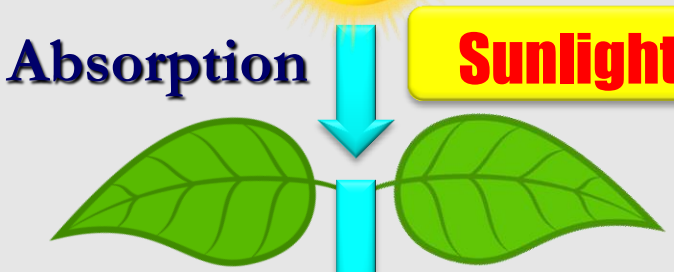
@@@ PLANT KINGDOM @@@

CLASSIFICATION AND ALGAE



Absorption

Sunlight

Conversion

Light Energy to Chemical Energy

Splitting of $H_2O \longrightarrow H^+ + O_2$

Reduction

$Co_2 \longrightarrow C_6H_{12}O_6$

# Plant Kingdom

# Classification

# Artificial System of classification

This is the earliest systems of classification that used only **morphological characters such as habit, colour, number and shape of leaves, etc.** and also based on the **androecium structure**.

This system was proposed by Linnaeus.

**Drawbacks of Artificial System of classification**

They separated the closely related species since they were based on a few characteristics.

The artificial systems gave equal weightage to vegetative and sexual characteristics.

This is not acceptable since the vegetative characters are more easily affected by environment.

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# Natural system of classification

It is based on natural affinities among the organisms and consider not only the external features, but also internal features **anatomy, embryology and phytochemistry.**

It was proposed by George Bentham and Joseph Dalton Hooker.

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# Phylogenetic system of classification

Phylogenetic classification system is based on **evolutionary relationships** between the various organisms.

This assumes that organisms belonging to the same taxa have a common ancestor.

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# Numerical Taxonomy

**Numerical Taxonomy** is based on all **observable characteristics** which is now easily carried out using computers.

**Number and codes** are assigned to all the characters and the data are then processed.

In this way each character is given equal importance and at the same time hundreds of characters can be considered.

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# Cytotaxonomy and Chemotaxonomy

Cytotaxonomy is the classification based on cytological information like **chromosome number, structure and behavior.**

Chemotaxonomy is the classification based on the **chemical components** of the plants to resolve confusions.

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# Algae

# Algae

Algae are chlorophyll-bearing, simple, thalloid, autotrophic and aquatic organisms living in both fresh water and marine water.

**Habitat**

They occur in a variety of other habitats: moist stones, soils and wood.

Some of them live with fungi (lichen)

Some of them live with animals (e.g., on sloth bear).

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# Habit of Algae

Microscopic unicellular forms like *Chlamydomonas*

Colonial forms like *Volvox*

Filamentous forms like *Ulothrix* and *Spirogyra*.

Alga Kelp form massive plant body, which may reach a **height of 100 metres.**

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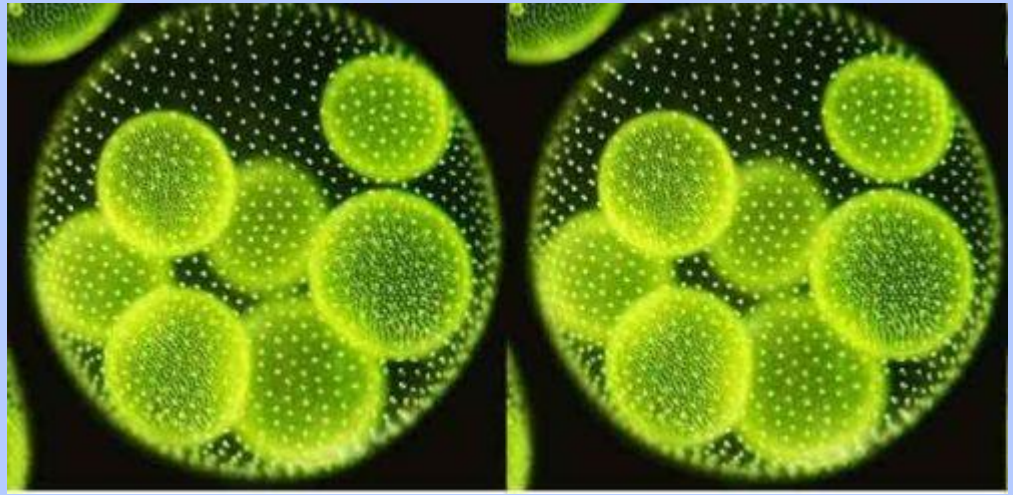
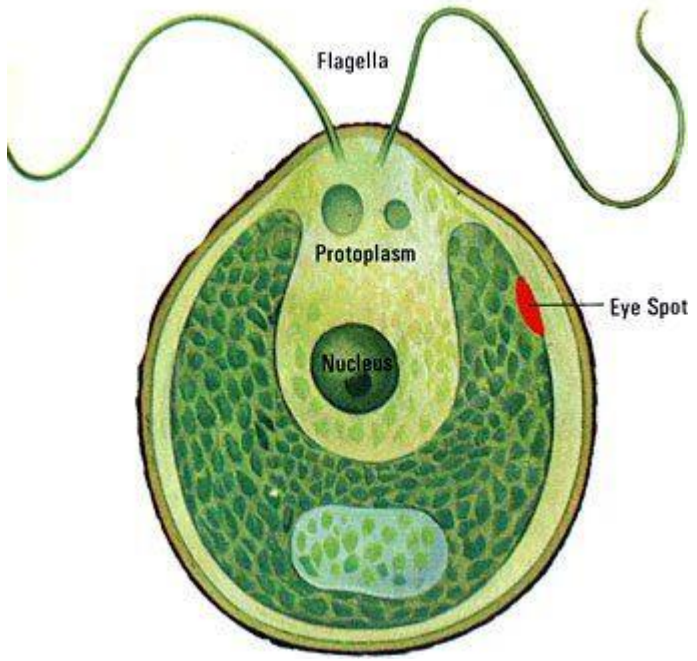
# Volvox, Chlamydomonas



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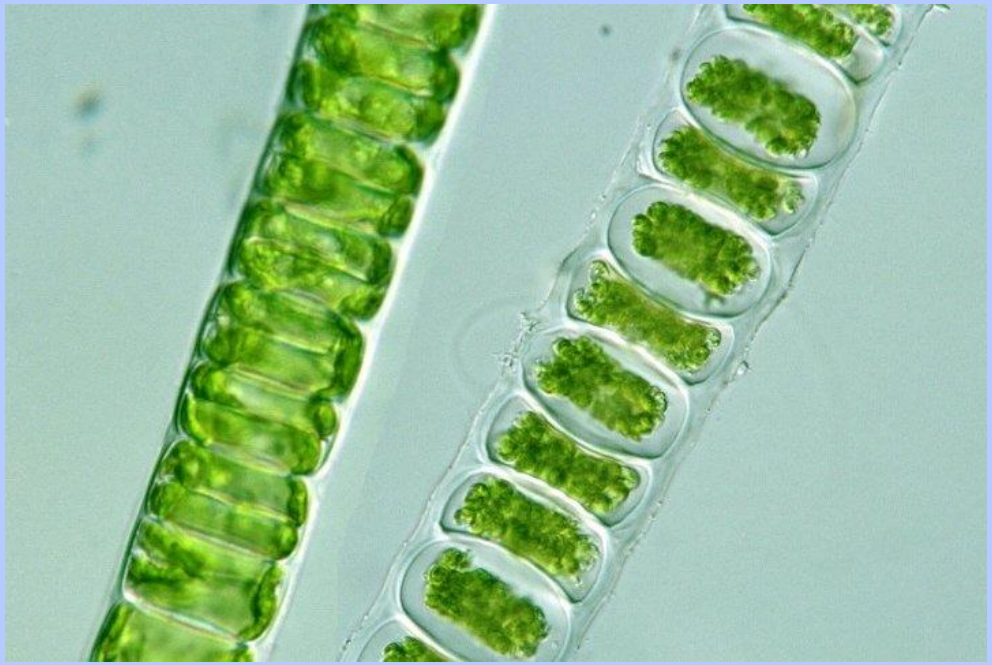
# Ulothrix



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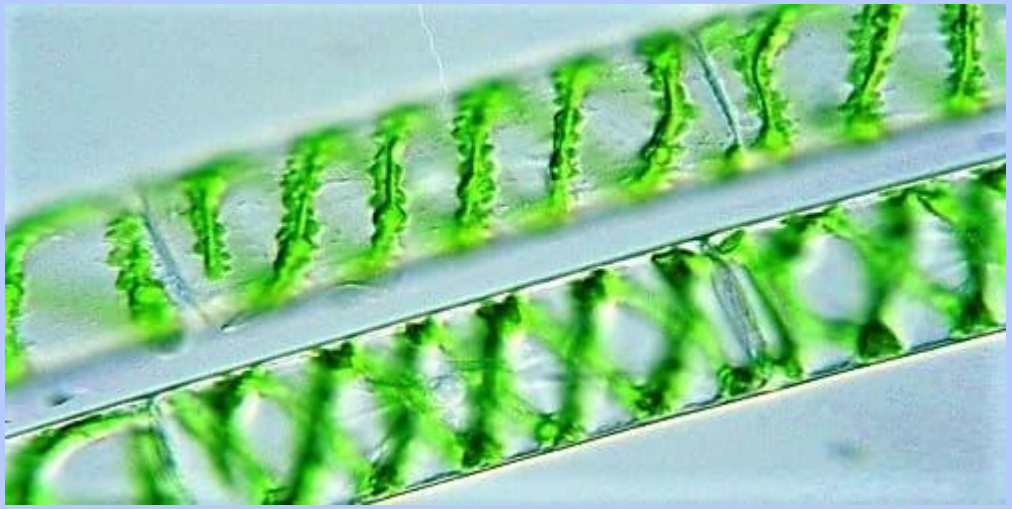
# Spirogyra



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# Habit of Algae

Vegetative reproduction occurs by **fragmentation**.

Each fragment develops into a thallus.

Asexual reproduction takes place by spores, the most common being the **zoospores.**

They are flagellated (motile) and on germination gives rise to new plants.

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# Sexual Reproduction

Sexual reproduction takes place through fusion of two gametes. The three different types are as follows.

**Isogamous**

These gametes are flagellated and similar in size as in *Chlamydomonas* or non-flagellated (non-motile) and similar in size as in *Spirogyra*. Such reproduction is called isogamous.

**Anisogamous**

Fusion of two gametes which are dissimilar in size, as in some species of *Chlamydomonas* is termed as anisogamous.

**Oogamous**

Fusion between one large, non-motile (static) female gamete and a smaller, motile male gamete is termed oogamous, e.g., *Volvox*, *Fucus*.

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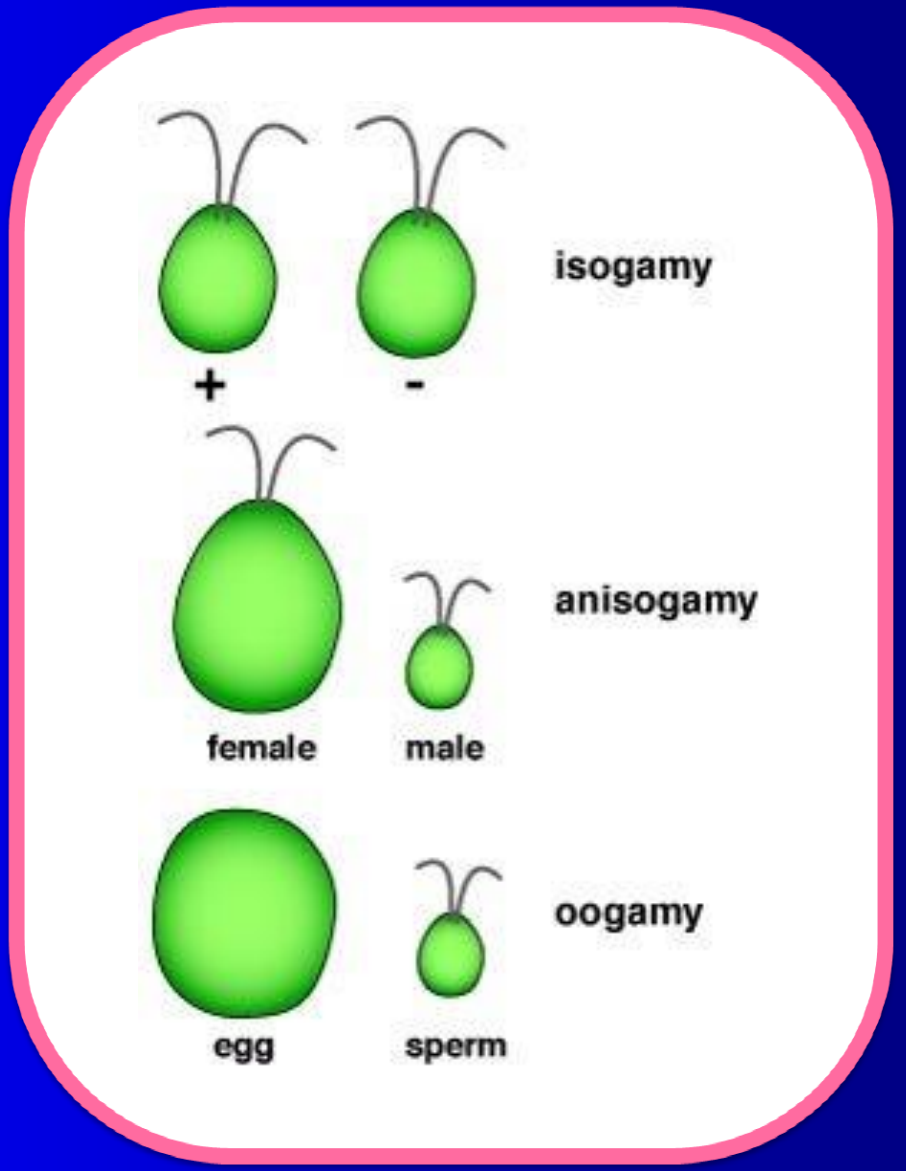
# Isogamy, Anisogamy and Oogamy

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# Economic Importance of Algae

At least **a half of the total carbon dioxide fixed** on earth is carried out by algae through photosynthesis.

