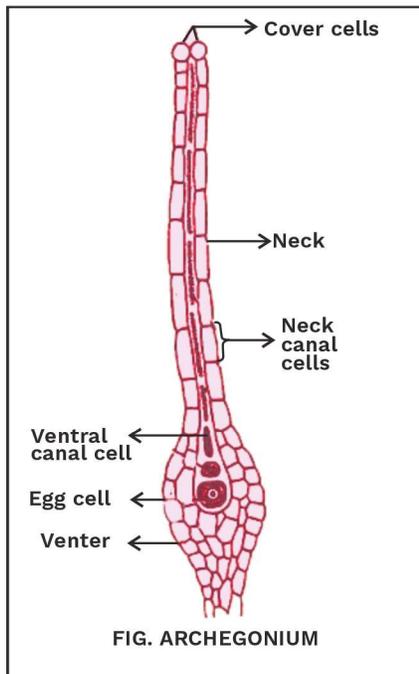


Female Sex Organ: **Archegonium**

It is flask shaped that consists of two parts –

- ◆ A tubular neck
- ◆ A swollen **venter**

Venter contains a single female gamete called **egg or oosphere**.

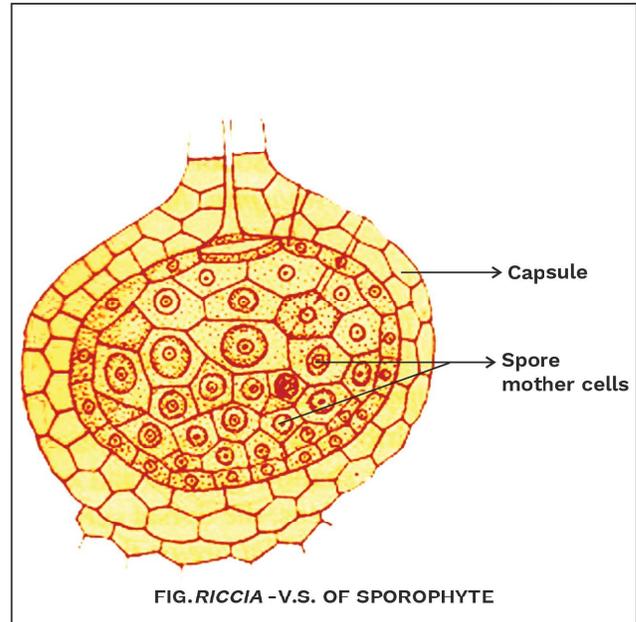
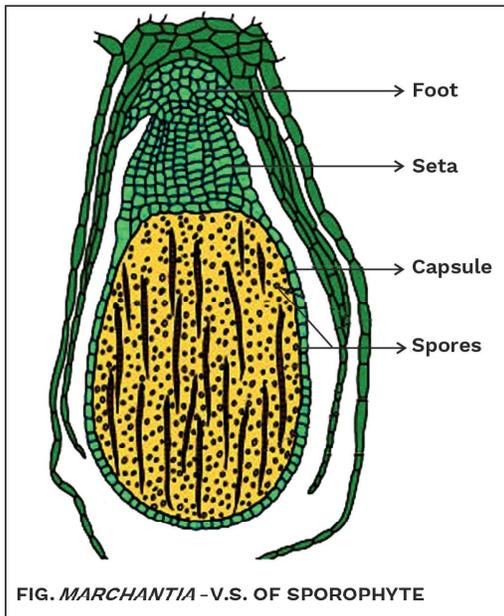


- Fertilisation: Male gametes swim and reach the female gamete to fertilize it that produces a diploid zygote inside the archegonium. The zygote develops to form an **embryo**, which grows into a sporophyte (diploid structure).
- Sporophyte: In bryophytes it is also called **sporogonium**. It remains attached to the gametophyte for support, shelter, and nutrition. The sporophyte has a filament and a capsule.
- Capsule of the sporophyte: It is the terminal part of the sporophyte that produces haploid spores through meiosis. On germination these spores produce gametophyte (haploid structure) directly or through a juvenile filamentous stage called **protonema** generally in moist places.

Rack your Brain



Which permanent tissue constitutes the gametophyte in Bryophytes?



Note:

Amphibians of the plant kingdom—Presence of water is essential for swimming the sperms to the archegonia for Fertilisation. Hence, bryophytes are described as **amphibians of the plant kingdom**.

Alternation of generation

The life of a bryophyte exhibits two distinct generations:

1. Gametophytic generation (haploid)
2. Sporophytic generation (diploid)
 - The **gametophytic generation** is represented by green, free-living thallus, sex organs and gametes.
 - The **sporophytic generation** is represented by the multicellular spore producing body called sporogonium or capsule, attached and dependent upon the gametophyte for nutrition, support and shelter.
 - The asexually produced haploid spores of this generation give rise to the gametophyte.

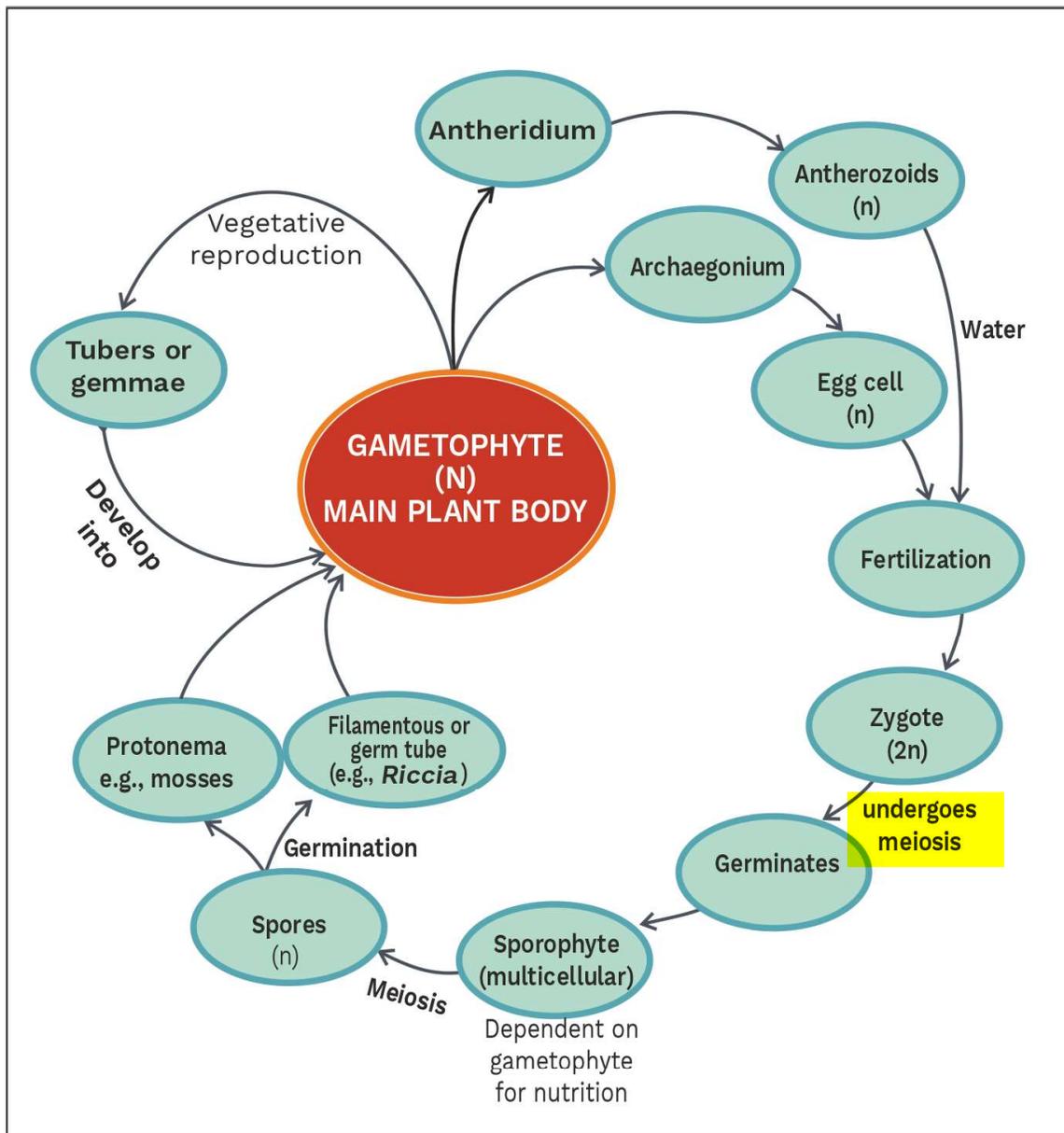
Rack your Brain



What is the ploidy of asexual generation in bryophytes?



