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Plant Kingdom

Classification and Characteristics

- Kingdom Plantae: multicellular, photosynthetic, aquatic or terrestrial.
- Divided into Cryptogamae (no seeds) and Phanerogamae (with seeds).
- Cryptogamae: Thallophyta (algae, no vascular tissue), Bryophyta (mosses, non-vascular), Pteridophyta (ferns, vascular but no seeds).
- Phanerogamae: Gymnospermae (naked seeds, no flowers), Angiospermae (seeds in fruits, flowering plants).
- Classification evolved from artificial (Linnaeus) to natural (Bentham & Hooker) to phylogenetic systems.
- Modern taxonomy includes numerical taxonomy, cytotaxonomy, and chemotaxonomy.

Memory Aids

- Cryptogamae = "hidden seeds" (no seeds).
- Phanerogamae = "visible seeds" (seed plants).
- Artificial systems focus on few traits; natural systems consider anatomy and chemistry.

Quick Checkpoints

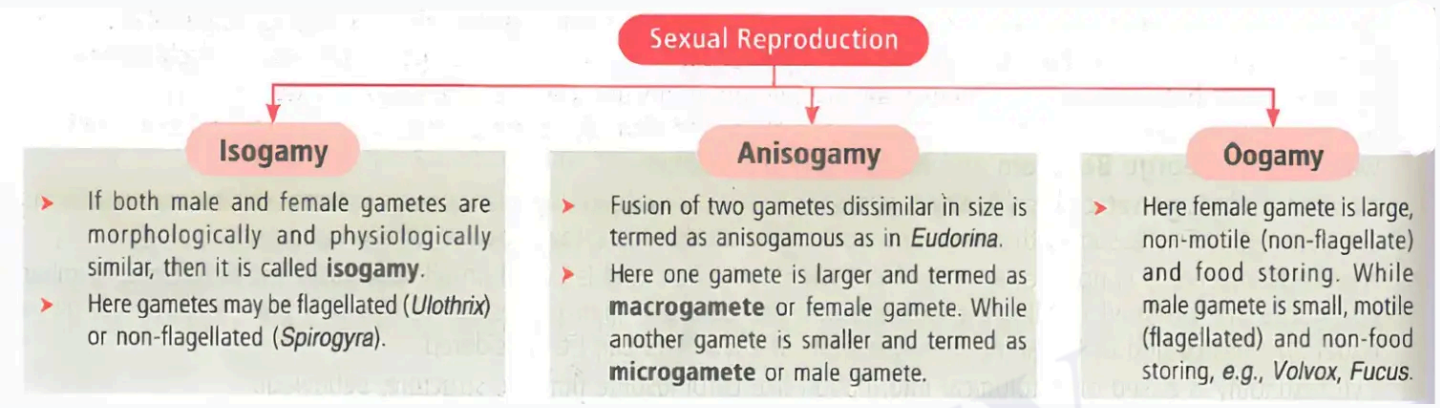
- What are the two main groups of Kingdom Plantae?
- Which group has vascular tissue but no seeds?
- Who proposed the natural classification system?
- What is the basis of phylogenetic classification?

Algae

General Characteristics

- Simple, autotrophic, mostly aquatic organisms with chlorophyll.
- Habitat: freshwater, marine, moist terrestrial, symbiotic (e.g., lichens).

- Unusual habitats: halophytic, epiphytic, epizoic, endozoic, parasitic, thermophytic algae.
- Forms: unicellular (motile/non-motile), colonial, filamentous, large kelps.
- Thallus: vegetative body; cell wall has cellulose (inner) and pectin (outer).
- Photosynthetic pigments: chlorophyll a (all), b, c, d; carotenoids (carotenes, xanthophylls); phycobilins (phycocyanins, phycoerythrins).
- Food reserves: starch, laminarin, mannitol, floridean starch.
- Reproduction: vegetative (fragmentation), asexual (zoospores), sexual (isogamy, anisogamy, oogamy).



Memory Aids

- Isogamy: gametes alike; Anisogamy: gametes differ in size; Oogamy: large non-motile egg, small motile sperm.
- Kelps = large brown algae, "trees of the sea".
- Thallus = algal body without differentiation.

Quick Checkpoints

- What pigments are common to all algae?
- Name three types of sexual reproduction in algae.
- What is the vegetative body of algae called?
- Which algae live in hot water springs?

Classification of Algae

Classes and Features

- Based on phylogeny and affinities, algae classified by Dr. F. E. Fritsch and Whittaker.
- Main classes: Chlorophyceae (green algae), Phaeophyceae (brown algae), Rhodophyceae (red algae).
- Chlorophyceae: unicellular/colonial/filamentous; chlorophyll a & b; pyrenoids store protein & starch; cell wall cellulose + pectose; reproduction by fragmentation, flagellated zoospores, sexual types.
- Phaeophyceae: marine; from filamentous to large kelps; pigments chlorophyll a, carotenoids, xanthophylls (fucoxanthin); plant body with holdfast, stipe, frond; reproduction by fragmentation, biflagellate zoospores, sexual types.
- Rhodophyceae: red pigment phycoerythrin; found near surface and deep water; food stored as floridean starch; multicellular thalli; reproduction vegetative by fragmentation, asexual non-motile spores, oogamous sexual reproduction.

Table : Characteristics of different classes of algae

Classes	Structure	Occurrence	Major pigments	Reserve food material	Reproduction	Reproduction Sexual
Chlorophyceae (Green algae) *e.g., Spirogyra, Ulothrix*	Unicellular, colonial, coenobial, filamentous, siphonaceous. Cell wall cellulosic and pectic. Motile cells with 2-4 equal flagella.	Mostly freshwater, a few marine. A marked tendency towards terrestrial habitat.	Chl. *a* and *b*, carotenes and xanthophyll.	True starch and sugar	Fragmentation or fission	Isogamous to advanced oogamos
Phaeophyceae (*e.g., Fucus, Sargassum*	Branched, filamentous or parenchymatous stru-sture, cell wall composed of cellulose, alginic and fucinic acids, motile cells with 2 lateral flagella.	Mostly marine.	Chl. *a* and c, fucoxanthin, flavoxanthin, β-carotenes.	Laminarin, mannitol	Fragmentation or adventitious branching	Zoospores
Phaeophyceae (*e.g., Fucus, Sargassum*	Branched, filamentous or parenchymatous struc-ture, cell wall composed of cellulose, alginic and fucin acids, motile cells with 2 lateral flagella.	Mostly marine.	Chl. *a* and c, fucoxanthin, flavoxanthin, β-carotenes.	Laminarin, mannitol	Fragmentation or adventitious branching	Zoospores, aplanospores, etc.
Rhodophyceae (*e.g., Polysiphonia, Porphyra*	Unicellular, filamentous or pseudoparenchymatous, cell wall cellulosic and pe rnoids not known, pyren-oids simple or compound, embedded sometimes stalked.	Mostly marine.	Chl. *a* and *d*, phycocyanins, allophycocyanin, carotenoids.	Floridean starch	Fragmentation	Fragmentation