**Increase the level of dissolved oxygen**

Being photosynthetic **they increase the level of dissolved oxygen** in their immediate environment.

**Primary producers of energy-rich compounds:**

They are the **primary producers of energy-rich compounds** which form the basis of the nutrient cycles of all aquatic animals.

**Source of Food**

Many species *of Porphyra*, *Laminaria* and *Sargassum* are among the 70 species of marine algae used as **food.**

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**Hydrocolloids:** (water holding substances)

Certain marine brown and red algae produce large amounts of **hydrocolloids** (water holding substances), e.g., **algin** (brown algae) and **carrageen** (red algae) are used commercially.

**Culture medium for microbe and ice creams and jellies:**

**Agar**, one of the commercial products obtained from *Gelidium* and *Gracilaria* are used to **grow microbes** and in preparations of **ice-creams and jellies.**

**Protein rich food:**

***Chlorella* and *Spirullina*** are unicellular algae, **rich in proteins** and are used as food supplements even by space travellers.

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# Three main classes of Algae

The algae are divided into three main classes: **Chlorophyceae, Phaeophyceae** and **Rhodophyceae.**

The common members of green algae are *Chlamydomonas*, *Volvox*, *Ulothrix*, *Spirogyra* and *Chara*.

**Common members of Phaeophyceae**
The common forms are *Ectocarpus*, *Dictyota*, *Laminaria*, *Sargassum* and *Fucus.*

**Common members of Rhodophyceae.**
The common members are: *Polysiphonia*, *Porphyra*, *Gracilaria* and *Gelidium.*

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# Chlorophyceae

# Main features of Chlorophyceae

Green algae usually have a rigid **cell wall** made of an inner layer of **cellulose** and an outer layer of **pectose**.

The plant body may be **unicellular, colonial** or **filamentous**.

They are usually **grass green** due to the dominance of pigments **chlorophyll a and *b*.**

The pigments are localised in definite chloroplasts.

The chloroplasts may be discoid, plate-like, reticulate, cup-shaped, spiral or ribbon-shaped.

Most of the members have one or more storage bodies called pyrenoids located in the chloroplasts. Pyrenoids contain protein besides starch.

Some algae may store food in the form of **oil droplets**.

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# Types of Chloroplast in Chlorophyceae

The chloroplasts may be
Discoid
Plate-like
Reticulate
Cup-shaped
Spiral or ribbon-shaped

The common members of green algae are *Chlamydomonas*, *Volvox*, *Ulothrix*, *Spirogyra* and *Chara*.

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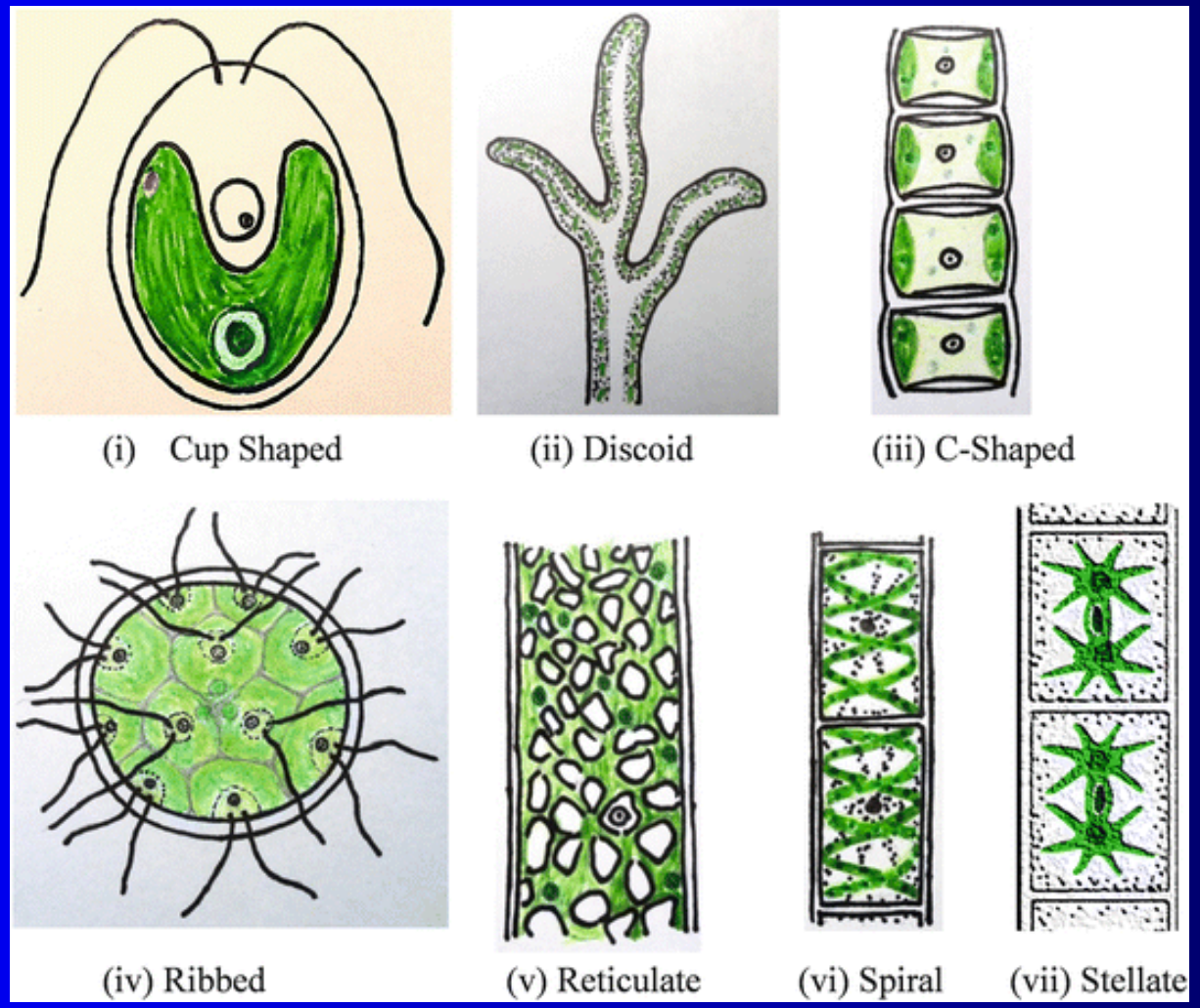
# Types of Chloroplast in Chlorophyceae

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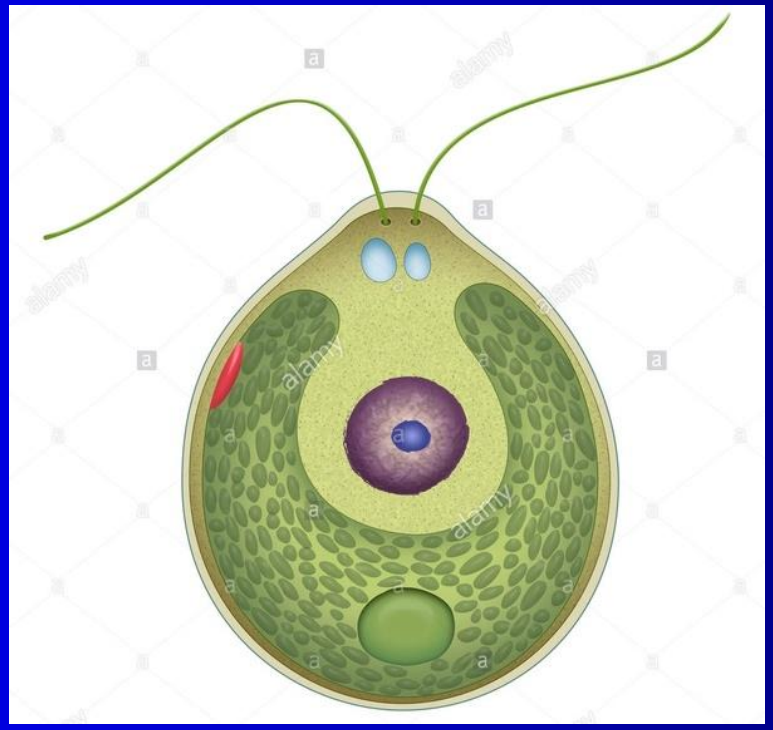
# Types of Chloroplast in Chlorophyceae



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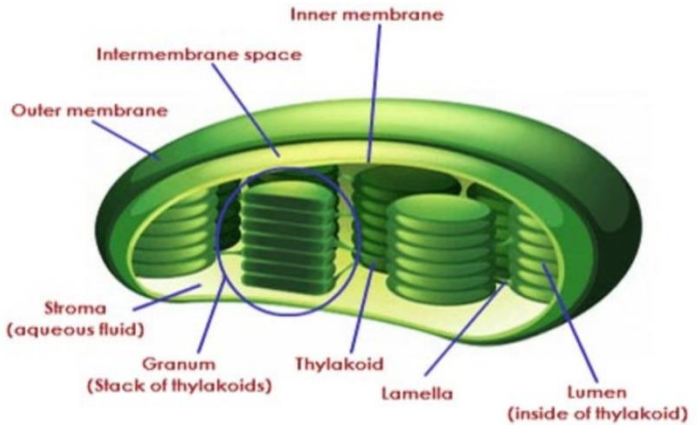
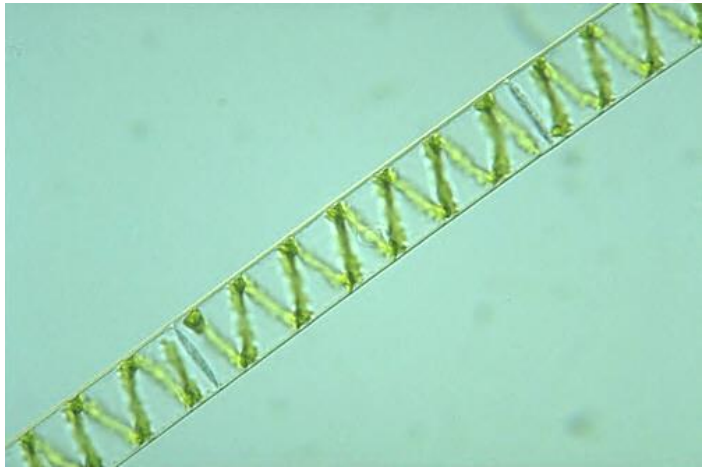
# Types of Chloroplast in Chlorophyceae



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# Phaeophyceae

# Phaeophyceae

The members of phaeophyceae or **brown algae** are found primarily in marine habitats.

They show great variation in size and form.

They range from simple branched, filamentous forms *(Ectocarpus)* to profusely branched forms as represented by **kelps**, which may reach a **height of 100 metres.**

They possess **chlorophyll a, c, carotenoids and xanthophylls**.

They vary in colour from **olive green** **to** **various shades of brown** depending upon the amount of the **xanthophyll pigment, fucoxanthin** present in them.

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# Kelp Alga

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Food is stored as complex carbohydrates, which may be in the form of **laminarin or mannitol**.