Bryophytes have multicellular sporophytic generation which is not found in algae. Thus, bryophytes are more advanced than the green algae.

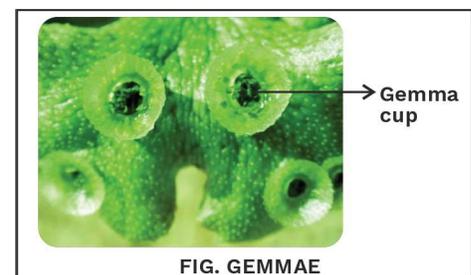
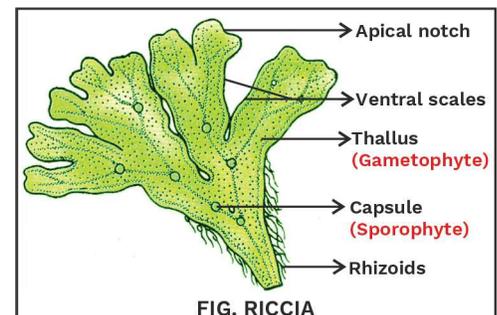
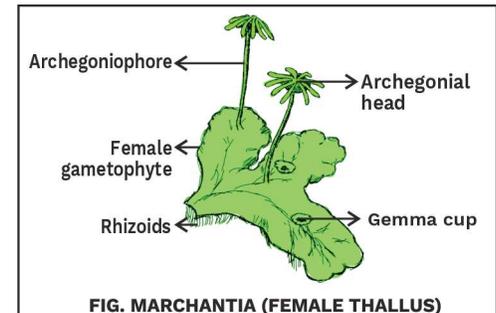
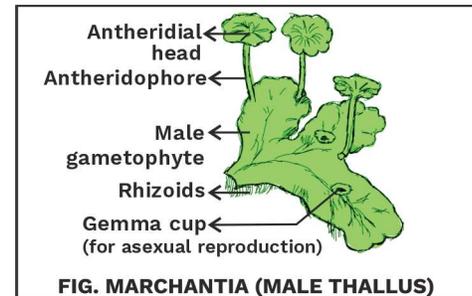




Main Classes of Bryophytes

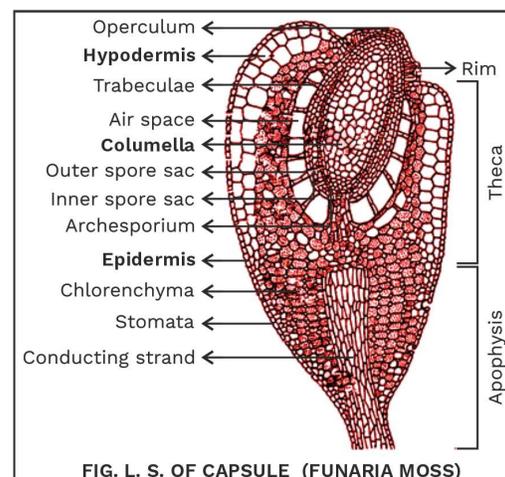
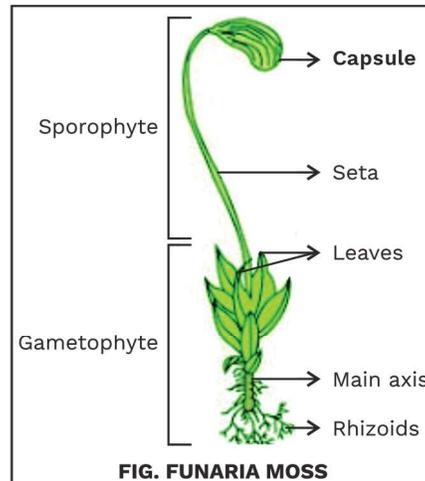
Bryophyta comprises three classes –

- Hepaticae (Liverworts)
- Anthocerotae (Hornworts)
- Musci (Mosses)
- **Hepaticae** (Liverworts)
 - Plant body is dorsoventrally flattened, lobed and bears fine hair like unicellular rhizoids.
 - Mode of asexual reproduction: By fragmentation of thallus, or by specialized structures called **gemmae** (singular, gemma).
 - Gemmae are asexual buds that develop on the gametophytic body in small receptacles called gemma cups. These are multicellular and green in colour.
 - Fully developed gemmae get detached from the parent body and germinate to form new individuals.
 - Sexual reproduction: During sexual reproduction, male and female sex organs are produced either on the same or on different thalli.
 - The **sporophyte** consists of three parts *viz.* a **foot**, **seta** and **capsule**. After meiosis, spores are produced within the capsule. In *Riccia*, the sporophyte is represented only by capsule.
 - These spores germinate to form free-living gametophyte.
 - The sporophyte of liverworts has no or very little green tissue and is completely dependent upon the gametophyte for its nutrition e.g., *Riccia*, *Marchantia*.
- **Anthocerotae** (Hornworts)
 - These have dorsiventral, thalloid plant body with unicellular rhizoids.
 - The sporophyte is cylindrical like a horn with great amount of green tissue and is partially dependent upon the gametophyte e.g., *Anthoceros*.
- **Musci** (Mosses)





- The adult plant body is leafy, erect, radially symmetrical that develops from a filamentous or thalloid juvenile stage called **protonema**.
- Gametophytic body (parent body) bears multicellular branched rhizoids.
- Vegetative reproduction occurs by fragmentation and budding in protonema.
- In sexual reproduction, female gametes are Fertilised by male gametes. These gametes are produced in antheridium (male reproductive organ) and archegonium (female reproductive organ). The leafy shoots of gametophytic body bears these sex organs, at their apex.
- After Fertilisation, the zygote develops into a sporophyte. Consisting of a foot, seta, and capsule.
- The sporophyte in mosses is more elaborate than in liverworts.
- The capsule contains spores formed after meiosis. The mosses have elaborate mechanisms of spore dispersal.
- The sporophyte has abundant green tissue and is partially dependent upon the gametophyte for water and minerals to perform its own food making process (photosynthesis) e.g., *Funaria* (cord-moss). *Sphagnum* (Bog or Peat moss), *Polytrichum* etc.,



BRYOPHYTES ARE AMPHIBIANS OF PLANT

KINGDOM

- The gametophyte of bryophytes lacks cuticle covering and so are found growing in moist habitat to prevent desiccation.
- In absence of vascular tissues in the gametophyte, all parts of it are able to absorb water directly from moist habitat.
- The flagellated sperms of both the groups require an external supply of water for swimming to reach archegonia for successful fertilisation. Thus, it can be concluded that mosses and ferns are amphibians of the plant kingdom just like amphibians of animal kingdom needs water for fertilisation.



Economic Importance of Bryophytes

- Bryophytes grow densely on the substratum forming a mat-like structure and prevent soil erosion.
- Mosses play an important role in plant succession on rocky areas. The bare rocks which are inhabited by lichens during ecological succession are replaced by mosses and thus, these mosses play a significant role in soil formation. The growth of *Sphagnum* ultimately fills ponds and lakes with soil.
- *Sphagnum* that generally grows in bogs can absorb large amounts of water i.e., up to 18 times its weight. It is considerably used by gardeners to keep seedlings and cut plant parts moist during transportation and propagation. It was favoured over absorbent cotton in ancient times.
- Peat moss is formed by the process of decomposition, in the absence of air. It consists of *Sphagnum* plants which got compacted and fossilized over the past several millennia. Hence, peat is a valuable fuel like coal.
- Mosses are good source of animal food in rocky and ice-clad areas.

VASCULAR PLANTS

Tracheophyta (Gk. *trachia* – windpipe; *phyton* – plant)

Vascular plants include more than 2,75,000 living species. They are the most visible green plants around us. Vascular plants, with some of the largest (e.g., over 100 metres in height) and longest (i.e., 6000 years of age) living forms, dominate land flora.

Vascular plants are characterized by the following features:

- Plant Body:
 - The plant body is differentiated into true stem, leaves and roots and show a distinct division of labour for leading photoautotrophic life on land.

Rack your Brain



Name the source of the antibiotic 'Sphagnazn'.

Gray Matter Alert!!!

Tallest angiosperm is *Eucalyptus regans* and smallest angiosperm is *Wolffia*

Previous Year's Question



The sporophyte of *Riccia* lacks which of the following structures?