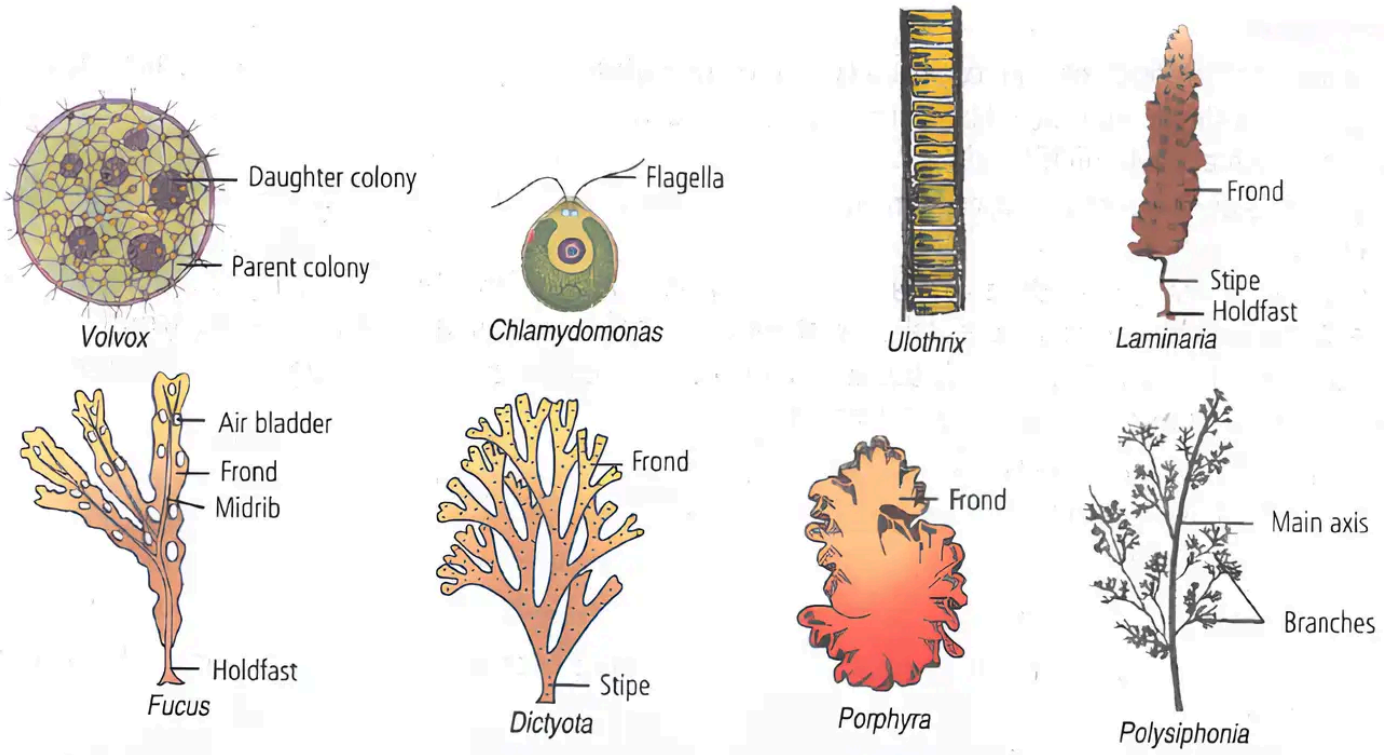


Fig.: Green (*Volvox, Chlamydomonas, Ulothrix*), Brown (*Laminaria, Fucus, Dictyota*) and Red (*Porphyra, Polysiphonia*) algae

Memory Aids

- Chlorophyceae = green, chlorophyll a & b, pyrenoids present.
- Phaeophyceae = brown, fucoxanthin pigment, kelps are large.
- Rhodophyceae = red, phycoerythrin pigment, floridean starch.

Quick Checkpoints

- Which class of algae has pyrenoids?
- What pigment gives brown algae their color?
- Where are red algae found in water?
- What type of spores do red algae produce asexually?

Economic Importance of Algae

Uses and Benefits

- Food: Porphyra, Laminaria, Sargassum; Chlorella rich in protein supplement.

- Photosynthesis: contributes ~50% of Earth's photosynthesis; vital for aquatic respiration.
- Phycocolloids: Alginic acid (from brown algae) used in emulsions, plastics, security glass.
- Agar-agar: from red algae, used as solidifying agent in culture media.
- Carrageen: from red algae, used in pharmaceuticals, textiles, leather, brewing.
- Medicines: Red algae Corallina (anti-worm), brown algae Laminaria & Ascophyllum (antibiotics), Durvillea (vermifuge), green algae Chlorella & Caulerpa (antibiotics).
- Sewage disposal: green algae like Chlamydomonas, Chlorella, Scenedesmus aid aerobic sewage treatment.

Memory Aids

- Phycology = study of algae.
- Algae = non-embryophytes, no embryo, unicellular sex organs.
- Macrocystis pyrifera = largest algae; Laminaria = Devil's Apron.
- Spirogyra = pond silk due to mucilage shine.

Quick Checkpoints

- Name a protein-rich algae used as food supplement.
- What phycocolloid is extracted from brown algae?
- Which algae help in sewage treatment?
- What is the study of algae called?

General Characteristics

Features

- Bryophytes are called amphibians of the plant kingdom; live on soil but need water for sexual reproduction.
- Found in damp, humid, shaded places; important in succession on bare rocks/soil.
- Plant body is thallus-like, prostrate or erect, attached by unicellular/multicellular rhizoids.
- Lack true roots, stems, or leaves but may have root-like, leaf-like, or stem-like structures.
- Main plant body is haploid gametophyte producing gametes.
- Sex organs are multicellular: male antheridium produces biflagellate antherozoids; female archegonium is flask-shaped producing one egg.

- Antherozoids swim in water to fertilize egg forming zygote.
- Zygote forms sporophyte attached to gametophyte; sporophyte produces haploid spores by meiosis.
- Spores germinate into gametophyte, completing life cycle.

Memory Aids

- Amphibians of plants = need water for reproduction.
- Gametophyte = dominant haploid stage.
- Antheridium = male; Archegonium = female.
- Sporophyte depends on gametophyte.