The vegetative cells have a cellulosic wall usually covered on the outside by a gelatinous coating of **algin.**

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

The plant body is usually attached to the substratum by a **holdfast,** and has a stalk, the **stipe** and leaf like photosynthetic organ - the **frond.**

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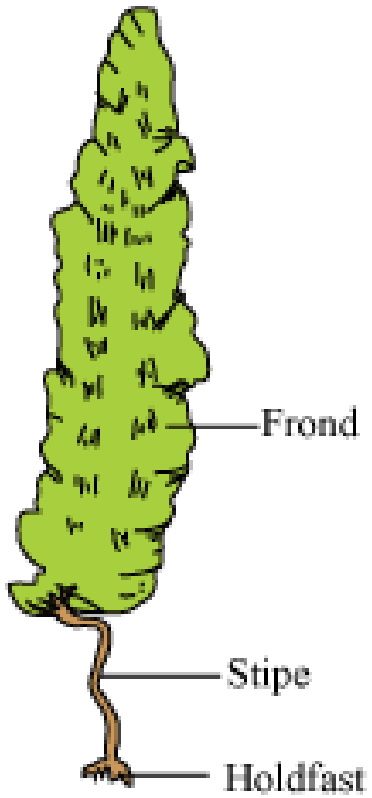


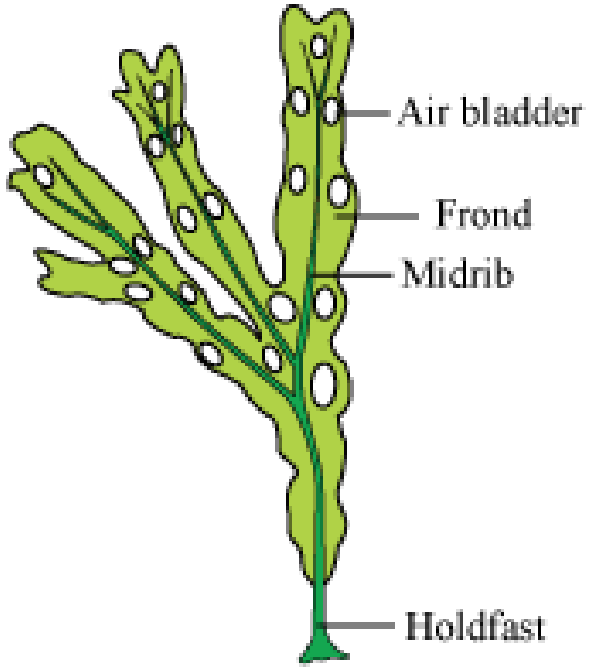


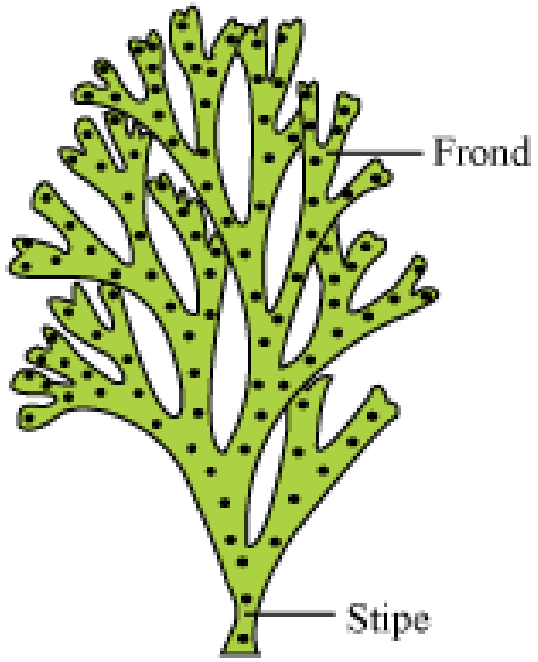


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# Reproduction in Phaeophyceae

Vegetative reproduction takes place by **fragmentation.**

Asexual reproduction in most brown algae is by biflagellate **zoospores** that are pear-shaped and have two unequal laterally attached flagella.

Sexual reproduction may be **isogamous, anisogamous or oogamous**. Union of gametes may take place in water or within the oogonium (oogamous species).

The gametes are pyriform (pear-shaped) and bear two laterally attached flagella.

The common forms are *Ectocarpus*, *Dictyota*, *Lamiriaria*, *Sargassum* and *Fucus*.

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# Phaeophyceae

## Dictyota

## Fucus

## Laminaria

## Sagassum

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# Rhodophyceae

# Rhodophyceae

The members of Rhodophyceae are commonly called **red algae** because of the predominance of the red pigment, **r-phycoerythrin** in their body.

## Habitat

Majority of the red algae are marine with greater concentrations found in the warmer areas.

They occur in both **well-lighted regions close to the surface of water** and also **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.

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The food is stored as **floridean starch** which is very **similar to amylopectin and glycogen** in structure.

## Reproduction

The red algae usually reproduce vegetatively by **fragmentation**.

They reproduce asexually by **non-motile spores.**

Sexual reproduction is **oogamous** and accompanied by complex post fertiisation developments.

The common members are: *Polysiphonia*, *Porphyra*, *Gracilaria* and *Gelidium.*

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## Polysiphonia

## Porphyra

## Gracilaria

## Gelidium

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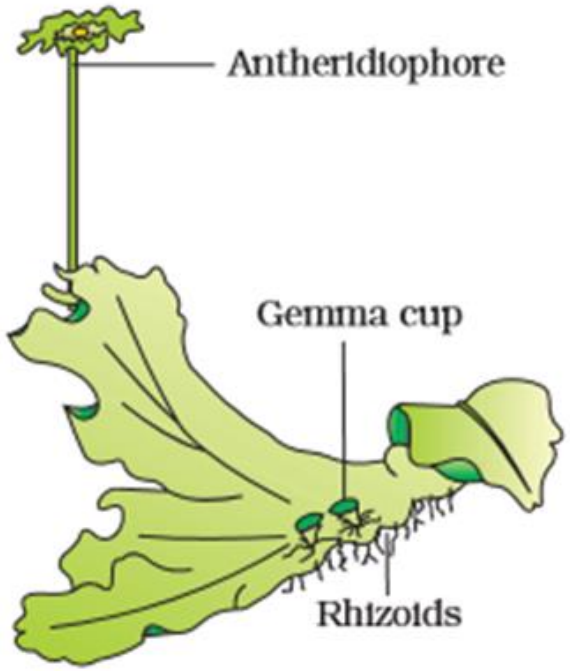
# LIFECYLE OF BRYOPHYTES




## LIVERWORTS AND MOSSES

# Bryophytes

# Habitat of Bryophytes

Bryophytes are the plants with root-like, stem-like and leaf-like structures.

They are also called **amphibians of the plant kingdom** because they live in soil but they need water for reproduction.

They occur in **damp, humid and shaded places**. They play an important role in plant succession on bare rocks.

Bryophytes include the **mosses and liverworts** which grow in moist shaded areas in the hills.

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# Structure of Bryophytes

The plant body of bryophytes is more differentiated than that of algae.

It is thallus-like **prostrate or erect** and attached to the substratum by unicellular or multicellular **rhizoids.**

They lack true root, stem and leaves.

But they possess root-like, stem-like and leaf-like structures.

The main plant body of bryophyte is haploid.

As this plant body produces gametes, it is called a **gametophyte.**

The bryophytes are classified into **Liverworts** and **Mosses.**

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# Reproduction in Bryophytes

The sex organs in bryophytes are multicellular.

The male sex organ is called **antheridium.** They produce biflagellated **antherozoids.**

The female sex organ is called **archegonium, which** is flask-shaped and produces a single ovum.

The antherozoids are released in water and they reach the archegonium.

The antherozoid fuses with the ovum to produce the zygote.

But the zygote does not undergo reduction division immediately.

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The zygote produces a multicellular body called a **sporophyte.**

The sporophyte is not free-living but attached to the photosynthetic gametophyte and derives nourishment from it.

Some cells of the sporophyte undergo reduction division to produce haploid spores.

These spores germinate to produce a haploid gametophyte.



# Economic Importance of Bryophytes

- Some mosses provide **food for mammals, birds and other animals.**
- *Sphagnum*, a moss, provides **peats** that have long been used as **fuel**.
- Due to their water holding capacity, they are used as **packing material** for the transport of living materials.

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- Mosses along with lichens are the first organisms to invade rocks and hence, are of great ecological importance.
- They **decompose rocks** making the substrate suitable for the growth of higher plants.
- Since mosses form **dense mats** on the soil, they reduce the impact of falling rain and prevent soil erosion.

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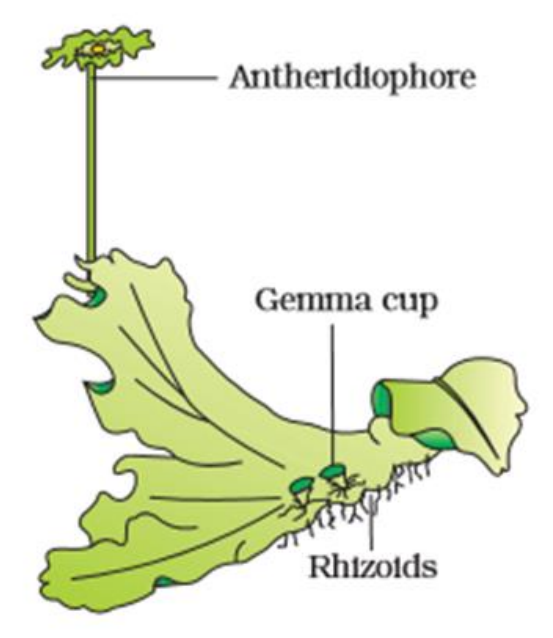
# Liverworts

# Liverworts




The liverworts grow in **moist, shady places** such as banks of streams, marshy ground, damp soil, bark of trees and deep in the woods.

The plant body of a **liverwort** is thalloid as in *Marchantia*.

The thallus is dorsiventral and closely attached to the substratum.

The leafy members have tiny leaf-like appendages in two rows on the stem-like structures.

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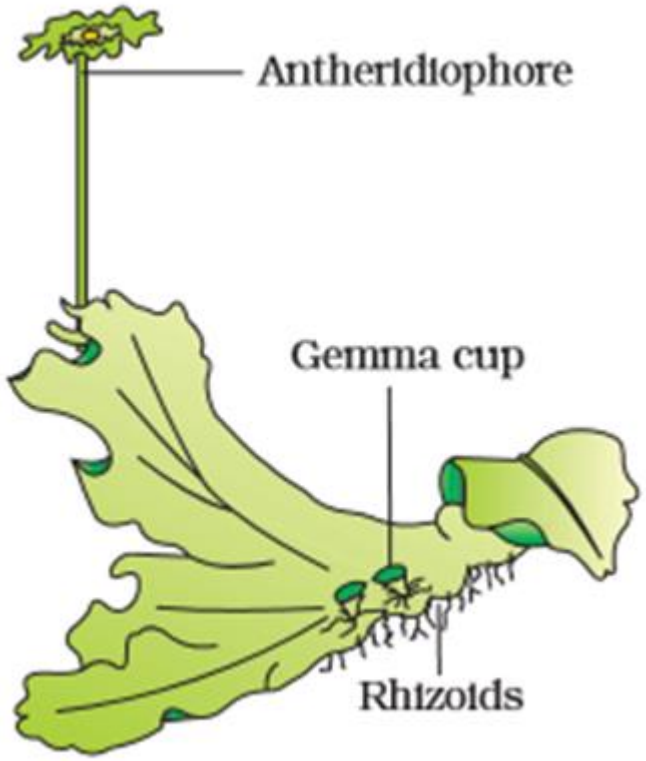
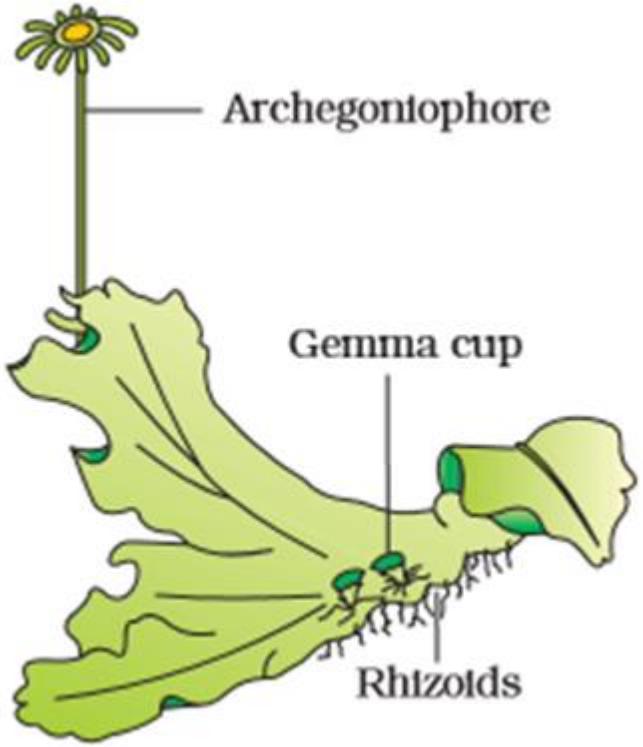
# Liverwort - Marchantia




Male Thallus




Female Thallus

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# Reproduction in Liverworts

# Reproduction in Liverworts

Asexual reproduction in liverworts takes place by fragmentation of thalli, or by the formation of specialised structures called **gemmae** (sing. gemma).

Gemmae are green, multicellular, asexual buds, which develop in small receptacles called gemma cups located on the thalli.

The gemmae detach from the parent body and germinate to form new individuals.