- (1) Capsule
- (2) Foot
- (3) Seta
- (4) Spores



- Roots are the organs of anchorage and absorption for the plant.
- The leaves manufacture organic food by intercepting sunlight and absorbing carbon dioxide from the atmosphere.
- The stem provides support to the leaves and connects the latter to the roots.
- Vascular Tissue:
 - These possess vascular or conductive tissues – xylem and phloem.
 - Xylem transports water and minerals, while phloem conducts organic food.
- Dominant phase in life:
 - The dominant phase or plant body is a sporophyte (diploid).
 - Gametophyte is reduced, either lives independent life or dependent upon the sporophyte.
- Modes of reproduction:
 - Vegetative propagation
 - Sexual reproduction

Note:

Meiosis occurs at the time of spore formation (sporic meiosis) inside sporangia borne on leaves called sporophylls in vascular plants.

- Embryo is formed during the life cycle of the plants.
- Vascular plants have adapted themselves to diverse environments by modification of their organs for other functions.

REASONS FOR DOMINANCE OF VASCULAR PLANTS.

- Development of strong roots capable of penetrating deep into the soil.
- Development of cutin or a waterproof layer on aerial surface especially the leaves to reduce transpiration.

Definition

Gametophyte Stage: The haploid stage in the lifecycle of a plant. It is the dominant stage in the life cycle of non-vascular plants.

Definition

Sporophyte Stage: The diploid stage in the lifecycle of a plant. It is the dominant stage in the lifecycle of vascular plants.

Gray Matter Alert!!!

Primitive type of stomata are present on the apophysis of the capsule in ferns.



- Development of strong woody mechanical tissue to provide mechanical support to aerial parts and to allow them to rise to a great height.
- Development of long-distance transport system in the form of vascular tissue.
- Development of modifications in structure and functions to suit the diverse environment.

Groups of Vascular Plants.

Vascular plants are classified into three groups

- **Pteridophytes** (vascular plants without seeds)
- **Gymnosperms** (plants with naked seeds but no fruits)
- **Angiosperms** (flowering plants bearing fruits and enclosed seeds)

PTERIDOPHYTES (Gk. *ptēris* – fern; *phyton* – plant)

Pteridophytes are **seedless vascular plants**.

Characteristic Features of Pteridophytes

- The dominant phase (plant body) is a sporophyte, with true stem, leaves and roots.
- These are the first land plants to have vascular tissues, but their xylem lacks true vessels and phloem lacks companion cells.
- Meiospores are formed inside sporangia associated with leaves called sporophylls.
 - **Homosporous Pteridophytes.** Majority of pteridophytes produce spores of similar kind. Hence, they are called **homosporous**.
 - **Heterosporous Pteridophytes:** Some pteridophytes produce two kinds of spores, macrospores (large) and microspores (small). Hence, are termed **heterosporous** e.g. *Selaginella*, *Salvinia* etc.,
 - ◆ Megaspores germinate to produce female gametophyte.
 - ◆ Microspores germinate to produce male gametophyte.

Definition

Homosporous: Plants that produce spores of similar kinds.

Definition

Heterosporous: Plants that produce spores of two different kinds.

- The female gametophytes in these plants remain attached on the parent sporophytes for variable periods.
- Inside the female gametophytes, the zygotes develop and later on develop into young embryo.
- The gametophyte is independent and autotrophic but is small and unobtrusive.
- The male gametes or sperms are flagellated requiring the presence of water for swimming to reach archegonia.

Note:

The development of zygotes into young embryos takes place within the female gametophytes. This event is a precursor to the **seed habit**, considered as an important step in evolution demonstrated by pteridophytes.

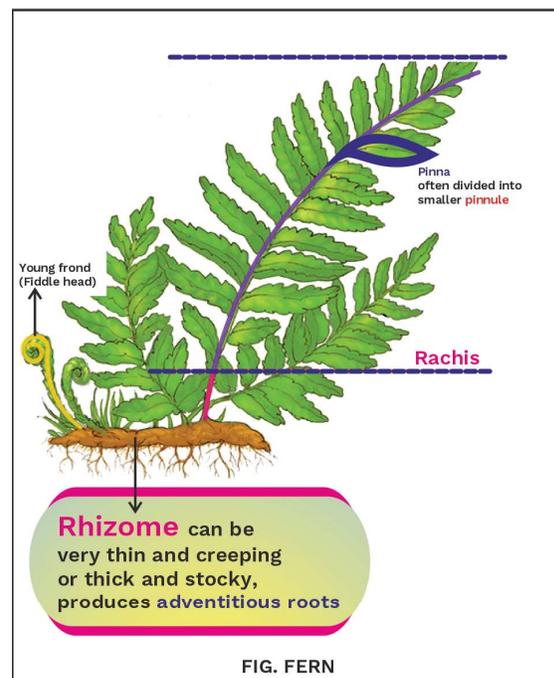
Rack your Brain



Name the extant member of Sphenopsida.

Main Groups of Pteridophytes

- Pteridophytes comprise four classes:
 - **Psilopsida** (Psilophytes)
 - **Lycopsidea** (Club mosses)
 - **Sphenopsida** (Horsetails)
 - **Pteropsida** (Ferns)
- Most of the members of **psilophytes** are known only as fossils except only a few living members e.g., *Psilotum*.
- The **club mosses** grow prostrate in aggregates like mosses e.g. *Lycopodium*, *Selaginella*.
- The **horsetails** have articulated stem with whorls of branches and scale-like leaves. The spore producing bodies are borne at the ends of branches and resemble the horse tail e.g., *Equisetum*.
- The **ferns** are the most conspicuous Pteridophytes which bear underground stem called rhizome, adventitious roots and aerial leaves e.g., *Dryopteris*, *Pteris*, *Adiantum*, *Marsilea*, *Cyathea*.



FERNS

Ferns include about 10,000 species and

constitute the largest group of primitive vascular plants. Ferns dominated the earth in Carboniferous period (about 300 million years ago).

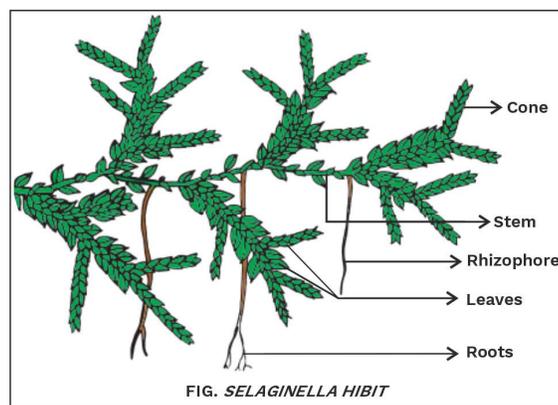
Common Features of Ferns

- **Habitat**
 - They chiefly grow in humid tropics but are found in subarctic conditions too.
- **Structure of main plant body (sporophyte)**
 - Stem is underground (in most of the ferns) with horizontally growing **rhizome**.
 - Rhizome can survive forest fires and is also an organ of perennation when aerial parts wither off.
 - The rhizome bears numerous **adventitious roots**.
 - The leaves are large and are called **fronds**.
 - Most of the ferns have **pinnately compound leaves**.
 - The pinnate compound leaves may be of the following types:
 - ◆ Unipinnate (leaflets are not divided further)
 - ◆ Bipinnate (leaflets sub-divided once)
 - ◆ Tripinnate (leaflets sub-divided twice)
 - Some ferns have simple leaves i.e., leaf with one blade.
 - Apical meristem or growing point is present on the leaves and at maturity it loses meristematic activity .
 - Young leaves show characteristic **circinate ptyxis** or coiling like a spring. The coiling protects the growing point responsible for leaf growth.
 - Ramenta: These are multicellular hair or scales present on the younger parts of stem, leaves and mature petiole, for protection.

Rack your Brain



Name the tissue responsible for vegetative propagation in *Adiantum* (Pteridophytes).





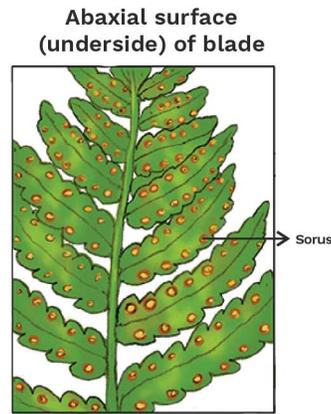
Note:

Ferns are usually regarded as ornamental plants because of their elegant and showy compound leaves. Few ferns have aerial stems and may attain height over 20 metres. They are called tree ferns e.g., *Cyathea*, *Celeotium*.

• **Reproductive structure**

Sporophylls

- These are mature and fertile leaves that bear sporangia on their undersurface. Sporangia are present in clusters called **sori** (singular – sorus).
- A sorus is covered by a flap-like outgrowth from its surface called true indusium e.g. *Dryopteris* or turned margin of the sporophyll called false indusium e.g., *Pteris*, *Adiantum*.
- Haploid spores are formed, within each sporangium from spore mother cells through meiosis.
- Vegetative reproduction: By fragmentation, adventitious buds and bulbils.