Quick Checkpoints

- Why are bryophytes called amphibians of the plant kingdom?
- What is the dominant stage in bryophytes?
- Describe the structure and function of sex organs in bryophytes.
- How does sporophyte depend on gametophyte?

Liverworts

Characteristics and Reproduction

- Also called Hepaticopsida or Hepaticae.
- Grow in moist, shady habitats: banks, marshy ground, damp soil, tree bark.
- Plant body is thalloid (e.g., *Marchantia*), dorsiventral, closely attached to substratum.
- Leafy types have tiny leaf-like appendages in two rows on stem-like structures.
- Asexual reproduction by fragmentation of thalli or by gemmae (multicellular buds) in gemma cups.
- Sexual reproduction: male and female sex organs on same or different thalli.
- Sporophyte has foot, seta, and capsule; spores formed after meiosis in capsule.
- Spores germinate into free-living gametophytes.

Memory Aids

- Gemmae = asexual buds in gemma cups.
- *Marchantia* = common thalloid liverwort.
- Sporophyte parts: foot, seta, capsule.

Quick Checkpoints

- Where do liverworts commonly grow?
- How do gemmae help in asexual reproduction?
- What are the parts of the sporophyte in liverworts?

Mosses

Life Cycle and Reproduction

- Dominant stage is gametophyte with two stages: protonema and leafy stage.
- Protonema: creeping, green, branched, filamentous stage from spore.
- Leafy stage: develops from lateral bud on secondary protonema; upright axes with spirally arranged leaves.
- Attached to soil by multicellular, branched rhizoids.
- Sex organs (antheridia and archegonia) at apex of leafy shoots.
- Vegetative reproduction by fragmentation and budding in secondary protonema.
- After fertilization, zygote forms sporophyte with foot, seta, and capsule containing spores.
- Common mosses: *Funaria*, *Polytrichum*, *Sphagnum*.

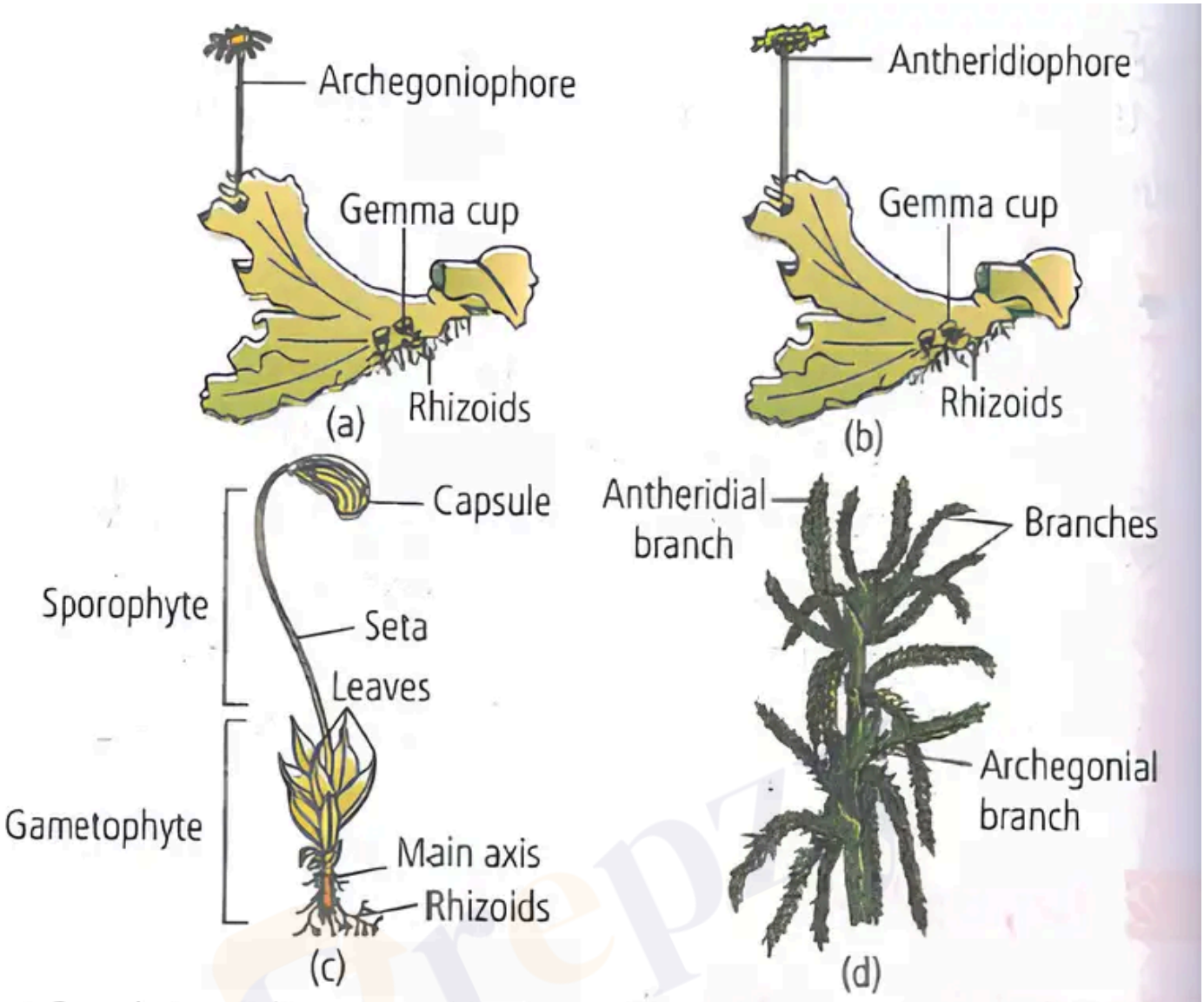


Fig.: Bryophytes : A liverwort – *Marchantia* (a) Female thallus (b) Male thallus, Mosses – (c) *Funaria* (gametophyte and sporophyte) (d) *Sphagnum* (gametophyte)

Memory Aids

- Protonema = first stage, filamentous growth.
- Leafy stage bears sex organs.
- Sporophyte parts: foot, seta, capsule.
- *Funaria* = common moss example.

Quick Checkpoints

- What are the two stages of moss gametophyte?
- How does vegetative reproduction occur in mosses?

- Describe the sporophyte structure in mosses.

Economic Importance of Bryophytes

Uses and Benefits

- **Prevention of soil erosion:** Mosses form dense mats reducing soil erosion by water and rain impact.
- **Soil formation:** Bryophytes aid ecological succession and soil formation on rocks (e.g., *Sphagnum* fills ponds).
- **Water retention:** Some mosses like *Sphagnum* absorb 18-26 times their weight in water; used in gardening and plant transport.
- **Peat formation:** Dead mosses in acidic marshes form peat, used as manure, fuel, and to improve soil aeration and water retention.
- **Ecological importance:** Mosses and lichens are pioneer colonizers of rocks.