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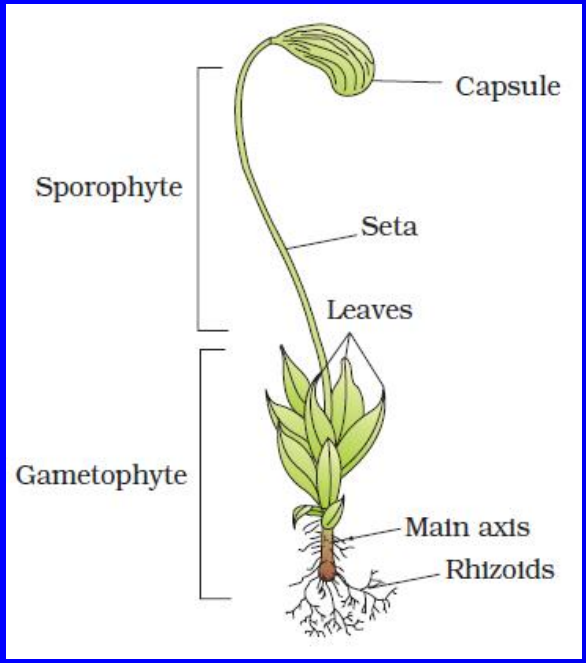


During sexual reproduction, **male and female sex organs** are produced either on the same or on different thalli.

Fusion of male and female gametes leads to the formation of zygote. Zygote develops into a diploid sporophyte.

The sporophyte is differentiated into **foot, seta and capsule**. After meiosis, haploid spores are produced within the capsule.

These spores germinate to form a free-living haploid gametophyte.

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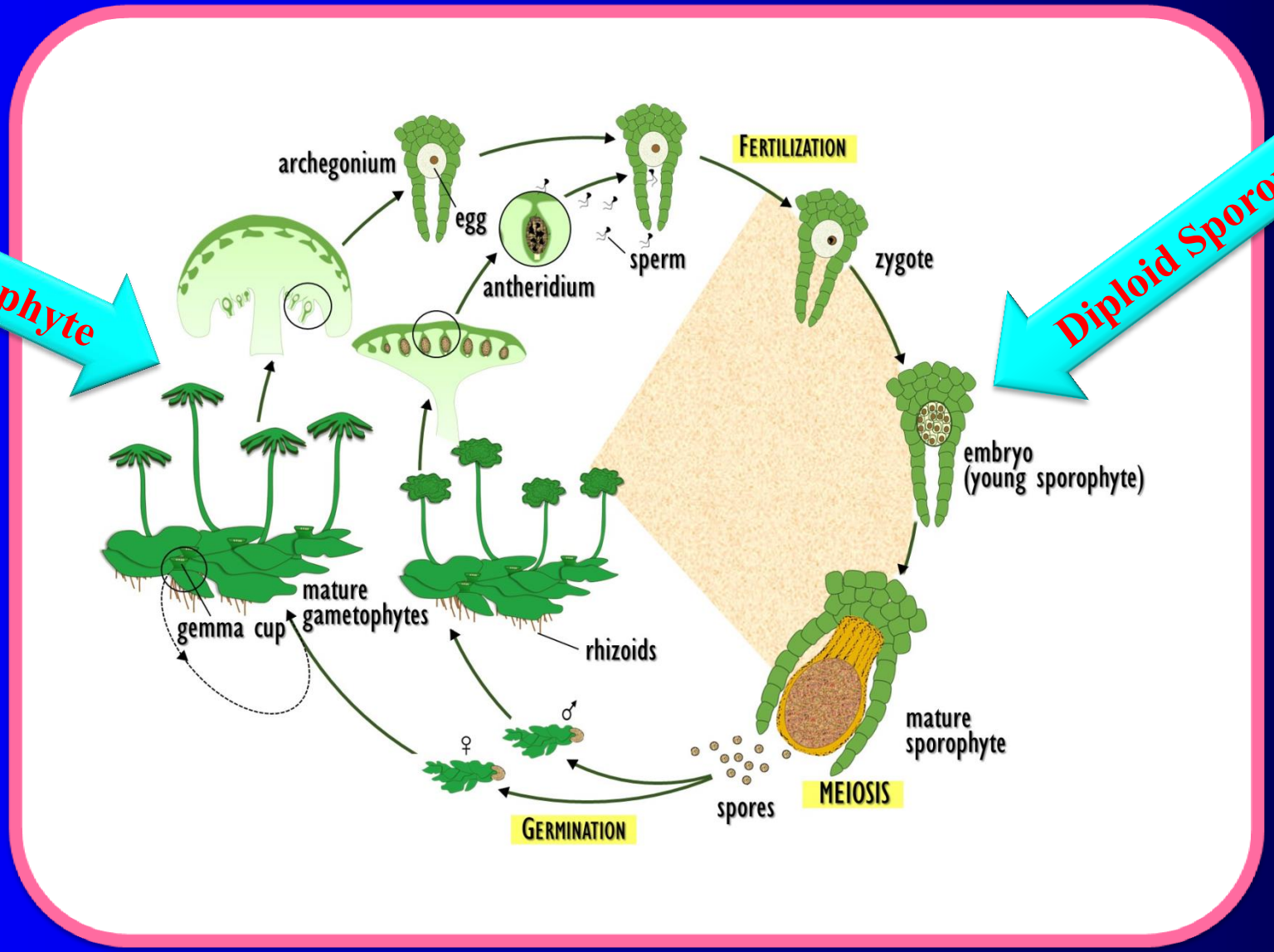
# Life Cycle of Liverworts

Haploid Gametophyte

Diploid Sporophyte

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# Mosses

# Mosses

The plant body of moss is the gametophyte which consists of two stages.

The first stage is the **protonema** stage, which develops directly from the spore. It is a green, creeping, branched and **filamentous stage.**

The second stage is a **leafy 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 the soil through multicellular and branched rhizoids. This stage bears the sex organs.

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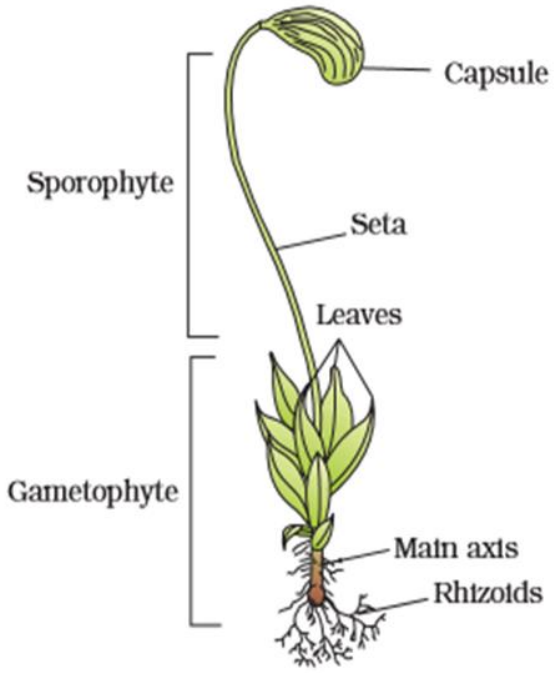
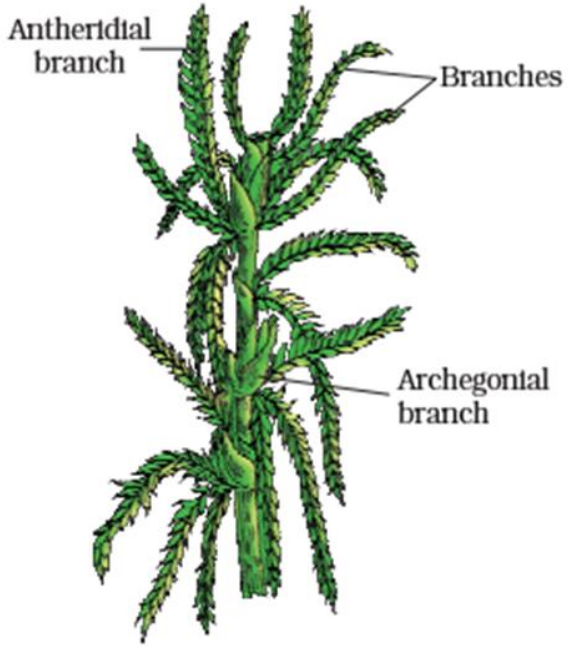
# Mosses




Funaria




Sphagnam

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# Reproduction in Mosses

Vegetative reproduction takes place by **fragmentation and budding** in the secondary protonema.

Sexual Reproduction take place by sex organs. The male sex organ is **antheridium** and the female sex organ is **archegonium,** which are produced at the apex of the leafy shoots.

After fertilisation, the zygote develops into a **sporophyte,** which consists of **foot, seta and capsule.**

The **capsule contains spores.** Spores are formed by meiosis.

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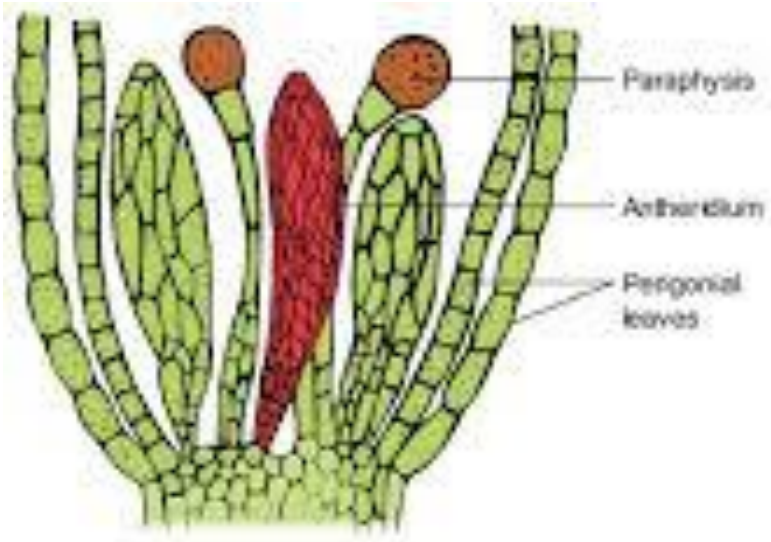
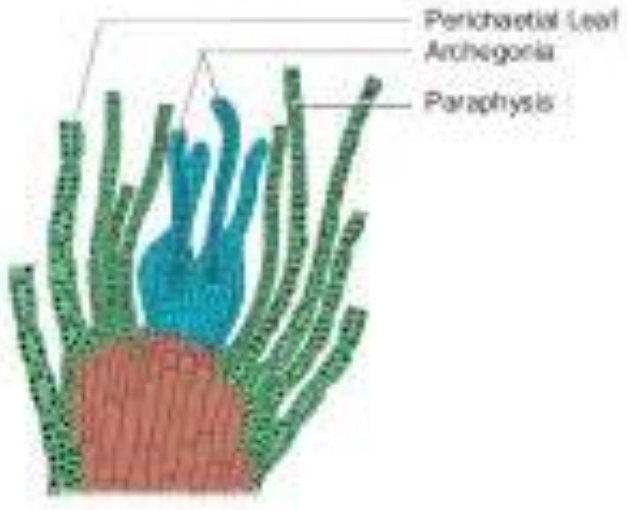
# Antheridium and Archegonium




Antheridium




Archegonium

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# CRYPTOGAMS AND PHANEROGAMS

PTERIDOPHYTES - GYMNOSPERMS - ANGIOSPERMS

# Pteridophytes

# Pteridophytes

Pteridophytes are the first terrestrial plants to possess vascular tissues xylem and phloem. So they are also called vascular cryptogams.

They are grown as ornamentals.

They include horsetails and ferns.

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# Habitat of Pteridophytes

The pteridophytes are found in cool, damp, shady hills.

Some may flourish well in sandy soil.

The main plant body of pteridophytes is the **sporophyte** which is well differentiated into true root, stem and leaves due to the presence of vascular tissues.

The leaves in pteridophytes are small or microphylls as in *Selaginella* or large or macrophylls as in ferns.

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# Leaves of Pteridophytes

Microphylls in *Selaginella*

Macrophylls in *Ferns*

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# Sporophyte

The sporophytes bear leaf like appendages called sporophylls.

Sporophylls bear sporangia, which consists of spores.