Fern leaves are **megaphylls** commonly referred to as **frond**

Note:

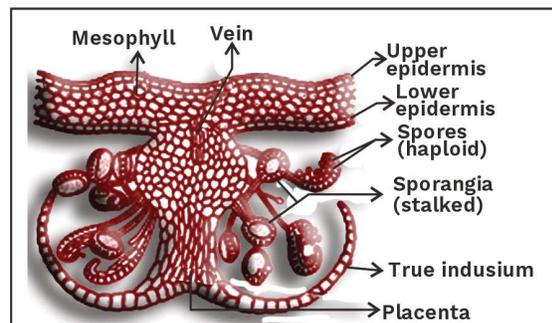
Walking fern (*Adiantum caudatum*) produces new plants, when its leaf tips come in contact with the soil. Thus, many new plants are formed near the parent plant.

- Gametophyte: It is thalloid and is called **prothallus**. It is produced by the germination of haploid spore.

Prothallus is a monoecious plant body that bears both male reproductive structure (antheridium) and female reproductive structure (archegonium) in different areas.

• **Male and female reproductive structures**

- **ANTHERIDIUM:** It is male reproductive structure, hemispherical in shape with generally three celled jacket enclosing



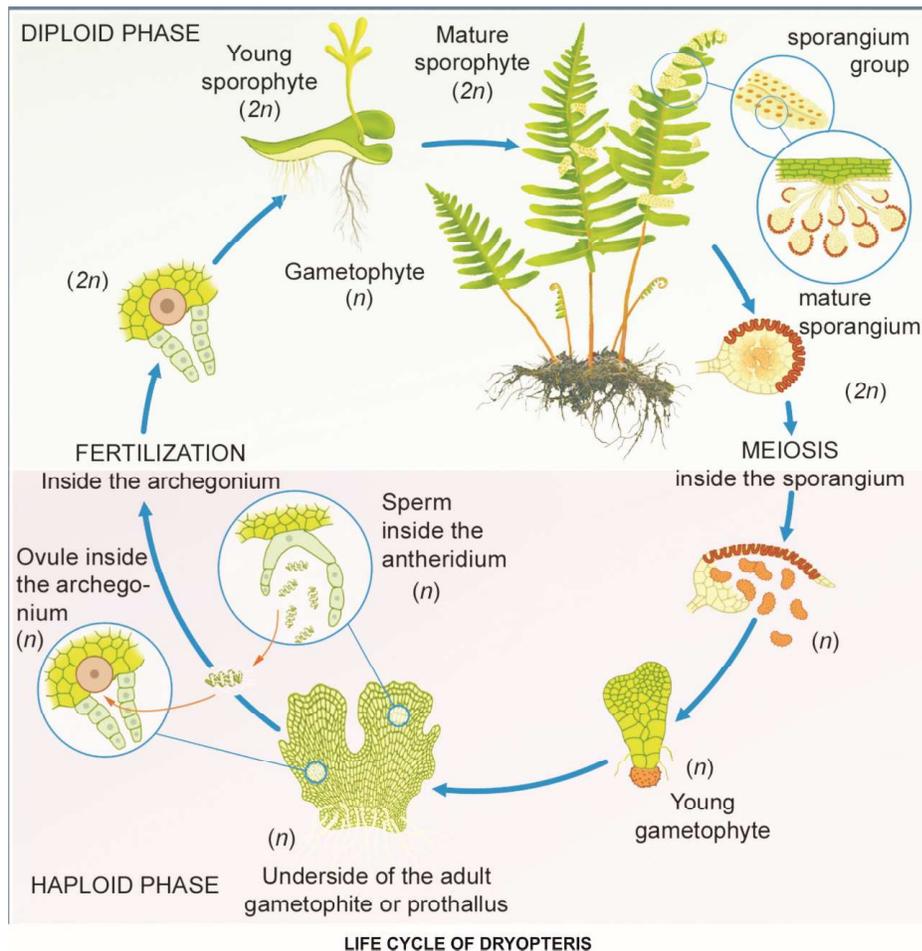


32-48 sperm mother cells. The sperms are multiciliate and require water for swimming to reach archegonia.

- **ARCHEGONIUM:** It is a female reproductive structure which is flask-shaped and is partially embedded in the prothallus. The neck of each archegonium has four rows of cells.
- **Embryo stage:** An embryo stage is present in the life-cycle of a fern.
- **Alternation of generation:** Ferns exhibit a **heteromorphic** or **heterologous** alternation of generation during the life cycle. Dominant sporophytic generation with an unobtrusive gametophytic generation is followed.

Gray Matter Alert!!!

Primitive type of stomata are present on the apophysis of capsule in ferns.



Economic Importance of Ferns

- These are valued ornamental plants because of their graceful foliage.
- A vermifuge drug is obtained from the rhizomes and leaf petioles of *Dryopteris* fern.
- Certain tribal people use sporocarp of *Marselia* (a water fern) as food.

GYMNOSPERMS

(Gk. *gymnos* – naked; *sperma* – seeds; Seed plants without flowers and fruits)

They are characterised by the following features:

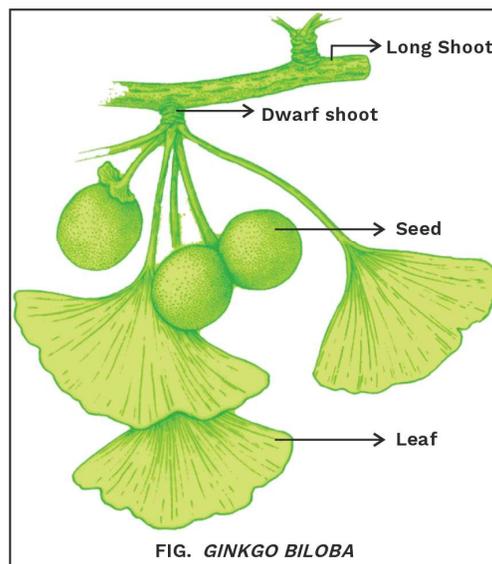
- Gymnosperms are seed-bearing, non-flowering plants and are represented by about 900 living species.
- Gymnosperms are dominant only in the colder regions, where snow is the source of water for the wild plants.
- Few gymnosperms like cycads thrive in warm weather. *Cycas circinalis* grows wild in South India. *Araucaria*, a tall-majestic conifer, native to South America thrives at lower elevations and warmer climates.
- All gymnosperms are woody trees or bushy shrubs that are perennial. Some of them are very large and live for thousands of years e.g., *Sequoia sempervirens* (giant red wood tree).
- 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 specialized roots called coralloid roots are associated with N_2 fixing cyanobacteria.
- Vascular tissues are arranged into vascular bundles. Xylem does not possess vessels and phloem is without companion cells like pteridophytes.
- Gymnosperms are **heterosporous**. They produce two types of meiospores – microspores (pollen grains) and megaspores.
- The spores are produced in different types of

Previous Year's Question



Coralloid roots are found in :

- (1) *Pinus*
- (2) *Lycopodium*
- (3) *Cycas*
- (4) *Dryopteris*



Gray Matter Alert!!!

Sequoia sempervirens (giant red wood tree) is one of the tallest species among gymnosperms.

Definition

Mycorrhiza: Association of a fungus with the roots of higher plants.



sporangia called microsporangia (pollen sacs) and megasporangia, respectively. The megasporangia are integumented and are called **ovules**.

- The microsporangia and ovules are borne on distinct sporophylls called microsporophylls and megasporophylls, respectively.
- The microsporophylls do not show distinction of filament and anther, and the megasporophylls are not rolled like carpels.
- Instead of flowers, microsporophylls and megasporophylls are aggregated to form distinct cones or **strobili** called **male cones** (pollen cones) and **female cones** (seed cones), respectively.
- Three layered integumental ovules are borne exposed on the megasporophyll with an opening called **micropyle**.
- **Anemophily** is common and the pollen grains directly reach into pollen chamber of a ovule through micropyle.
- The microspores (pollen grain) produce male gametophyte and one male gametophyte produces only two male gametes.
- The megaspores give rise to female gametophyte that bears archegonia.
- Both the gametophytes are reduced and are formed within the sporophyte.
- Fertilisation is facilitated by a pollen tube produced by the male gametophyte. It is called **siphonogamy**.
- A food laden tissue called **endosperm** is produced in a seed before Fertilisation hence, it is haploid. Endosperm is reserve food for future growth of embryo into a seedling.