Memory Aids

- *Sphagnum* = water absorber and peat source.
- Peat = fossilized moss, used as fuel and manure.
- Moss mats prevent soil erosion.

Quick Checkpoints

- How do bryophytes prevent soil erosion?
- What role do bryophytes play in soil formation?
- Why is *Sphagnum* important in water retention?
- What is peat and its uses?

Additional Facts

Key Points

- Study of bryophytes is called Bryology.
- Tallest bryophytes can reach 70 cm (e.g., *Dawsonia*).
- *Polytrichum* is known as hair cap moss.
- *Sphagnum* is called famine food.

Memory Aids

- Bryology = study of bryophytes.
- *Dawsonia* = tallest bryophyte.
- *Polytrichum* = hair cap moss.
- *Sphagnum* = famine food.

Quick Checkpoints

- What is Bryology?
- Name the tallest bryophyte.
- Which moss is called hair cap moss?
- Why is *Sphagnum* called famine food?

General Characteristics

Overview

- Pteridophytes include horsetails and ferns; used medicinally, as soil-binders, and ornamentals.
- First terrestrial plants with vascular tissues (xylem and phloem).
- Found mostly in cool, damp, shady places; some thrive in sandy soils.

Plant Body and Reproduction

- Main plant body is a sporophyte with true roots, stems, and leaves (microphylls or macrophylls).
- Sporophytes bear sporangia on leaf-like structures called sporophylls; may form strobili or cones (e.g., *Selaginella*, *Equisetum*).
- Sporangia produce spores by meiosis; spores germinate into free-living, photosynthetic gametophytes called prothallus.
- Gametophytes require cool, damp, shady conditions; bear antheridia (male) and archegonia (female).
- Water is essential for antherozoid transfer to archegonium; fertilization forms zygote, which grows into dominant sporophyte.
- Most pteridophytes are homosporous (one spore type); some like *Selaginella* and *Salvinia* are heterosporous (macro- and microspores).
- Heterosporous plants retain female gametophytes on sporophyte; embryo development inside female gametophyte is a precursor to seed habit.

Memory Aids

- Pteridophytes = First vascular plants without seeds.
- Sporophyte dominant, gametophyte free-living and photosynthetic.
- Homosporous = one spore type; heterosporous = two spore types.
- Water needed for fertilization.

Quick Checkpoints

- What are the main organs of pteridophyte sporophyte?
- Define sporophyll and strobili.
- Explain the role of water in fertilization.
- Difference between homosporous and heterosporous pteridophytes.

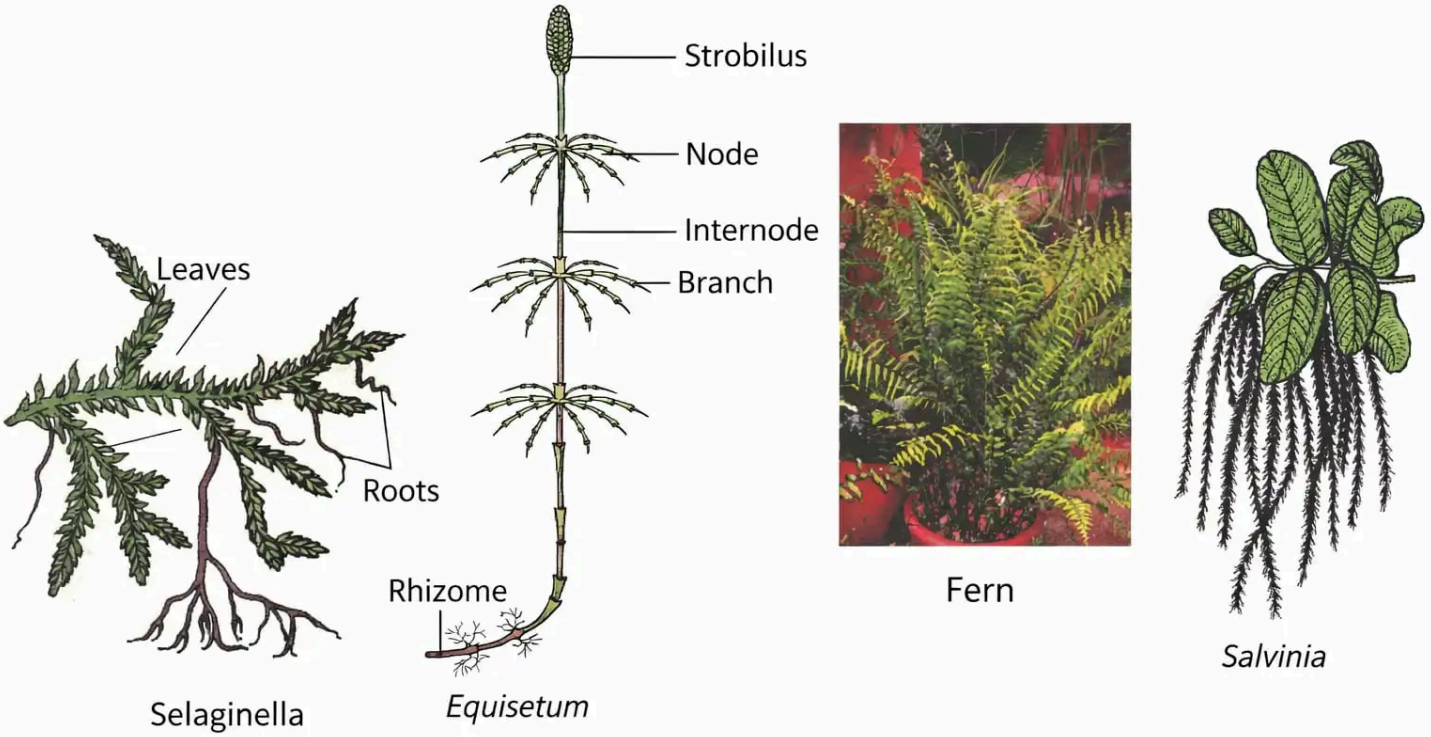


Fig.: Some pteridophytes

Classification of Pteridophytes

Classes and Features

- **Psilopsida**: Oldest, simplest vascular plants; no roots, have rhizoids; all extinct; e.g., *Psilotum*.
- **Lycopsida**: Club mosses/spike mosses; have roots, stems, leaves; homosporous or heterosporous; e.g., *Lycopodium*, *Selaginella*.
- **Sphenopsida**: Stems with ridges/grooves; small leaves in whorls; always homosporous; e.g., *Equisetum*.
- **Pteropsida**: Largest, most advanced; mostly lack aerial stem except tree ferns; spores in sori on leaves; homosporous or heterosporous; e.g., *Dryopteris*, *Marsilea*.