In some cases sporophylls may form distinct compact structures called strobili or cones

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# Strobilus

Sporophyte

Sporophlls, Strobili or Cones

Sporangia

Spores

# Cones

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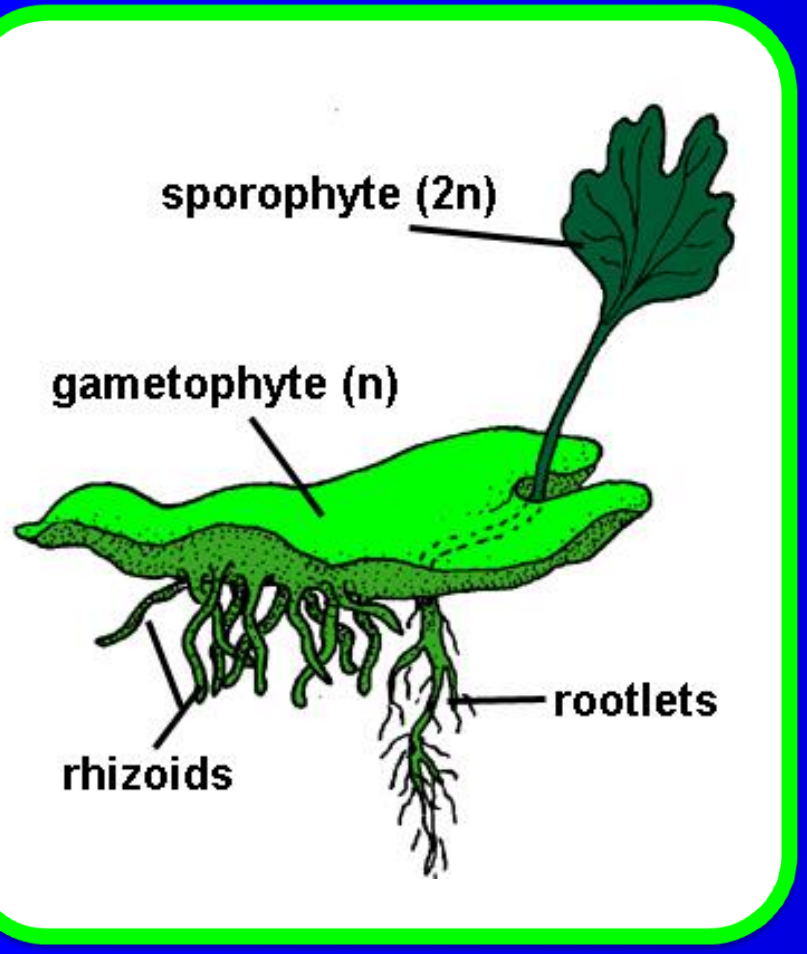
# Prothallus-Gametophyte




The spores germinate to give rise to inconspicuous, small but multicellular, living photosynthetic thalloid gametophytes called **prothallus.**

These gametophytes require cool, damp, shady places to grow.

Because of this specific requirement and the need of water for fertilisation, the spread of pteridophytes is limited and restricted to narrow geographical regions.

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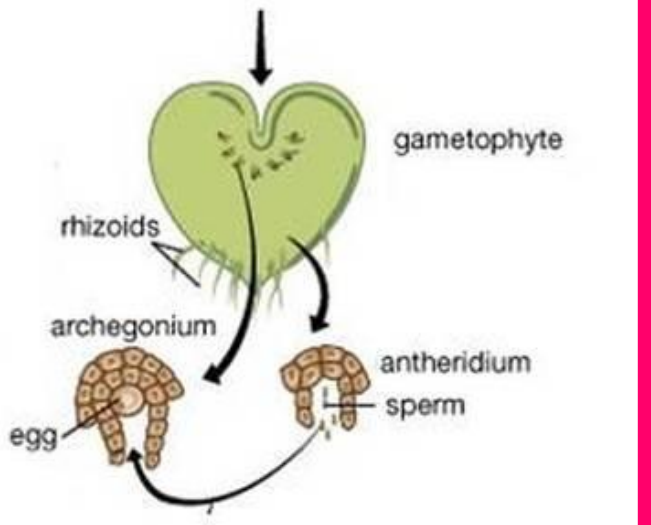
# Reproduction




The gametophytes bear male sex organs antheridia and female sex organs archegonia,

Water is required for transfer of male gametes-the antherozoids released from the antheridia, to reach the archegonium.

Fusion of male and female gametes in the archegonium leads to the formation of zygote.

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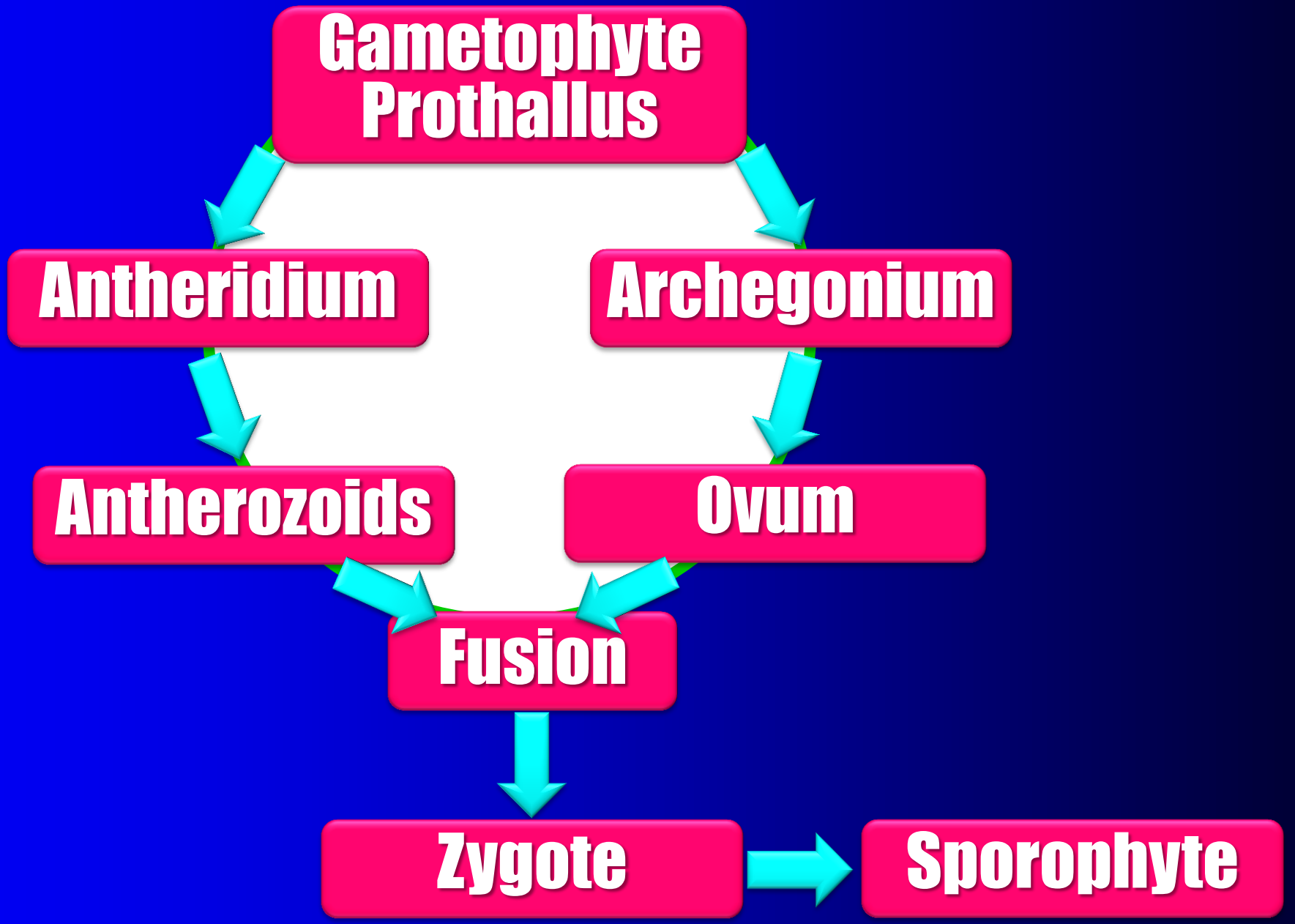


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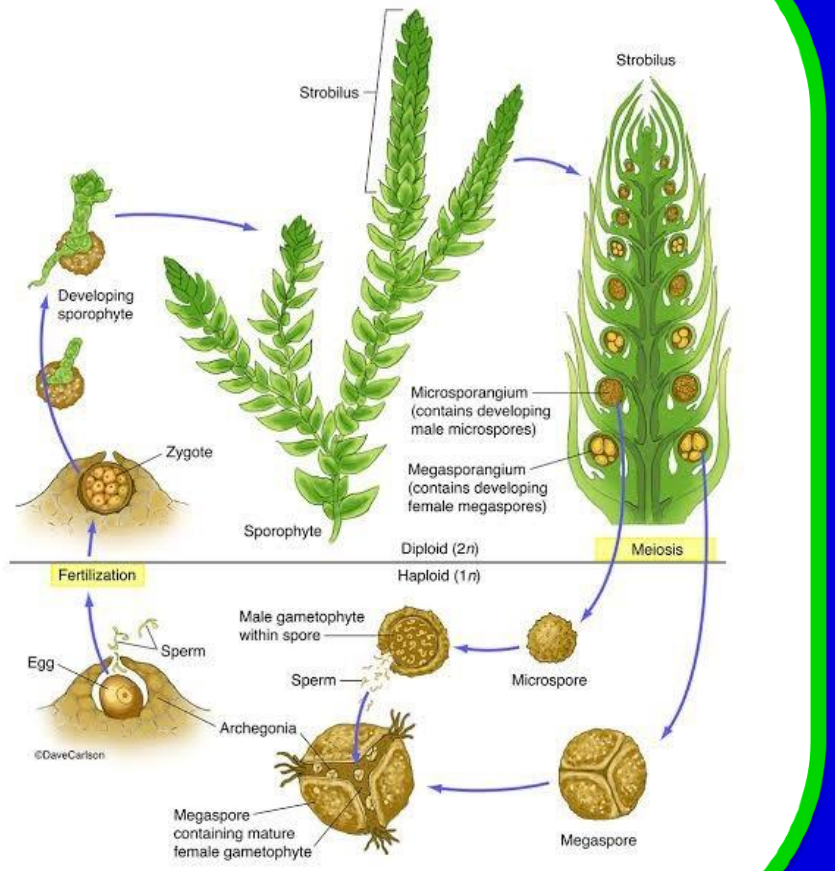
# Homosporous and Heterosporous Plants




Zygote develops into a multicellular well differentiated sporophyte which is the dominant phase of the pteridophytes.

Most of the pteridophytes produce same kind of spores, such plants are called **homosporous.**

Genera like *Selaginella* and *Salvinia* produce two kinds of spores, microspores (small spores) and macrospores (large spores) are known as **heterosporous.**

The microspores germinate into male gametophytes and megaspores germinate into female gametophytes.

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The development of the zygotes into embryos takes place within the female gametophytes.

This event is a precursor to the **seed habit** and considered as an important step in evolution.

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# Classification of Pteridophytes

The pteridophytes are classified into four classes.

| | |
|---|---|
| Psilopsida | Psilotum |
| Lycopsida | Selaginella, Lycopodium |
| Sphenopsida | Equisetum |
| Pteropsida | Dryopteris, Pteris, Adiantum |

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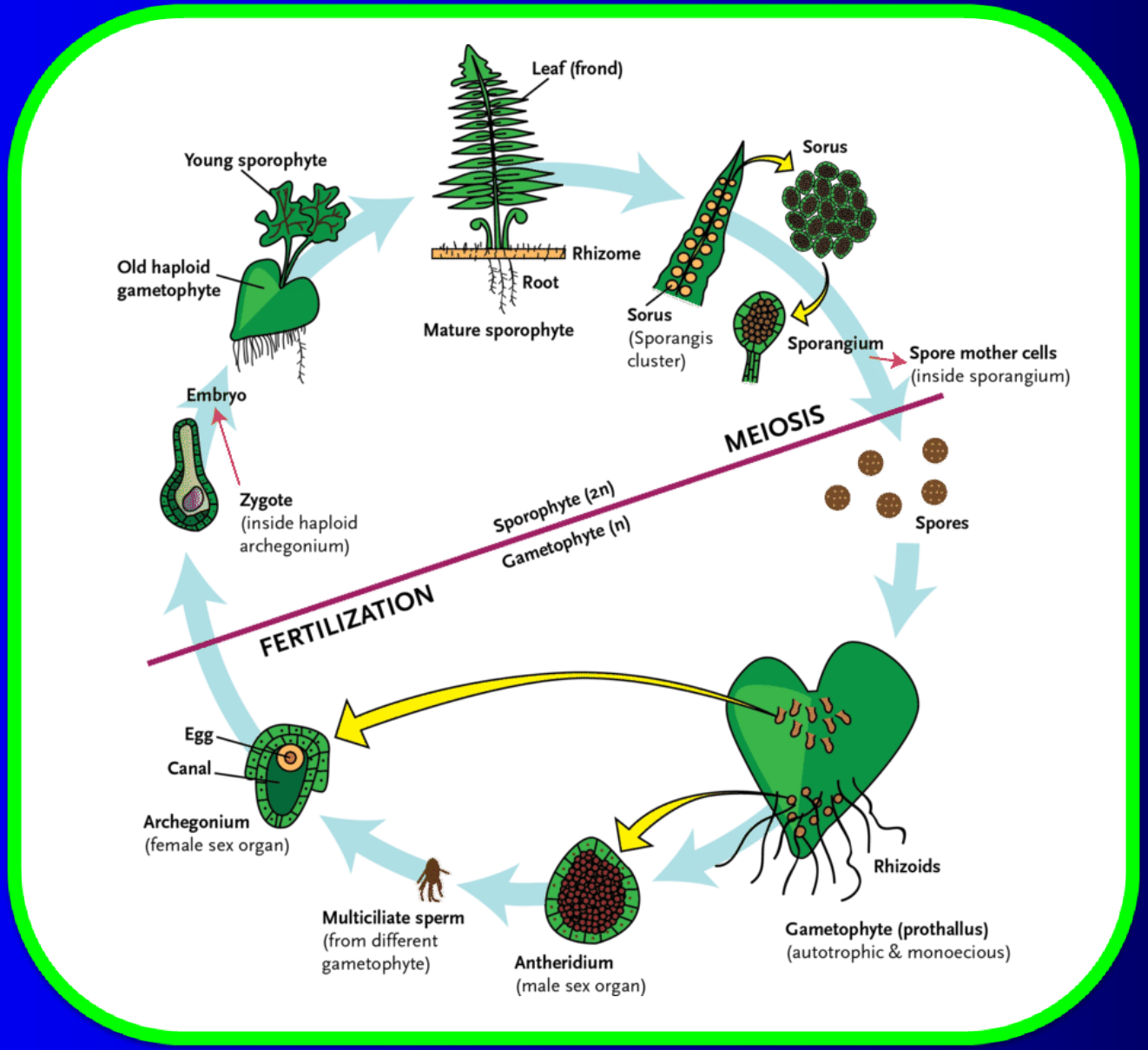
# Lifecycle of Pteridophytes

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# Gymnosperms

# Gymnosperms

The gymnosperms are the naked seeded plants in which the ovules are not enclosed by ovary and remain exposed.