Rack your Brain



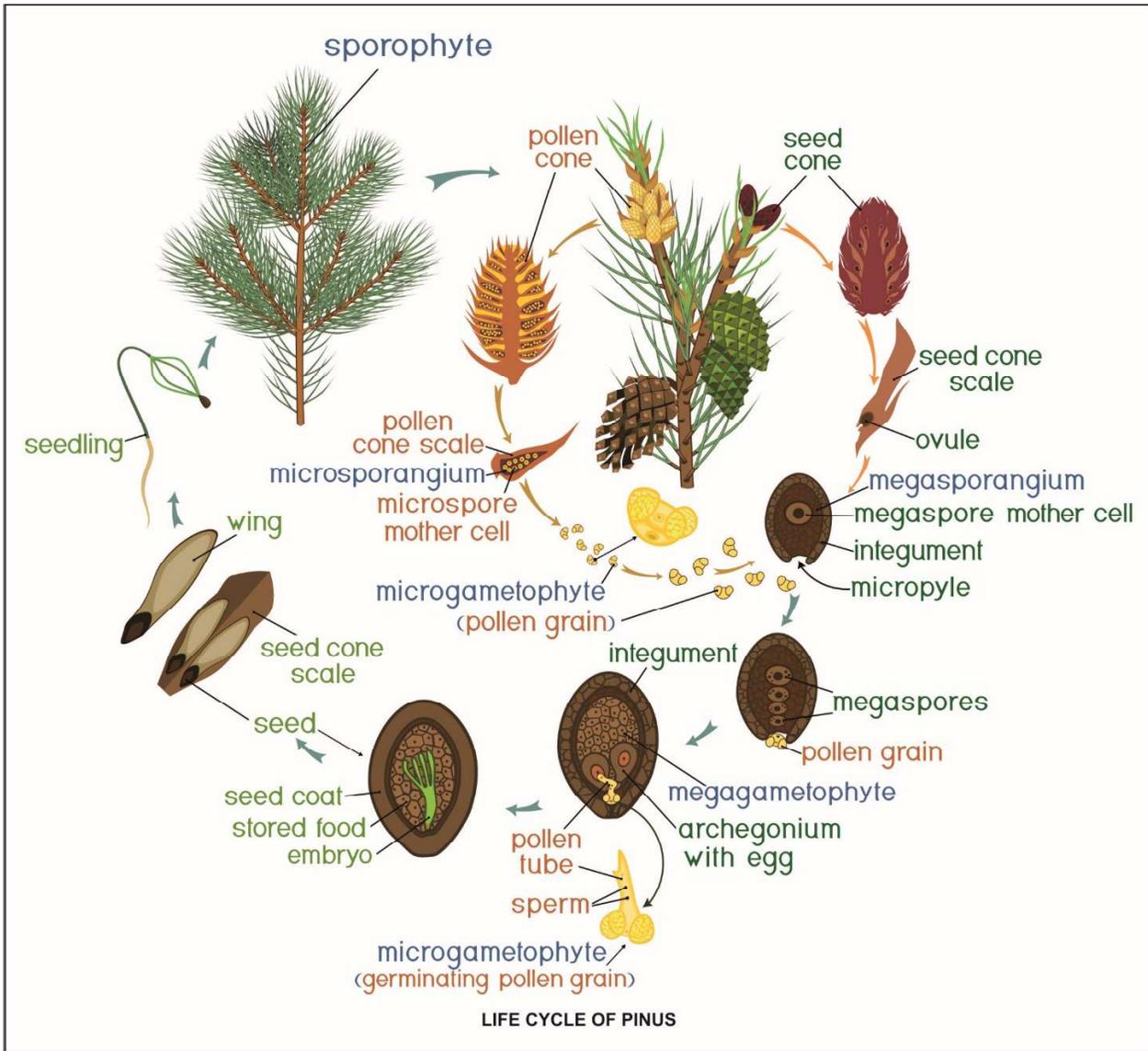
Name the vascular plants that lack companion cells.

Definition

Anemophily: Pollination facilitated by wind.

Gray Matter Alert!!!

The endosperm represents the female gametophyte.



Main Groups of Gymnosperms

Gymnosperms include three main classes:

- Cycadopsida (cycads)
- Coniferopsida (conifers)
- Gnetopsida



Cycadopsida (Cycads)

- Cycads constitute a small group of gymnosperms with palm-like habit and fern-like foliage.
- Plants are dioecious i.e., microsporophylls and megasporophylls are borne on separate plants.
- Cycads are mostly xerophytic and occur in warm regions. They are widely grown as ornamental plants e.g., *Cycas*.
- In *Cycas* pinnate leaves are present which persist for few years

Coniferopsida (Conifers)

- Conifers are the dominant gymnosperms with more than 500 living species.
- They are cone-bearing plants with **excurrent habit** (conical canopy).
- They possess an aromatic, antiseptic, semifluid called resin.
- Conifers mostly occur in colder regions, e.g., *Pinus*, *Cedrus*, *Juniperus*, etc.,

Gnetopsida

- This group includes climbing shrubs and small trees.
- Their xylem possesses vessels.
- The reproductive organs are borne in whorls or inflorescence.
- The reproductive organs are subtended by perianth, e.g., *Gnetum*, *Ephedra*.

ADAPTATION IN CONIFERS

To withstand extreme temperature, humidity and wind—

- Needle like leaves to reduce surface area
- Thick cuticle on leaves
- Sunken stomata
- Excurrent tree

Rack your Brain



If the somatic chromosome number of a gymnosperm plant is $2n = 22$, what would be the chromosome number in its endosperm tissue?

Gray Matter Alert!!!

Cycas produces largest sperms in the plant kingdom.

Previous Year's Question



Which of the following statements about *Cycas* is incorrect?

- (1) It has circinate vernation.
- (2) Its xylem is mainly composed of xylem vessels.
- (3) Its roots contain some blue-green algae.
- (4) It does not have a well-organized female flower.

Gray Matter Alert!!!

The seeds of *Pinus* have many cotyledons.



ECONOMIC IMPORTANCE OF GYMNOSPERMS

- Conifers are the source of **softwood** commonly used for construction, packing, plywood, and paper industry.
- Seeds of *Pinus gerardiana* (chilgoza) are edible and have high nutritive value.
- *Ephedra* is used to obtain a drug called **ephedrine** which is used to cure asthma and other respiratory problems.
- **Linoleum** and plastics are made from the saw dust of conifers.
- **Turpentine** is obtained from the resin of *Pinus* which is used in paints and polishes. It is used medicinally for pain, bronchitis and intestinal worms.
- **Rosin** is also obtained from the resin of *Pinus* which is used in waterproofing and sealing of joints.

ANGIOSPERMS (The Flowering Plants)

(Gk. *angeion* – vessel; *sperma* – seed)

Angiosperms or flowering plants are those plants in which seeds are formed inside fruits and the sporophylls are organized into flowers.

These plants appeared on earth about 130 million years ago. Angiosperms range in size from the smallest *Wolffia* to tall trees of *Eucalyptus* (over 100 metres).

Angiosperms are characterized by the following features:

- Flowering plants are cosmopolitan in distribution.
- The plant body is differentiated into root, stem and leaves. At maturity these plants bear **flowers**, which produce **fruits** and **seeds**.
- The vascular tissues are arranged in the form of vascular bundles. Xylem contains vessels, tracheids, fibres and parenchyma and phloem has sieve tubes, companion cells, phloem parenchyma and phloem fibres.

Previous Year's Question



Sunken type of stomata are found in –

- (1) *Eucalyptus*
- (2) *Marchantia*
- (3) *Cycas*
- (4) Neem tree

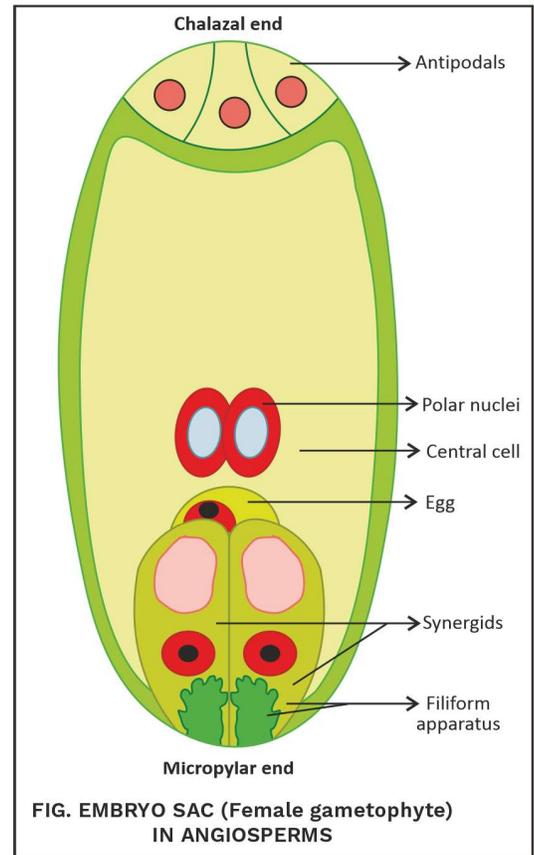
Definition



Angiosperms: Flowering plants that produce seeds enclosed in fruits.