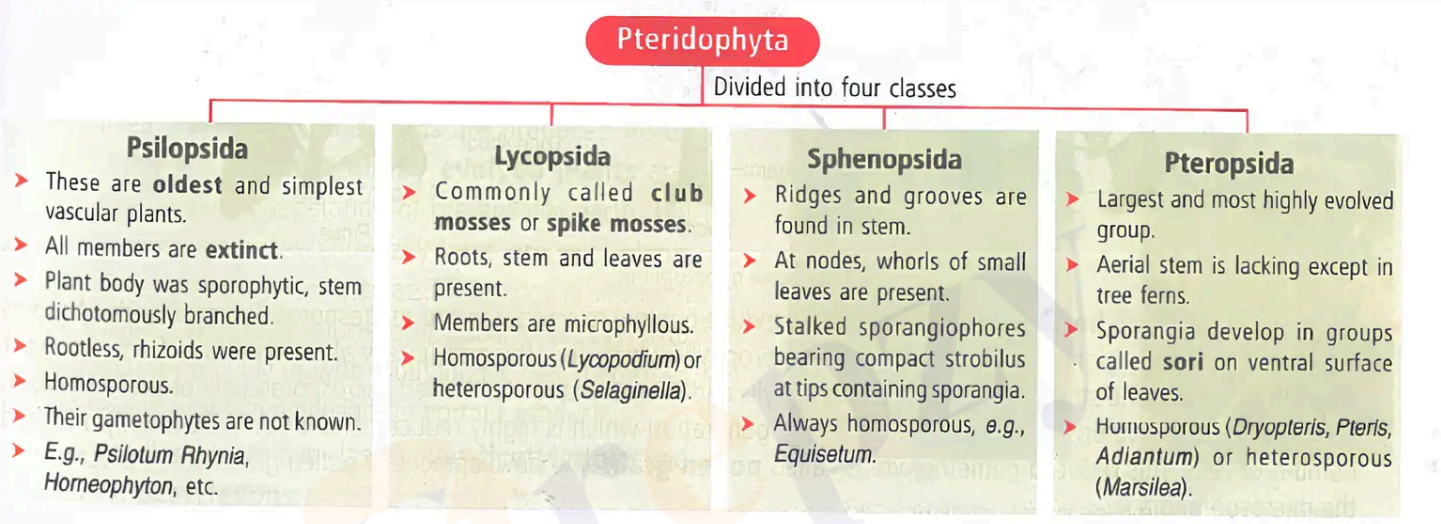
Memory Aids

- Four classes: Psilopsida (primitive), Lycopsida (club mosses), Sphenopsida (horsetails), Pteropsida (ferns).

- Psilopsida extinct; Lycopsida includes heterosporous plants.
- Sphenopsida always homosporous; Pteropsida most diverse.

Quick Checkpoints

- Name the four classes of pteridophytes.
- Which class is extinct?
- Identify homosporous and heterosporous classes.
- Examples of each class.



Economic Importance of Pteridophytes

Uses

- Food: Sporocarps of *Marsilea* eaten by some tribal communities.
- Soil binding: Prevent soil erosion on hill slopes.
- Scouring: Stems of *Equisetum* used for cleaning utensils and polishing metals.
- Nitrogen fixation: Water fern *Azolla* forms symbiosis with nitrogen-fixing cyanobacteria; used as biofertilizer in paddy fields.
- Medicines: Rhizomes of male shield fern (*Dryopteris*) yield anti-helminthic drugs; *Equisetum* used for diuretic, haemostatic, and haemopoietic drugs.
- Ornamental: Ferns grown for attractive foliage; used in bouquets and decorations.

Memory Aids

- *Marsilea* for food; *Equisetum* for scouring and medicine.
- *Azolla* fixes nitrogen; used as biofertilizer.
- Ferns popular as ornamental plants.

Quick Checkpoints

- List economic uses of pteridophytes.
- Which pteridophyte is used as biofertilizer?
- Name medicinal uses of pteridophytes.
- Why are ferns grown ornamentally?

Additional Facts

Key Points

- Term ‘Pteridophyta’ proposed by Haeckel in 1866.
- Study of pteridophytes is called Pteridology.
- *Adiantum* is called walking fern due to adventitious roots from leaf tips.
- *Salvinia* is rootless and known as “Sorrow of Kashmir.”
- *Alsophila* is the tallest pteridophyte; *Azolla* is the smallest aquatic fern.
- *Selaginella* species are resurrection plants; dry brown balls revive with water (e.g., *S. bryopteris*).

Memory Aids

- Pteridophyta named by Haeckel; study called Pteridology.
- Walking fern = *Adiantum*.
- Rootless fern = *Salvinia*.
- Tallest = *Alsophila*, smallest = *Azolla*.
- Resurrection plant = *Selaginella*.

Quick Checkpoints

- Who proposed the term Pteridophyta?
- What is Pteridology?
- Why is *Adiantum* called walking fern?
- Which pteridophyte is rootless?
- Identify the tallest and smallest pteridophytes.
- What are resurrection plants?

General Characteristics

Features

- Gymnosperms have naked ovules exposed before and after fertilisation.
- Include medium to tall trees and shrubs; e.g., *Sequoia* (giant redwood) is very tall.
- Roots are mostly tap roots; some have mycorrhizal association (*Pinus*), others have coralloid roots with nitrogen-fixing cyanobacteria (*Cycas*).
- Stems can be unbranched (*Cycas*) or branched (*Pinus*, *Cedrus*).
- Leaves are simple or compound; *Cycas* has persistent pinnate leaves.
- Leaves adapted to extreme conditions: needle-like with thick cuticle and sunken stomata to reduce water loss.