As the seeds are not covered, these plants are called naked seeded plants.

Gymnosperms include shrubs, medium sized trees and tall trees.

They have branched taproot system.

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# Gymnosperms

Gymnosperms are terrestrial plants and most of them are tall, woody, perennial, evergreen trees or shrubs and a very few are climbers.

They reproduce by cones and produce naked seeds.

The cones are unisexual either male and female.

The male and female cones may be present on the same tree as in *Pinus* or on different trees as in *Cycas*.

They are heterosporous as they produce two kinds of haploid spores- microspores and megaspores.

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They bear needle-like leaves to reduce loss of water.

The ovules are not enclosed by ovary and remain exposed due to the lack of ovary.

As the seeds are not covered, these plants are called naked seeded plants.

The stem is erect, woody, branched as in *Pinus*, unbranched as in *Cycas*.

They have branched taproot system.

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# Sequoia

The californian redwood trees are the superlative trees.

The giant redwood tree *Sequoia* is the tallest tree in the world, reaching a height of  120 metres.

They are the biggest trees whose trunks have a diameter of 10-12 metres.

They have the longest life span of 2500-3500 years.

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# Root and Stem

**Roots**

Roots of *Pinus* are associated with fungi, known as mycorrhizae.

*Roots of Cycas are associated* with Nitrogen fixing cyanobacteria, known as corolloid roots.

**Stems**

The stems are branched as in *Pinus and Cedrus* and unbranched as in *Cycas*.

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# Leaves

Needle like leaf of Pinus

Pinnately compound leaf of Cycas

The leaves may be simple or compound.

In *Cycas* the pinnately compound leaves persist for a few years.

The leaves in gymnosperms are well-adapted to withstand extremes of temperature, humidity and wind.

In conifers, the needle-like leaves reduce the surface area and prevent loss of water.

They have thick cuticle and sunken stomata.

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# Male Cones, Male Strobili or Microsporangiate

Pinus Male Cone

The male cones bear **microsporophylls** which consist of **microsporangia.**

The microsporangia bear microspores which develop into male gametophytes, which are highly reduced.

The reduced male gametophytes are called **pollen grains.**

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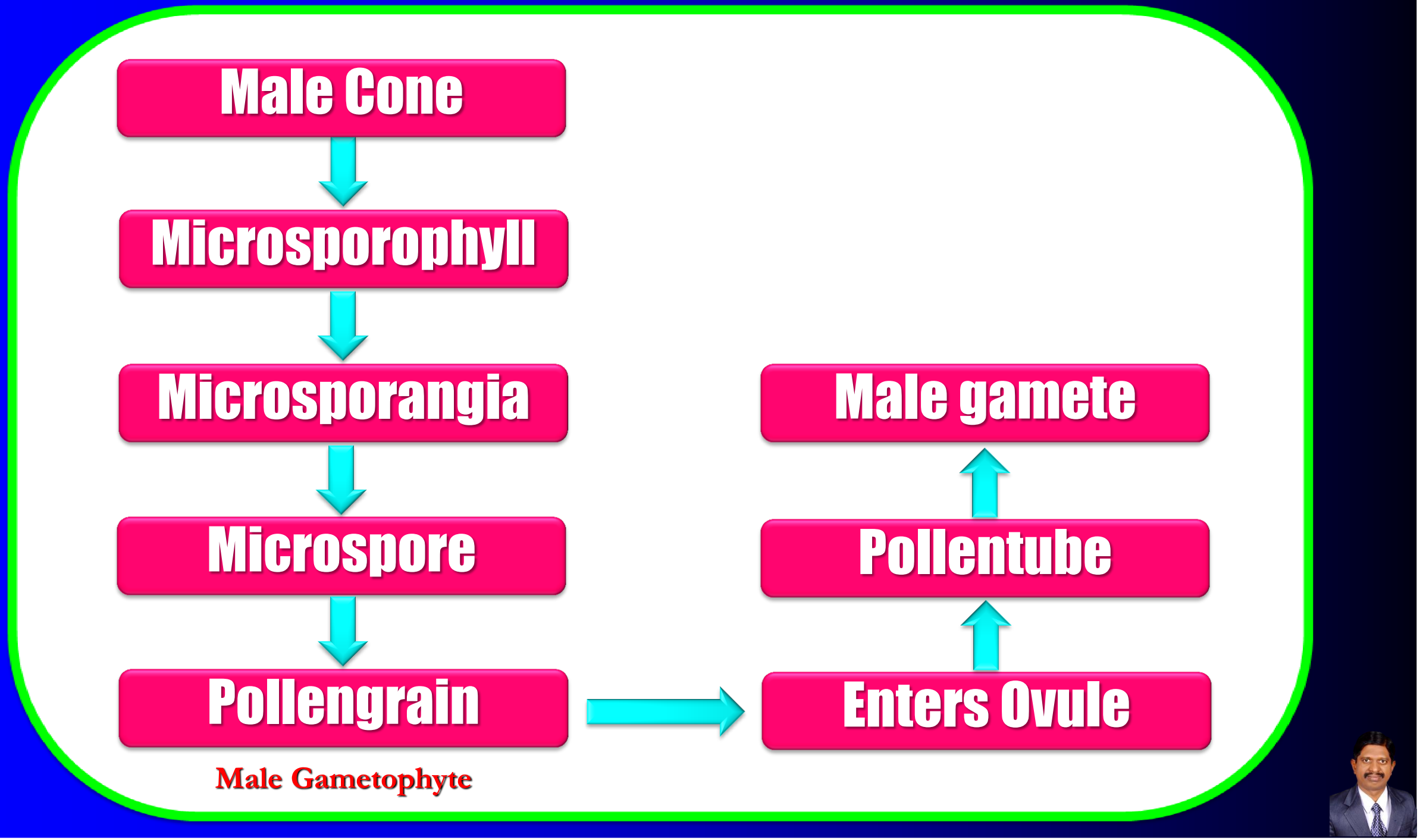
Male Cone
Microsporophyll
Microsporangia
Microspore
Pollengrain
Male Gametophyte
Enters Ovule
Pollentube
Male gamete

# Female Cones, Female Strobili or Macrosporangiate

Pinus Female Cone

The female cones bear megasporophylls which consists of **ovules.**

The ovules bear megasporangia which consists of archegonia.

The archegonium consists of felmale gamete, the ovum.

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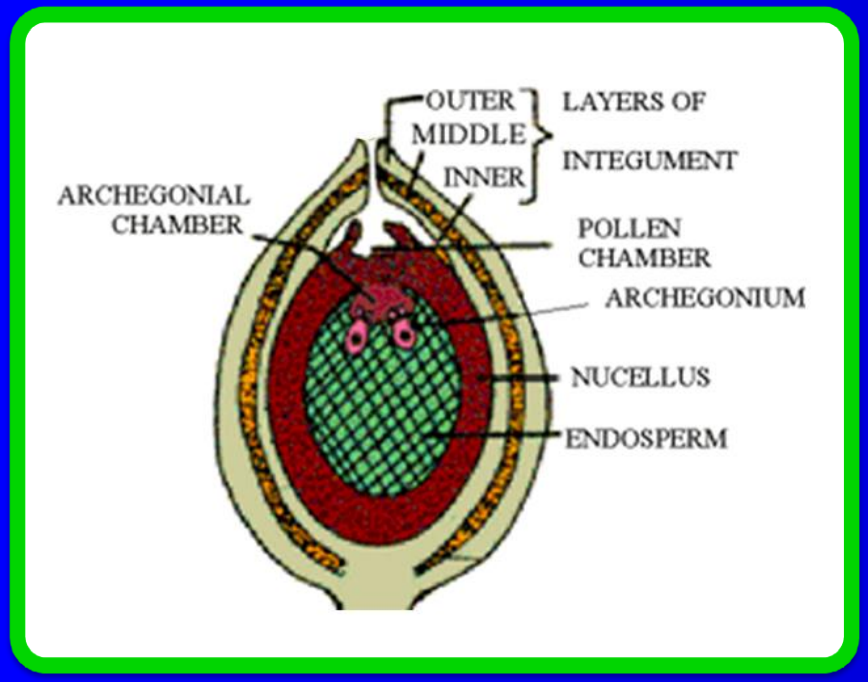
# Structure of ovule of Gymnosperms




The ovule consists of outer covering called integument.

The mass of tissue inner to the integument is called nucellus or megasporangium

One of the cells of the nucellus gets differentiated into megaspore mother cell.

The megaspore mother cell divides by meiosis to form four megaspores.

One of the megaspores develops into a multicellular female gametophyte that bears two or more archegonia.

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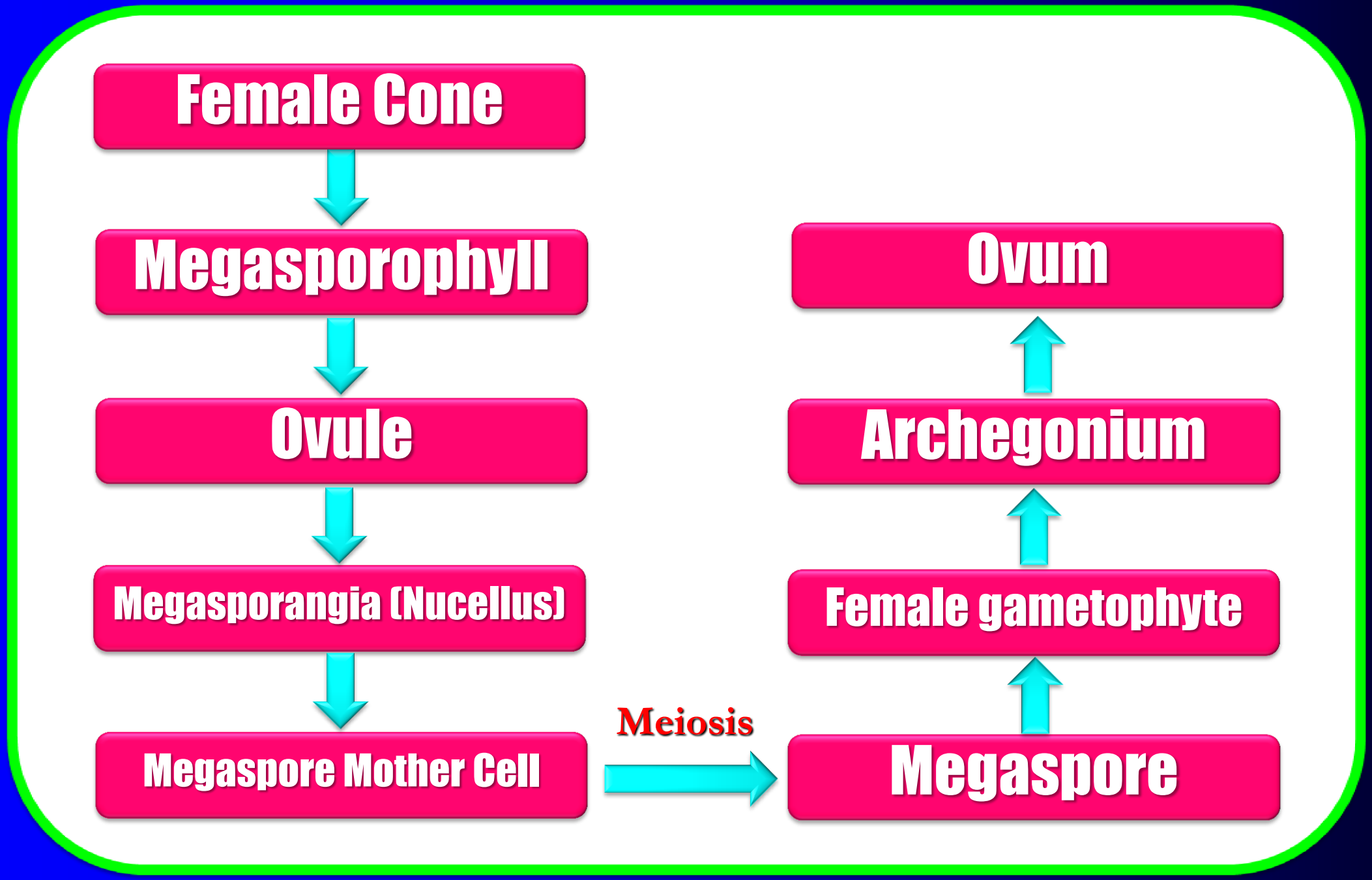
Female Cone
Megasporophyll
Ovule
Megasporangia (Nucellus)
Megaspore Mother Cell
Meiosis
Megaspore
Female gametophyte
Archegonium
Ovum

# Female Cones of Cycas

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# Pollination and Fertilization

The pollengrains are carried by air currents and fall in the ovule.