- The reproductive organs are flowers. A typical flower has a short axis called **thalamus** and four whorls of floral leaves – **calyx**, **corolla**, **androecium** and **gynoecium**. These whorls are composed of **sepals**, **petals**, **stamens** (*microsporophylls*) and **carpels** (*megasporophylls*), respectively.
- A microsporophyll or stamen consists of a filament and an anther containing microspore or pollen grains.
- A megasporophyll or carpel is rolled to produce a stigma, style and ovary containing ovules.
- Pollen grains reach stigma or tip of carpel through pollination, which occurs with the help of several agencies.
- The pollen grain germinates to produce male gametophyte or pollen tube containing two male gametes. The pollen tube grows through style to reach the ovary.
- An ovule consists of nucellus (megasporangium) and two integuments with a micropyle.
- The female gametophyte also called **embryo sac** is produced from a megaspore within the nucellus. An embryo sac consists of an **egg apparatus** towards the micropylar end, **antipodals** at the opposite end and a diploid nucleus in the centre called the **secondary nucleus**. Archegonia are absent, but the egg apparatus has an **egg** or **oosphere** surrounded by two **synergid cells**.
- Fertilisation is affected by pollen tube (siphonogamy). It involves the fusion of one male gamete of the pollen tube with egg to form a diploid (2n) oospore and that of the other male gamete with the secondary nucleus to form a triploid (3n) **primary endosperm nucleus** (PEN). The whole process is called **double Fertilisation** and is a characteristic of angiosperms.
- The oosphere develops into an embryo or future sporophyte, while primary endosperm cell produces endosperm.



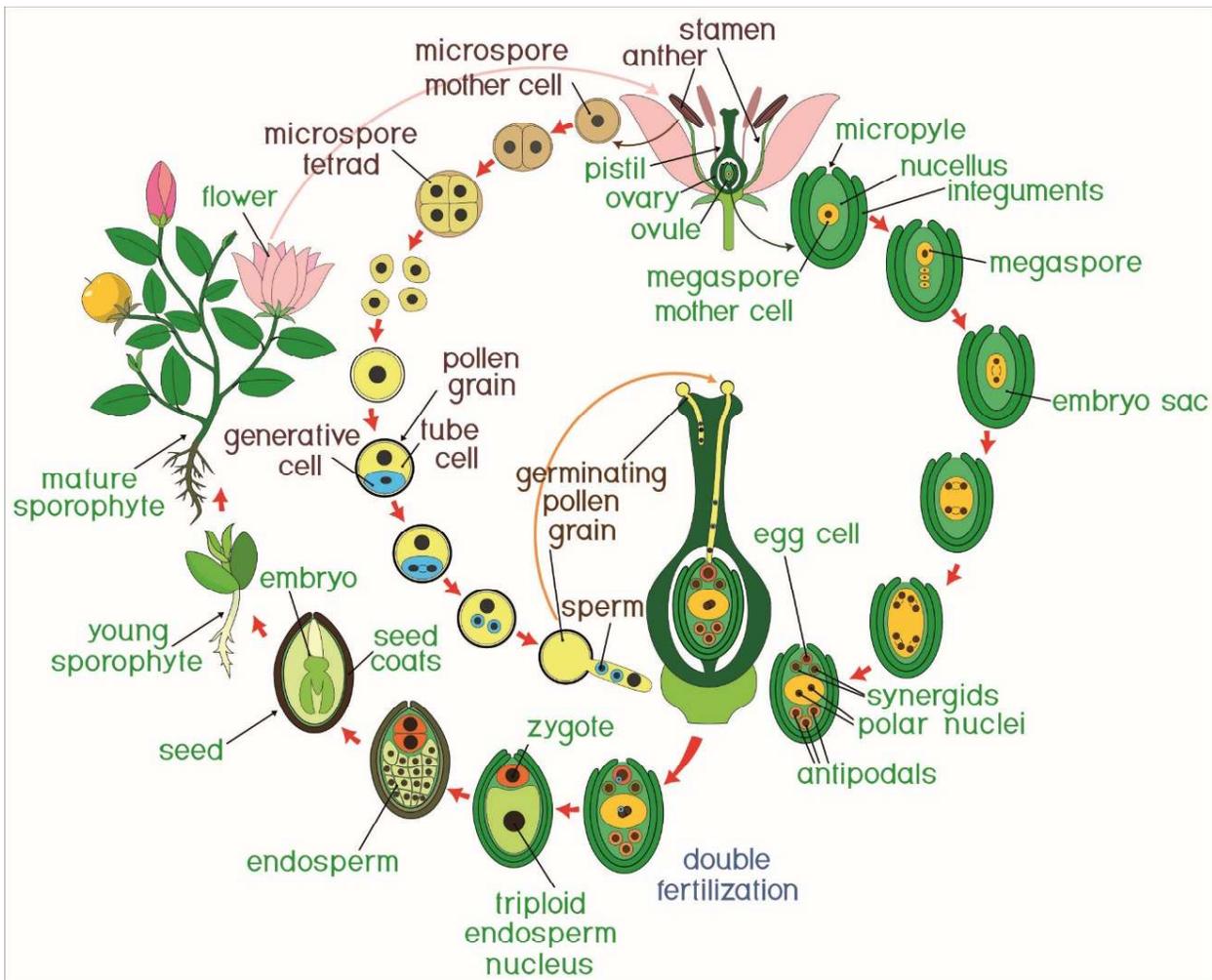
Previous Year's Question



Which of the following is present without exception in angiosperms?

- (1) Presence of vessels
- (2) Double fertilisation
- (3) Secondary growth
- (4) Autotrophic nutrition

- Fertilised ovules ripen into seeds and ovary matures into a fruit. The latter not only protects the seeds but also helps in their dispersal.



LIFE CYCLE OF AN ANGIOSPERM

Angiosperms are divided into two classes:

The dicotyledons and the monocotyledons.

- The dicotyledons are characterized by seeds having two cotyledons, reticulate venation and tetramerous or pentamerous flowers, i.e., having four or five members in each floral whorls.

Rack your Brain



Why is the endosperm of angiosperms triploid?



- The monocotyledons are characterized by single cotyledonous seed, parallel venation and trimerous flowers having three members in each floral whorls.

PLANT LIFE CYCLES AND ALTERNATION OF GENERATION

- In plants, both haploid and diploid cells can divide by mitosis.
- This ability led to the formation of two types of plant bodies—haploid and diploid. The haploid plant body produces gametes by mitosis. This plant body is called **gametophyte**.
- The zygote formed after Fertilisation, also divides by mitosis to produce a diploid sporophytic plant body.
- Haploid spores are produced by this plant body by meiosis. The haploid spores give rise to haploid plant body once again.
- There is an **alternation of generation** between gamete producing haploid **gametophyte** and spore-producing diploid **sporophyte**.

DEVELOPMENT OF SEED HABIT

Following features have also contributed to the development of seed habit:

- In seed plants, two types of sporangia are formed on a special leaf-like structure called **sporophylls**. They are **megasporangium** or **ovule** and the **microsporangium** or **pollen sac**.
- Within the ovule, an egg is formed from megaspore. The ovule remains attached to the parent plant.
- The pollen sac produces numerous pollen grains to ensure that some may reach the ovule through pollination. Each pollen grain forms two male gametes within it.
- **Siphonogamy** erased the need of external water for the male gametes to reach the ovule.
- The zygote develops into an embryo within the

Definition

Seed: It consists of an embryonic plant which is covered by seed coat.

Definition

Siphonogamy: Transfer of male gametes by means of pollen tube into the female gametophyte.



ovule, which in turn develops into a seed. The ovule wall or integument becomes the seed coat.

- During development of a seed from an ovule, nutrients are drawn from parent plant to which it is still attached.
- Seed is usually shed when it is fully ripe and dry.
- The dry seed within its seed coat protects an embryo or tiny plant in dormant state, with food reserve. The embryo germinates and grows continuously as a seedling when it obtains water.