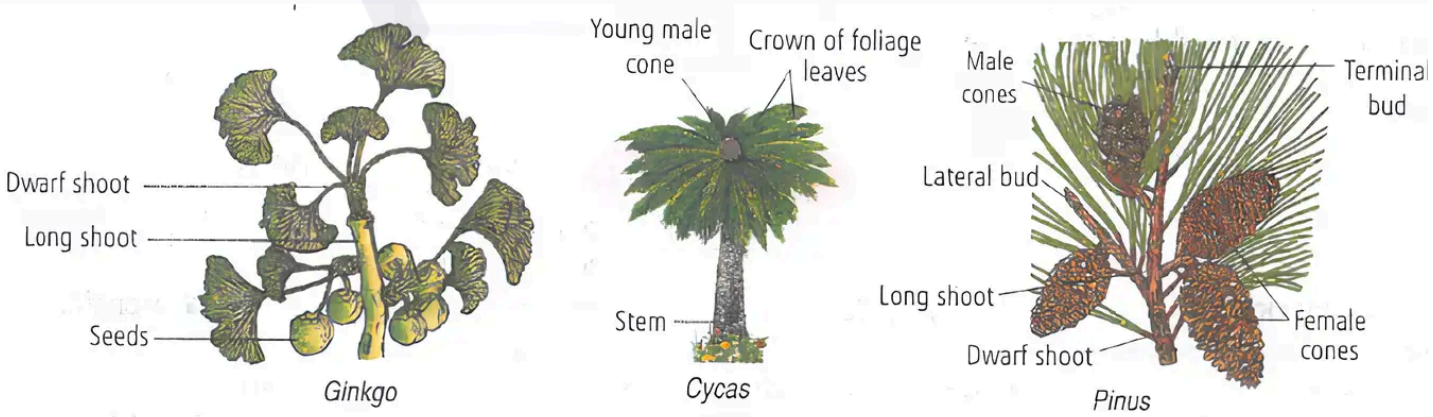


Fig.: Some gymnosperms

Memory Aids

- Gymnosperms = "naked seeds" (no ovary covering).
- Needle leaves = less water loss.

- *Sequoia* = tallest tree.

Quick Checkpoints

- What type of roots do gymnosperms have?
- How are gymnosperm leaves adapted to dry conditions?
- Which gymnosperm is known as the tallest tree?

Reproductive Structures

Key Points

- Gymnosperms are heterosporous: produce microspores (male) and megaspores (female).
- Spores develop in sporangia on sporophylls arranged in cones (strobili).
- Male cones (microsporangiate strobili) produce pollen grains (reduced male gametophyte).
- Female cones (megasporangiate strobili) bear ovules; ovule = nucellus + envelopes.
- Megaspore mother cell undergoes meiosis → 4 megaspores; one develops into female gametophyte with archegonia inside ovule.
- Male and female gametophytes remain inside sporophyte; no free-living gametophytes.
- Pollen grains released, carried by wind to ovules; pollen tube delivers male gametes to archegonia.
- Fertilisation forms zygote → embryo; ovule develops into seed.
- Four gymnosperm groups: *Cycadopsida*, *Ginkgopsida*, *Coniferopsida*, *Gnetopsida*.

Memory Aids

- Heterosporous = two spore types → male (pollen) and female (ovule).
- Cones = strobili; male = microsporangiate, female = megasporangiate.
- Pollen grain = reduced male gametophyte.

Quick Checkpoints

- What are the two types of spores in gymnosperms?

- Where do pollen grains develop?
- What is the structure called that bears ovules?
- How is fertilisation achieved in gymnosperms?

Economic Importance

Uses

- Edible seeds: *Pinus gerardiana* seeds are edible after roasting.
- Timber: Used for light furniture, plywood, railway sleepers.
- Paper: Wood from *Picea*, *Pinus*, *Larix*, *Abies* used in paper manufacture.
- Linoleum: Sawdust used in linoleum and plastics production.
- Ephedrine: Drug from *Ephedra* used for respiratory ailments.
- Resin: Extracted for turpentine (solvent) and rosin (waterproofing, paper).

Memory Aids

- Pinus seeds = edible nuts.
- Ephedra = source of ephedrine drug.
- Resin products = turpentine and rosin.

Quick Checkpoints

- Which gymnosperm seeds are edible?
- What are the main uses of gymnosperm wood?
- From which plant is ephedrine obtained?
- What are the products obtained from resin?

Special Adaptations

Adaptations and Features

- Gymnosperms grow on mountain slopes in cold regions; show xerophytic adaptations.

- Vascular plants with xylem and phloem; xylem mostly lacks vessels, phloem lacks companion cells.
- Exceptions with vessels in xylem: *Gnetum*, *Ephedra*, *Welwitschia*.
- Secondary growth occurs; stems are woody but wood is soft due to absence of vessels.
- Endosperm is haploid, formed before fertilisation.
- *Ginkgo biloba* = Maidenhair tree; *Sequoia* = Redwood tree.
- *Cycas* has largest egg, sperm, and ovule among gymnosperms.

Memory Aids

- Xerophytic = adapted to dry, cold mountain slopes.
- Softwood = gymnosperm wood without vessels.
- *Ginkgo* = Maidenhair tree; *Sequoia* = Redwood.

Quick Checkpoints

- What type of vascular tissues do gymnosperms have?
- Which gymnosperms have vessels in xylem?
- Why is gymnosperm wood called softwood?
- What is unique about *Cycas* reproductive cells?

Angiosperms

Overview

- Seed plants with sporophylls organized into flowers.
- Seeds develop inside fruits.
- Most evolved and dominant plants on Earth.
- Range from tiny *Wolffia* to tall *Eucalyptus* trees.
- Provide food, fodder, fuel, medicines, and commercial products.
- Divided into two classes: dicotyledons and monocotyledons.

Memory Aids

- Dicots: Two seed leaves, broad leaves, flower parts in 4s or 5s.
- Monocots: One seed leaf, narrow parallel-veined leaves, flower parts in 3s.

Quick Checkpoints

- What defines angiosperms?
- Difference between dicots and monocots?
- Examples of smallest and tallest angiosperms?



Fig.: Angiosperms : (a) A dicotyledon; (b) A monocotyledon

Plant Life Cycles and Alternation of Generations

Overview

- Life cycles vary among plant groups but follow a strict sequence of phases.
- This sequence is called alternation of generations.
- Three types of life cycles: haplontic, diplontic, haplodiplontic.

Memory Aids

- Alternation of generations means alternating haploid and diploid phases.
- Haplontic: dominant haploid phase.
- Diplontic: dominant diploid phase.
- Haplodiplontic: both phases multicellular and distinct.

Quick Checkpoints

- What is alternation of generations?
- Name the three life cycle types.
- Which phase is dominant in each type?