The pollengrains germinate to produce pollen tube.

The pollen tube carrying male gametes, grows towards archegonia and discharges the male gametes in the archegonia.

Fertilization occurs in the archegonia, leading to the development of zygote.

zygote develops into embryo and the ovules into seeds. The seeds are not covered due to the lack of ovary.

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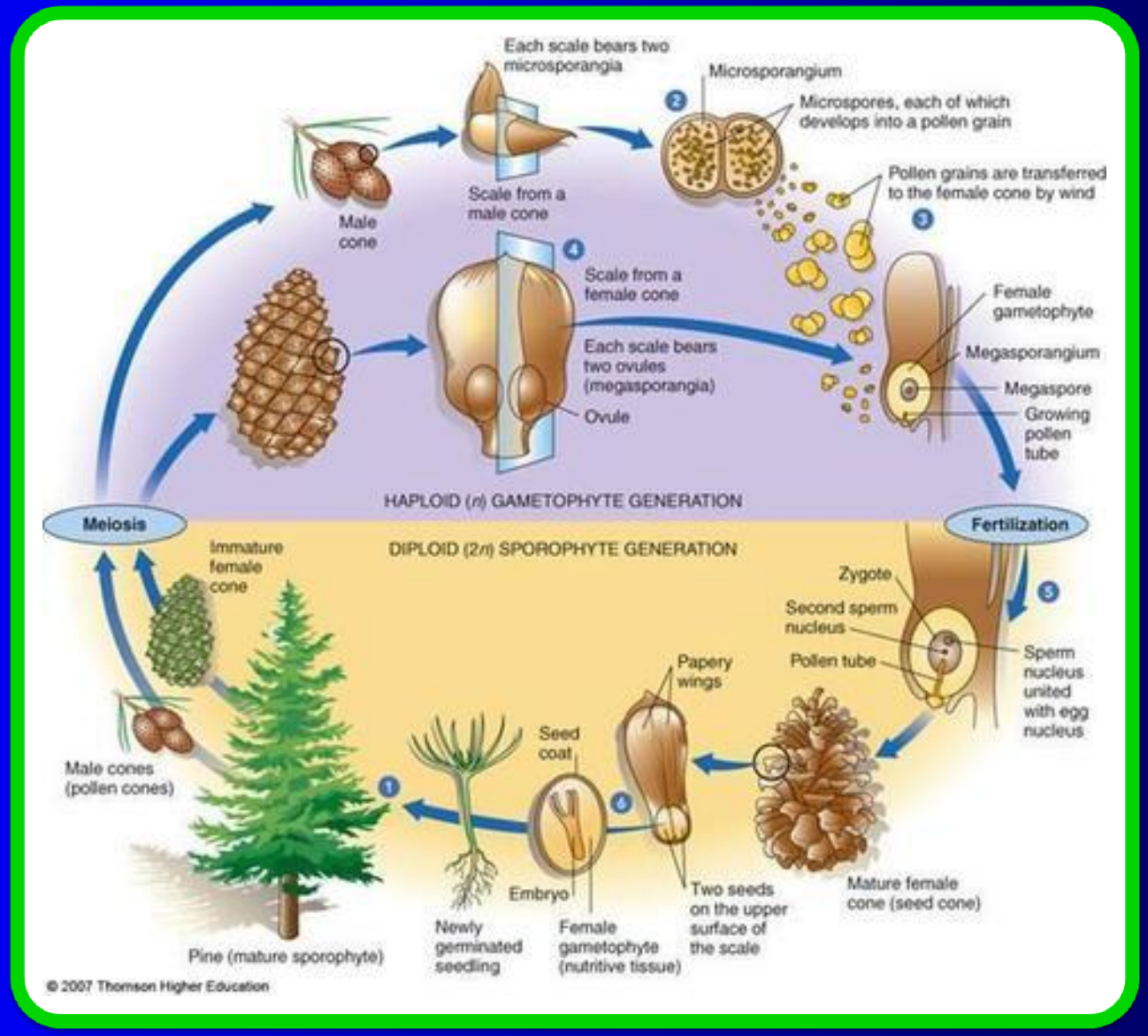
# Lifecycle of Gymnosperms

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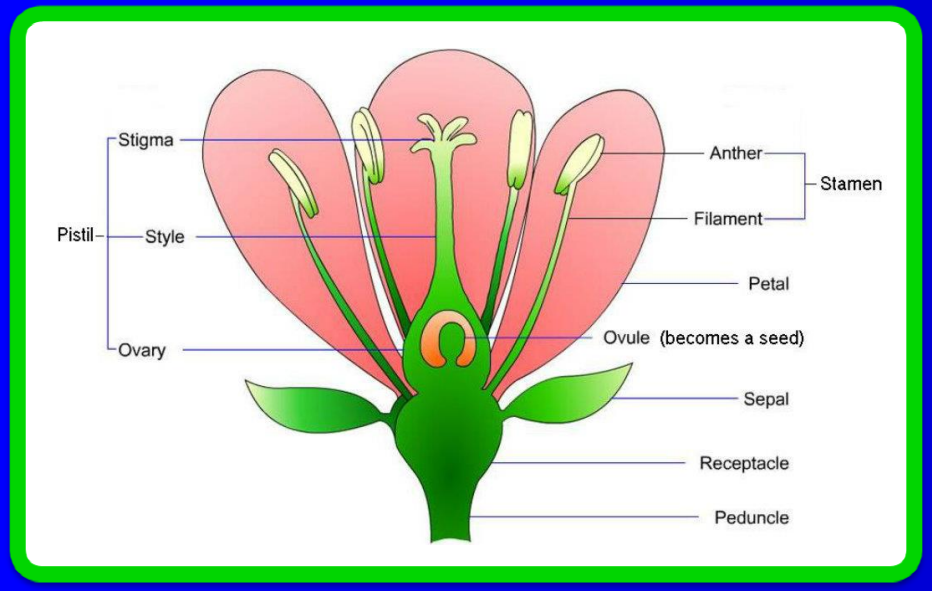
# Angiosperms

# Angiosperms




The angiosperms are flowering plants.

The pollen grains and ovules are developed in specialised structures called **flowers.**

The seeds are covered by fruits.

The angiosperms are large group of plants which are found in wide range of habitats.

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They range from tiny, almost microscopic *Wolffia* to tall trees of *Eucalyptus* which grows over 100 metres.

They provide us with food, fodder, fuel, medicines and several other important products.

They are divided into two classes: the **dicotyledons** and the **monocotyledons.**

The dicotyledons are characterised by having two cotyledons in their seeds while the monocotyledons have only one.

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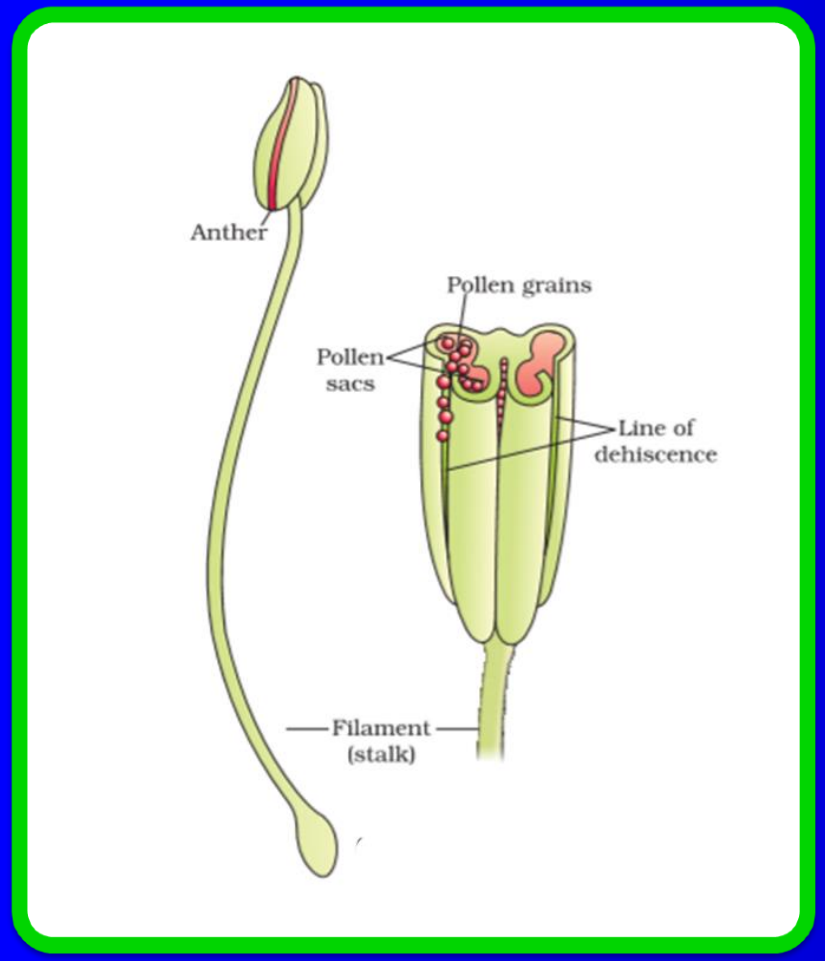
# Stamen




The male sex organ in a flower is the stamen.

Each stamen consists of a slender filament with a swollen anther at the tip.

The anther produces pollen grains following meiosis.

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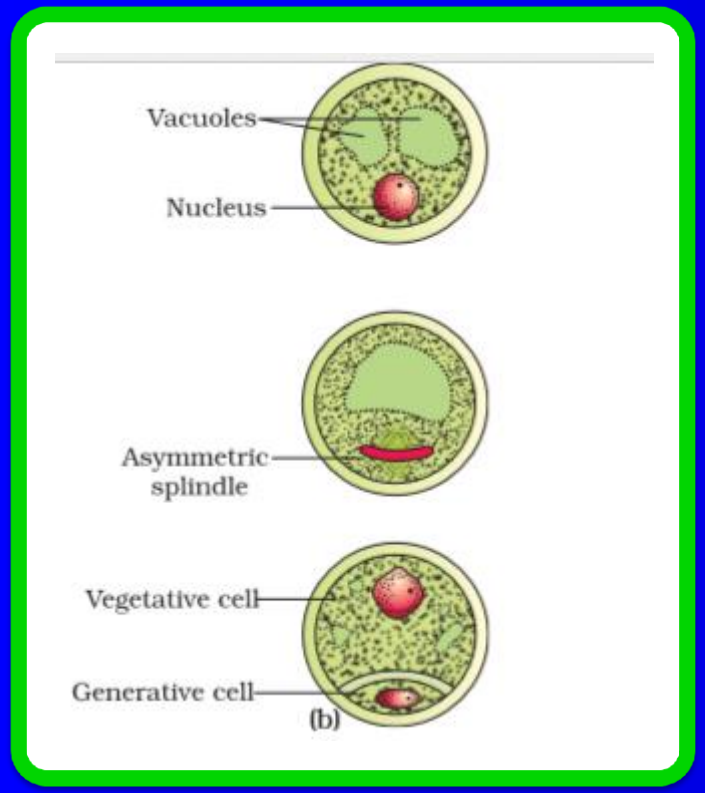
# Male Gametophyte




Pollen **grains** are carried by wind, water or other agencies to the stigma of the pistil after dispersal from the anther. This is called pollination.

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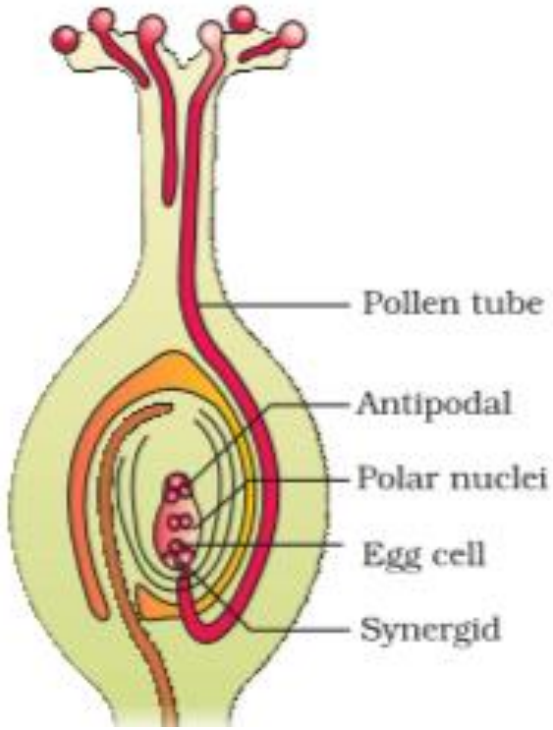
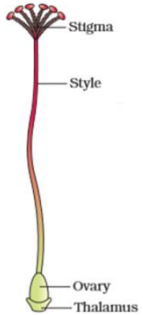
# Pistil




The female sex organ in a flower is the pistil or carpel.