SEED CONSISTS OF THREE GENERATIONS

- A seed encloses **three** generations one within the other. The **ovule** or **megasporangium** formed from the parent sporophyte is diploid ($2n$).
- The megaspores developing within the ovule are formed by meiosis and are haploid (n) female gametophyte. The female gametophyte represents haploid (n) **gametophytic generation**.
- The egg (n) is fertilised by a male gamete (n) to form diploid ($2n$) zygote. The zygote develops into an embryo or **future sporophyte** ($2n$).

ADAPTATION OF SEED PLANTS TO LAND

Seed plants are the most successful of all the land plants. Following are the distinguishing characters of seed plants that have made them specially adapted to thrive successfully on land:

- Extensive root system for anchorage and absorption of water and nutrients.
- Presence of mechanical tissues for support and vascular tissue for long distance transport of sap and food.
- Emergence of various methods for pollination to transfer pollen grains to the megasporophylls (carpels).
- Siphonogamy replaced the need of external supply of water for fertilisation.
- Transformation of megasporangium into an

Rack your Brain



In the life cycle of a plant the gametophyte is independent and short lived. It is which type of life cycle ?



Previous Year's Question

Angiosperms have dominated the land flora primarily because of their

- (1) Power of adaptability in a diverse habitat
- (2) Property of producing a large number of seeds
- (3) Nature of self-pollination
- (4) Domestication by man



ovule, formation of female gametophyte inside the megasporangium and production of embryo in the ovule.

- Suspended growth of the embryo for some time in the ovule and transformation of the ovule in a seed for dispersal.

LIFE CYCLES IN DIFFERENT PATTERNS

Plant life cycles and alternation of generations

- In plants, all type of cells that are haploid or diploid can divide by mitotic cell division.
- This property leads to the development of haploid and diploid plant bodies.

Gametophyte Parent

- If the parent plant body is haploid (gametophyte) then it produces gametes by mitosis.
- These gametes fuse together during Fertilisation and produce zygote, this zygote undergoes mitosis and produces sporophyte (diploid).
- Sporophyte produces spores (haploid) by meiosis cell division. And each haploid spore germinates and develops into a gametophyte.

Sporophyte Parent

- If the parent plant body is diploid (sporophyte) then it produces spores by meiosis.
- Haploid spores of sporophyte germinate and produce gametophyte (haploid). This gametophyte produces male and female gametes that fuse during Fertilisation and give rise to a zygote.
- Zygote (diploid) undergoes mitosis and produces a sporophytic plant body.

Haplontic life cycle

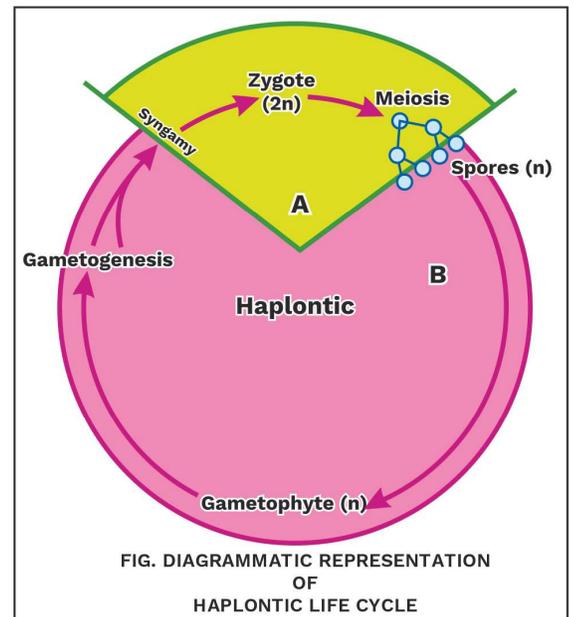
The dominant photosynthetic phase is a gametophyte produced by haploid spores. The gametes fuse and produce a zygote, that represents sporophytic generation. Meiosis in the **zygote** results in the formation of haploid spores.

Previous Year's Question



Which one of the following has a haplontic life cycle?

- (1) *Polytrichum*
- (2) *Ustilago*
- (3) Wheat
- (4) *Funaria*



Definition

Haplontic life cycle: When gametophytic phase (haploid phase) is dominating in the life cycle.

- Many algae such as *Volvox*, *Spirogyra* *Chlamydomonas* represent this pattern of life cycle.

Diplontic

- In this type, the diploid sporophyte is the dominant photosynthetic independent phase of the plant.
- The gametophytic phase is represented by a single to few cells called haploid gametophyte like pollen grains and egg cell.
- This pattern of life cycle is represented by all seed-bearing plants *i.e.*, gymnosperms and angiosperms.

Haplo-diplontic

- In this type, both haploid and diploid phases are multicellular and often free living. Bryophytes and pteridophytes exhibit this pattern of life cycle.

Life pattern in bryophytes

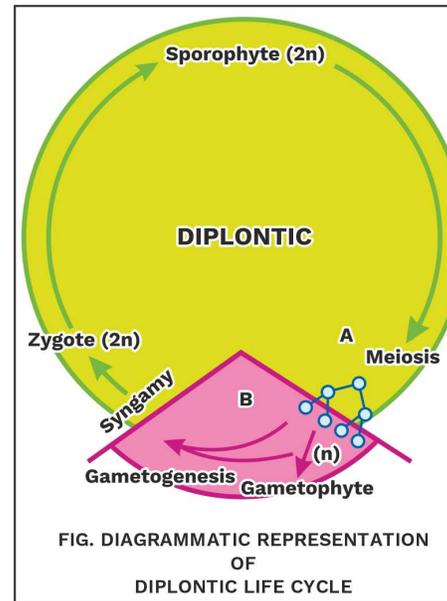
- The dominant photosynthetic thalloid plant body represents the haploid gametophytic phase
- It alternates with short-lived, multicellular sporophyte totally or partially dependent on the gametophyte for its anchorage and nutrition.

Life pattern in pteridophytes

- The diploid sporophyte is represented by a dominant independent photosynthetic vascular plant body.
- It alternates with multicellular, autotrophic or saprophytic, independent but short-lived haploid gametophyte.

Exception: Some algal forms like *Ectocarpus*, *Polysiphonia*, kelps etc., exhibit haplo-diplontic life cycle.

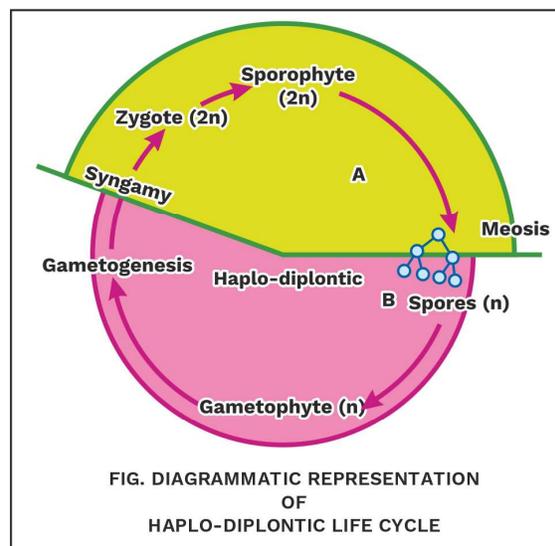
Fucus (a brown algae) shows diplontic life cycle.