Haplontic Life Cycle

Characteristics

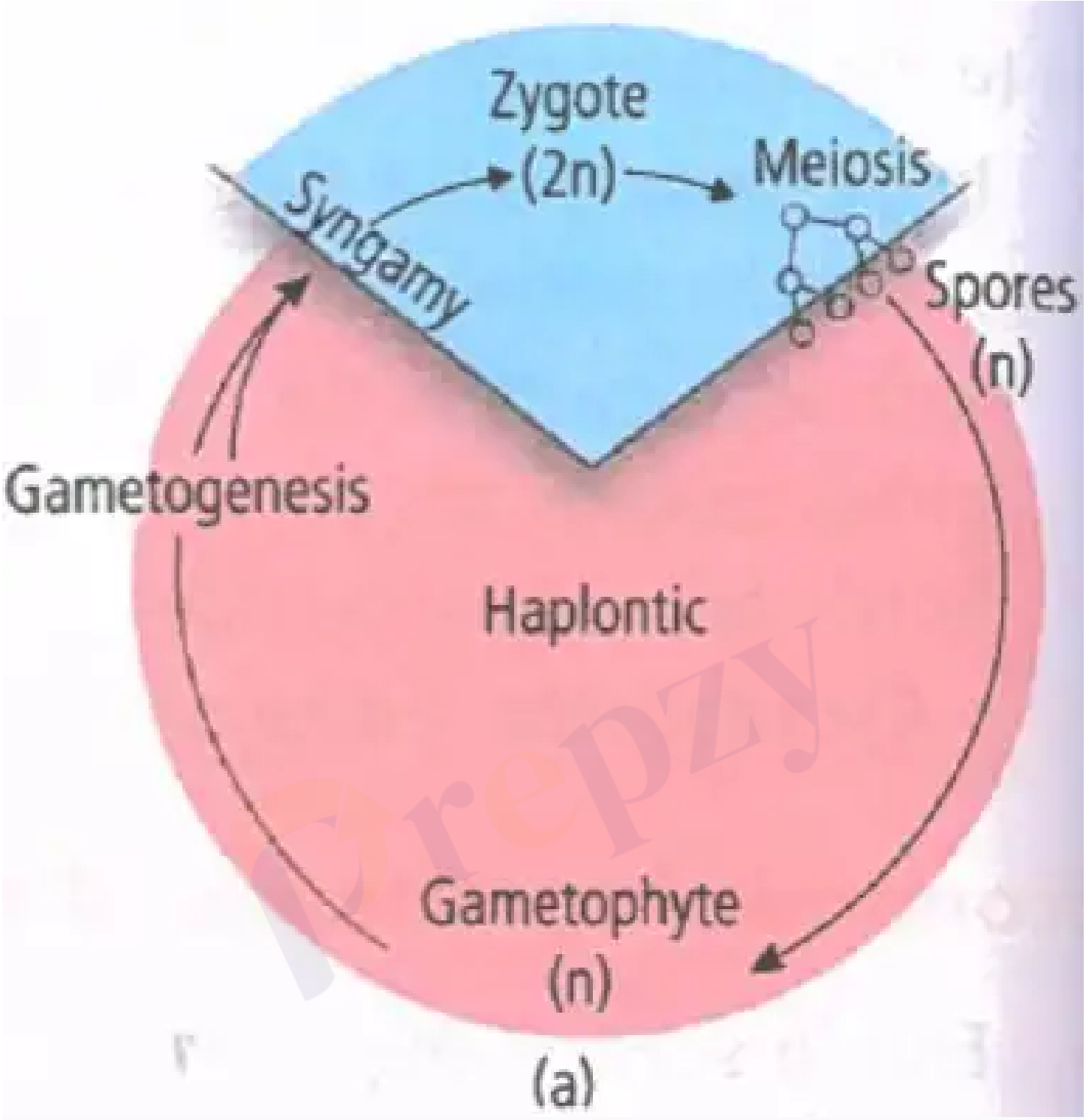
- Single haploid vegetative phase called gametophyte.
- Gametophyte produces haploid gametes.
- Gametes fuse to form diploid zygote (single-celled).
- Zygote does not form multicellular diploid structure; meiosis occurs at germination.
- Meiosis produces haploid nuclei/spores that develop into new gametophytes.
- No true alternation of generations; sporophyte phase is only the single-celled zygote.
- Examples: algae like *Volvox*, *Spirogyra*, *Chlamydomonas*.

Memory Aids

- Haplo = single set of chromosomes dominant.
- Zygote is brief diploid stage only.

Quick Checkpoints

- What is the dominant phase in haplontic cycle?
- When does meiosis occur?
- Does the zygote form a multicellular sporophyte?



Diplontic Life Cycle

Characteristics

- Single diploid vegetative phase called sporophyte.
- Sporophyte produces haploid gametes via meiosis in sex organs.
- Gametes are the only haploid stage.
- Fertilization produces diploid zygote that grows into sporophyte.

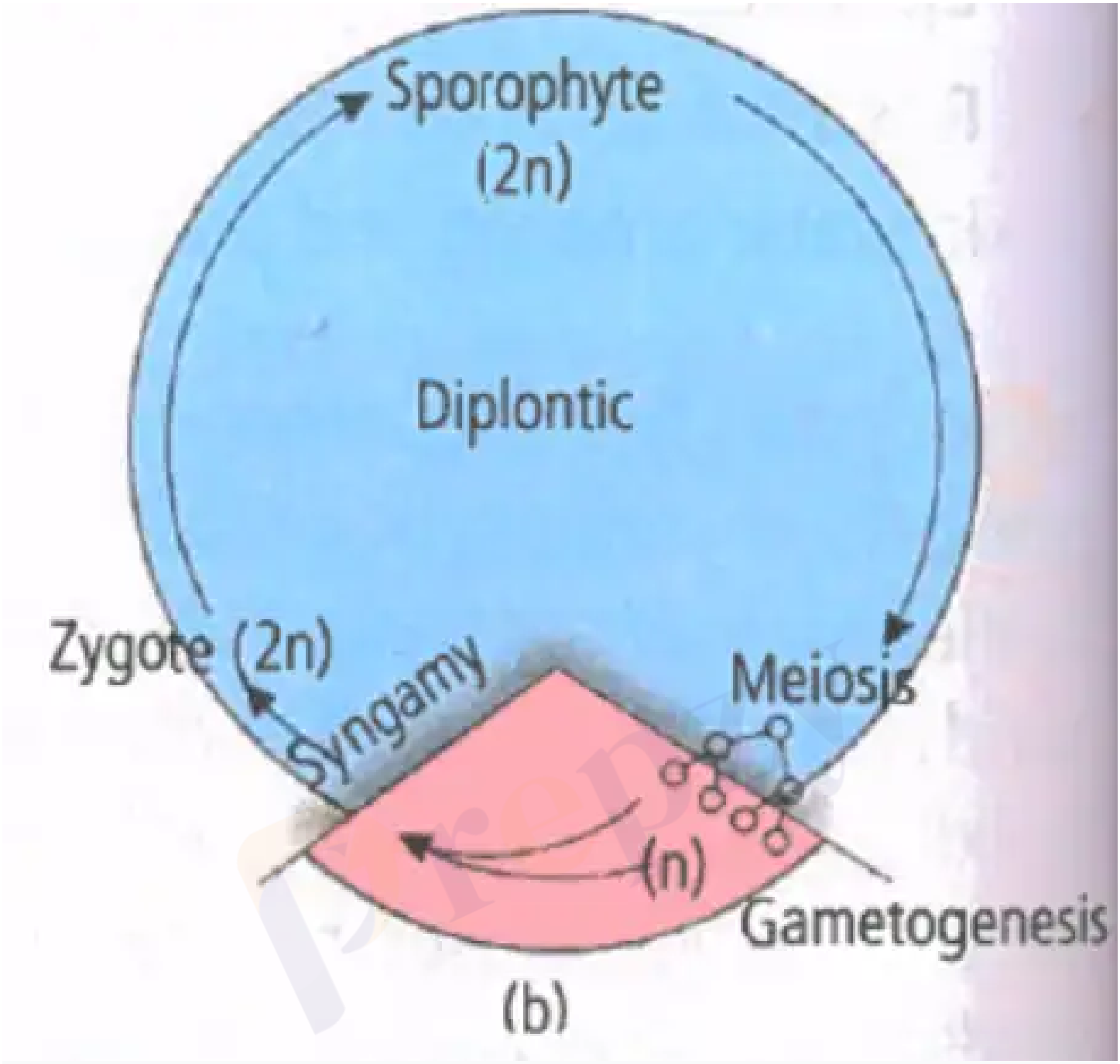
- Occurs in *Fucus*, *Cladophora*, and all seed plants (gymnosperms, angiosperms) with some gametophyte variation.