Pistil consists of stigma, style and ovary enclosing one to many ovules.

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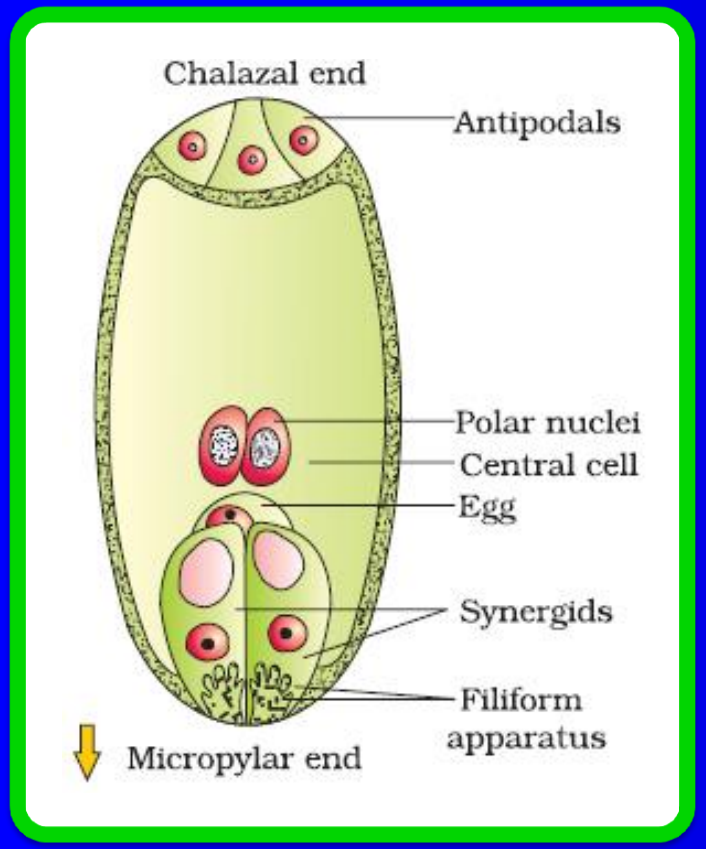
# Female Gametophyte




The highly reduced **female gametophytes** termed as **embryo- sacs** are present within ovules**.**

The embryo-sac formation is preceded by meiosis.

Hence the cells of embryo-sac are haploid.

Each embryo-sac has:

Three celled **egg apparatus** - one **egg cell** and two **synergids** at the micropylar region.

Three **antipodal** cells at the chalazal region

Two **polar nuclei** at the centre**.**

The polar nuclei fuse to form a diploid secondary nucleus.

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# Fertilization

The pollen grains germinate on the stigma and the resulting pollen tubes grow through the tissues of stigma and style and reach the ovule.

The pollen tubes enter the embryo-sac where two male gametes are discharged.

One of the male gametes fuses with the egg cell to form a zygote (syngamy).

The other male gamete fuses with the diploid secondary nucleus to produce the triploid Primary Endosperm Nucleus (PEN).

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As there are two fertilizations, this event is termed as **double fertilization,** a unique feature of angiosperms.

The zygote develops into an embryo with one or two cotyledons

The PEN develops into endosperm which provides nourishment to the developing embryo.

The synergids and antipodals degenerate after fertiisation.

The ovules develop into seeds and the ovaries develop into fruits.

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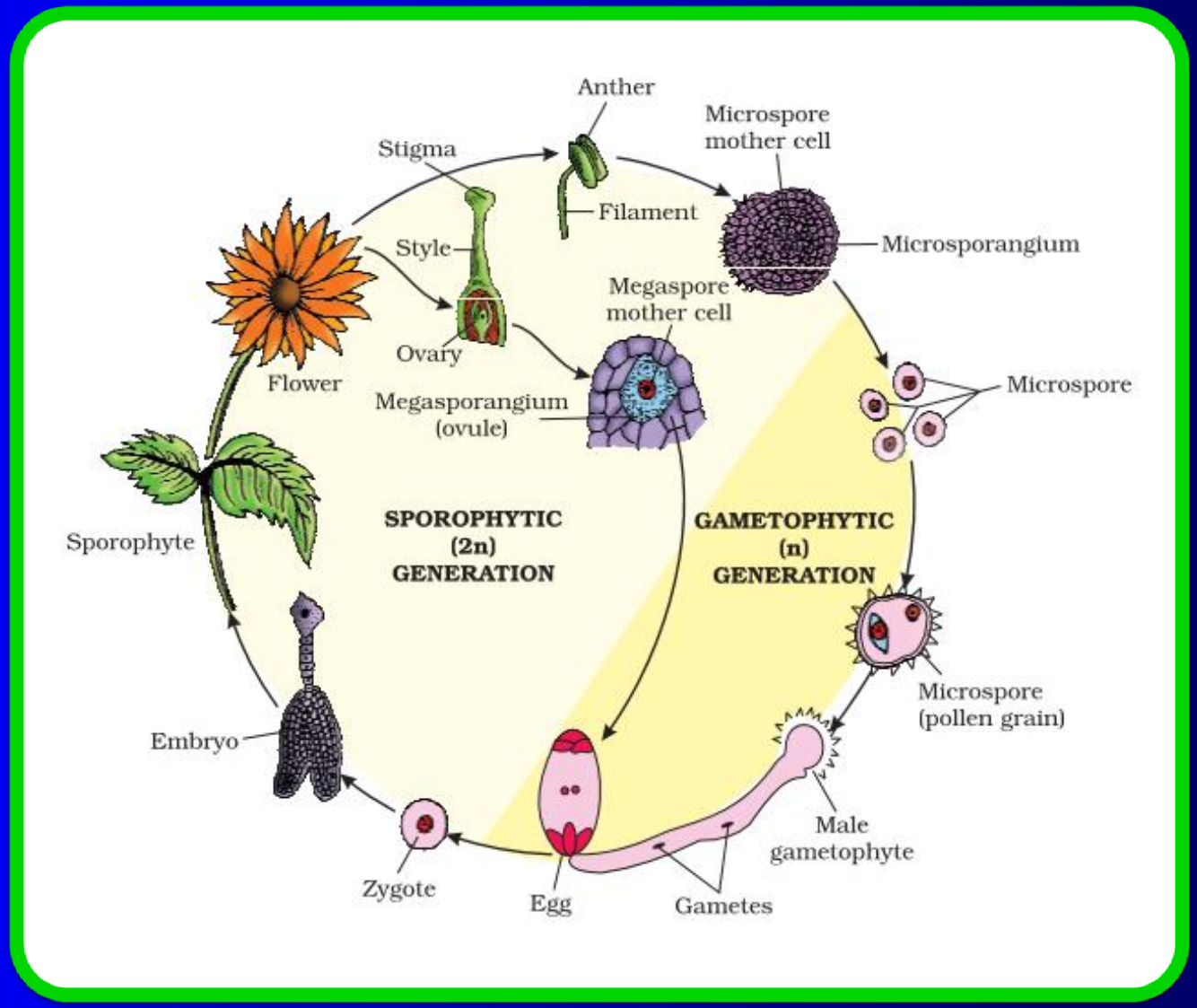
# Lifecycle of Angiosperms

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# Lifecycle Patterns

# Alternation of Generation

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

This ability leads to the formation of different plant bodies - haploid and diploid.

The haploid plant body produces gametes by mitosis.

This plant body represents a gametophyte.

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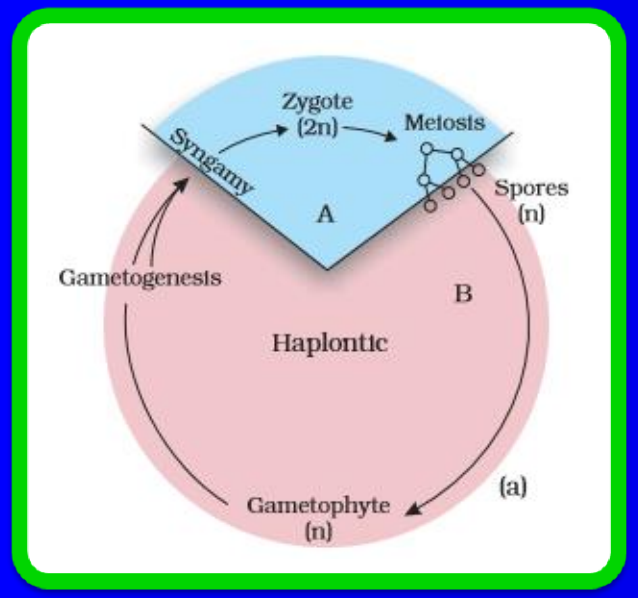
# Haplontic Phase

## Most of the Algae




In most of the algae sporophytic generation is represented only by the one-celled zygote.

There are no free-living sporophytes.

Meiosis in the zygote results in the formation of haploid spores.

The haploid spores divide mitotically and form the gametophyte.

The dominant, photosynthetic phase in such plants is the free-living gametophyte.

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This kind of life cycle is termed as **haplontic.** Many algae such as *Volvox*, *Spirogyra* and some species of *Chlamydomonas* represent this pattern .

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

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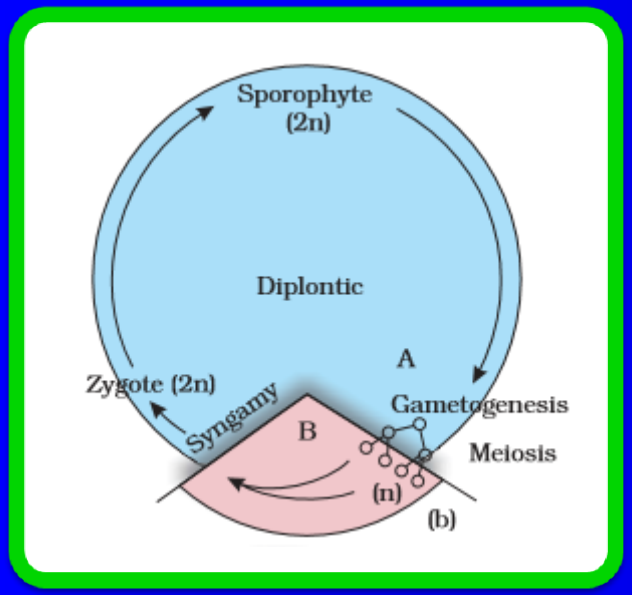
# Diplontic Phase

## Gymnosperms and Angiosperms




In Gymnosperms and Angiosperms, the diploid sporophyte is the dominant, photosynthetic, independent phase of the plant.

The gametophytic phase is represented by the single to few-celled haploid gametophyte. This kind of life cycle is termed as **diplontic.**

All seed-bearing plants i.e. gymnosperms and angiosperms follow this pattern.

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# Haplo-Diplontic Phase

## Bryophytes and Pteridophytes

Bryophytes and pteridophytes exhibit an intermediate condition **called Haplo-diplontic pattern.**

## Bryophytes

In Bryophytes, the dominant, independent, photosynthetic, thalloid or erect phase is represented by a haploid gametophyte.

It alternates with the **short- lived multicellular diploid sporophyte** which is partially or completely dependent on the gametophyte for its anchorage and nutrition.

All bryophytes represent this pattern.

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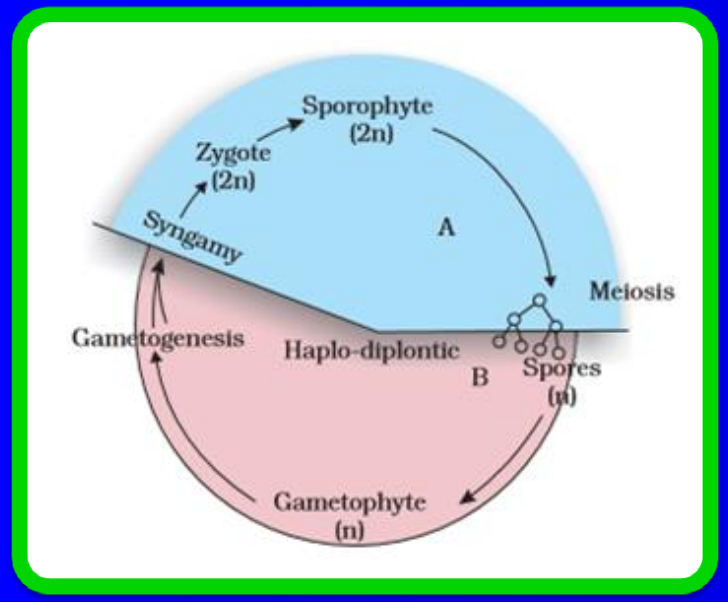
# Pteridophytes




The diploid sporophyte is represented by a dominant, independent, photosynthetic, vascular plant body.

It alternates with **multicellular**, saprophytic/autotrophic, **independent but short-lived haploid gametophyte.**

Such a pattern is known as haplo-diplontic life cycle.

All pteridophytes exhibit this pattern.

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God Bless You!