Definitions

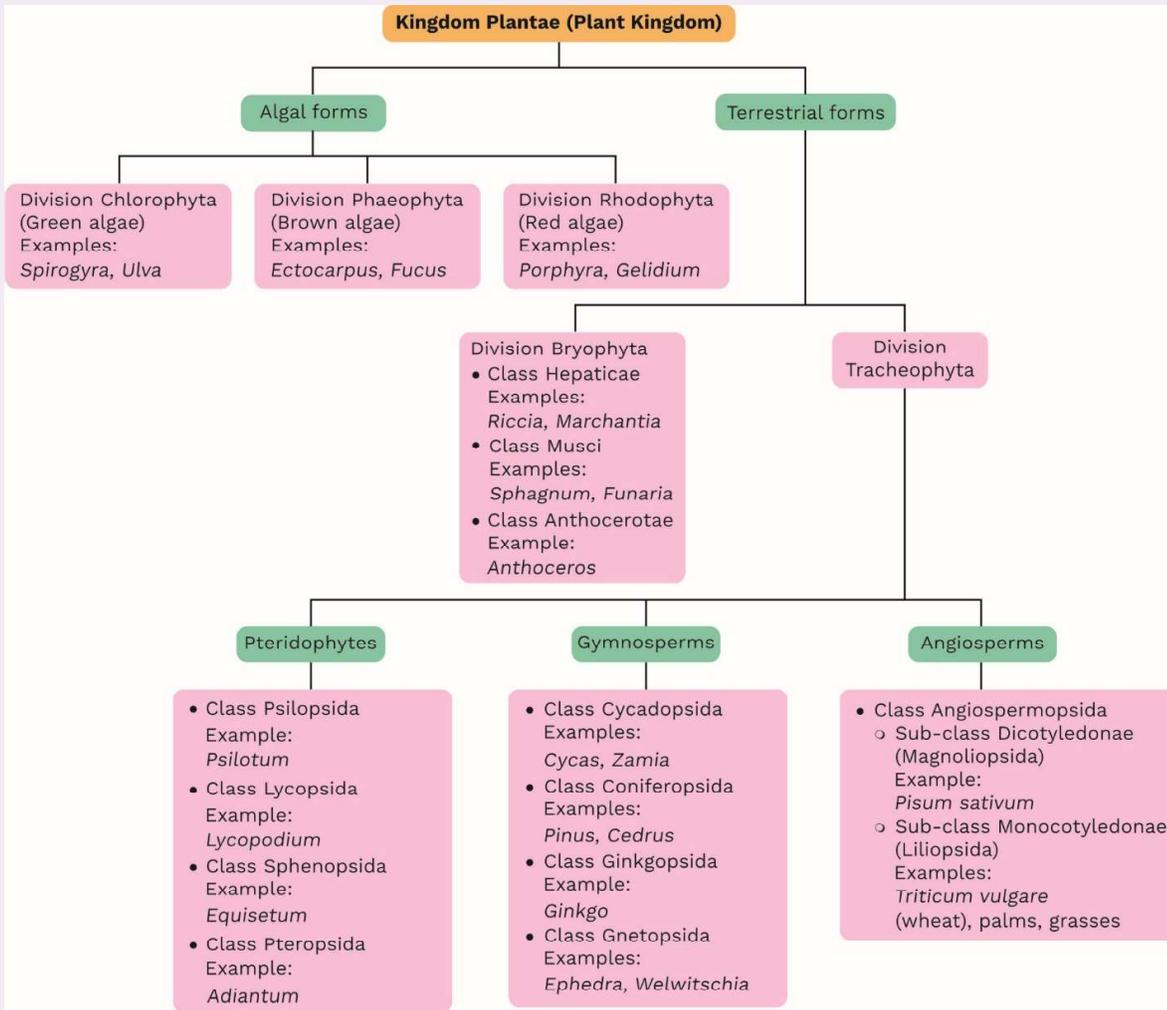
Diplontic life cycle: When sporophytic phase is dominating.

Haplo-diplontic life cycle: When both the gametophyte and the sporophyte of a plant are equally dominant.





Chapter Summary





Chapter Summary



COMPARISON: LIVERWORTS AND MOSSES

S.No.	Character	Liverworts	Mosses
1	Plant body symmetry	Dorsiventrally symmetrical	Radially symmetrical
2	Plant body structure	Thalloid, rarely foliage, with dichotomous branching.	Usually foliage, with lateral branching.
3	Rhizoids	Unicellular	Multicellular
4	Scales	Often present	Absent
5	Protonema (filamentous stage)	Absent	Always present
6	Sporophyte (nature)	Very little photosynthetic tissue present. So, it is fully dependent on gametophyte for nutrition.	Abundant photosynthetic tissue. So, it is partially dependent on gametophyte.
7	Capsule	Central columella does not occur inside the capsule. Capsule has elaters that assist the dispersal of spores but peristome teeth are absent.	A central columella is present inside the capsule. Peristome teeth splay outward to facilitate dispersal of spores. Elaters are absent in the capsule



Chapter Summary



COMPARISON: MOSSES AND FERNS

S.No.	Character	Mosses (Pryophytes)	Ferns (Pteridophytes)
1.	Vascular elements	Not present (non-vascular land plants)	Present (These are vascular land plants)
2.	Structure of main plant body	The plant body is not differentiated into true roots, stem and leaves.	The plant body is differentiated into roots, stem and leaves.w
3.	Dominant phase in the life cycle	Gametophyte	Sporophyte
4.	Nature of sporophyte	Dependent upon the gametophyte for support, shelter and nutrition.	The sporophyte and gametophyte have individual identity. They both are autotrophic plant bodies.
5	Spore developing body	Inside the capsule of the sporophyte, spores are produced.	Inside the sporangia spores are produced and sporangia are found on the sporophyll.



SOLVED EXERCISE

Q1 Brown algae are characterized by the presence of
(1) fucoxanthin (2) hematochrome
(3) phycocyanin (4) phycoerythrin

A1 (1)
Fucoxanthin is an accessory pigment in the chloroplasts of brown algae giving them characteristic brown or olive green colour.

Q2 *Volvox* demonstrates which type of sexual reproduction?
(1) Isogamous (2) Anisogamous
(3) Oogamous (4) No sexual reproduction observed

A2 (3)
In *Volvox*, oogamous reproduction is observed. The motile male gamete fertilises non-motile female gamete.

Q3 Which of the following algae is unicellular?
(1) *Gelidium* (2) *Laminaria* (3) *Chlorella* (4) *Spirogyra*

A3 (3)
Chlorella is unicellular green algae that belongs to division chlorophyta.

Q4 Which of the following are more in concentration in warmer seas?
(1) Green algae (2) Brown algae (3) Red algae (4) *Fucus*

A4 (3)
Red algae are more in warmer seas as these have xylan or mannan fibrils in their cell wall that can tolerate high temperature.



Q5 In which type of taxonomy chromosome number structure and their behaviour is the main parameter?

- (1) Phylogenetic classification system (2) Numerical taxonomy
(3) Cytotaxonomy (4) Chemotaxonomy

A5

(3)

In cytotaxonomy, the basis is of classification structure, number, behaviour of chromosomes chiefly during mitosis.

Q6

The plant body of moss (*Funaria*) is

- (1) Completely sporophyte
(2) Predominantly gametophyte with sporophyte
(3) Completely gametophyte
(4) Predominantly sporophyte with gametophyte

A6

(2)

Main plant body of *Funaria* is gametophyte, i.e., haploid which bears sporophyte (diploid) temporarily.

Q7

A well developed archegonium with neck consisting of 4-6 rows and neck canal cells, characterizes

- (1) Gymnosperms and flowering plants
(2) Pteridophytes and gymnosperms
(3) Gymnosperms only
(4) Bryophytes and pteridophytes

A7

(4)

In Bryophytes and Pteridophytes, the female reproductive organ has a neck canal cell and swollen venter. Neck has few cells in rows.



Q8 Which of the following plant divisions is called 'amphibian'?
(1) Pteridophyta (2) Thallophyta (3) Tracheophyta (4) Bryophyta

A8 (4)
For Fertilisation, bryophytes need water to reach the egg cell in the archegonium. Hence, these are called amphibians of the plant kingdom.

Q9 Which one of the following is not common between *Funaria* and *Selaginella*?
(1) Archegonium (2) Embryo
(3) Flagellated sperms (4) Roots

A9 (4)
Selaginella has roots that are similar to the root meristem in ferns. These originate from rhizophores.

Q10 Peat is obtained from
(1) *Marchantia* (2) *Sphagnum*
(3) *Funaria* (4) *Polytrichum*

A10 (2)
Species of *Sphagnum* provide peat. It is formed when plant material decay incompletely in acidic and anaerobic conditions.

Q11 *Pinus* differs from mango in having
(1) Tree habit (2) Green leaves
(3) Ovules not enclosed in ovary (4) Wood

A11 (3)
Pinus is a gymnosperm that does not bear flowers so, naked ovules are present on the cones.



Q12 In which of the following would you place the plants having vascular tissues and only seeds?

- (1) Pteridophytes
- (2) Bryophytes
- (3) Angiosperms
- (4) Gymnosperms

A12 (4)
Gymnosperms are vascular plants but do not bear flowers, only ovules are present which convert into seed.

Q13 Which one pair of examples will correctly represent the grouping a spermatophyte according to one of the schemes of classifying plants?

- (1) *Acacia*, Sugarcane
- (2) *Pinus*, *Cycas*
- (3) Maize, *Cycas*
- (4) *Ginkgo*, *Pisum*

A13 (4)
Spermatophyta includes seed-bearing plants that includes first gymnosperms and second angiosperms.

Q14 Which of the following is a dioecious plant?

- (1) *Cycas*
- (2) *Pinus*
- (3) *Mangifera indica*
- (4) *Eucalyptus*

A14 (1)
In *Cycas*, male and female cones are borne on separate trees.

Q15 What is the product of syngamy?

- (1) Egg cell
- (2) Pollen grain
- (3) Zygote
- (4) PEN

A15 (3)
Syngamy means fusion between male and female gametes that results into a diploid zygote