Memory Aids

- Diplo = diploid phase dominant.
- Gametes are haploid but short-lived.

Quick Checkpoints

- Which phase is dominant in diplontic cycle?
- Where does meiosis occur?
- What is the ploidy of gametes?



Haplodiplontic Life Cycle

Characteristics

- Two distinct multicellular phases: haploid gametophyte and diploid sporophyte.
- Sporophyte (2n) undergoes meiosis to produce haploid spores.
- Haploid spores grow into gametophytes (n).
- Gametophytes produce gametes; gametes fuse to form diploid zygote.
- Clear alternation of generations between gametophyte and sporophyte.
- Occurs in bryophytes, pteridophytes, and some algae like *Dictyota*, *Ectocarpus*, *Polysiphonia*, kelps.

Memory Aids

- Both haploid and diploid phases are multicellular and independent.
- Alternation of generations is clear and distinct.

Quick Checkpoints

- What are the two phases in haplodiplontic cycle?
- Where does meiosis occur?
- Which phase produces gametes?

Prepzy

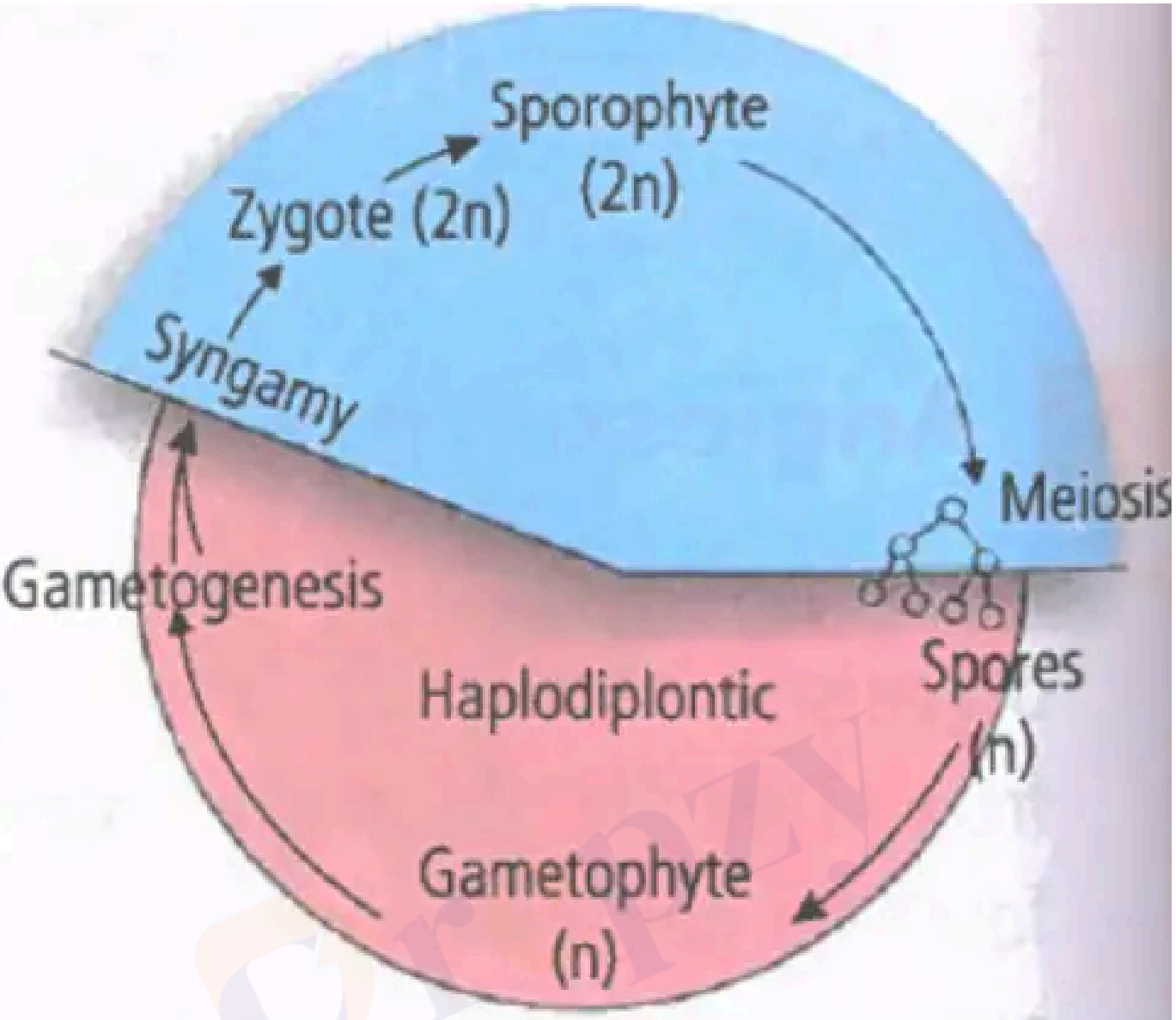


Fig.: Life cycle patterns : (a) Haplontic (b) Diplontic (c) Haplodiplontic