Unit I: Diversity of Living World

Chapter 2

Plant Kingdom

Learning Objectives

The learner will be able to,

- *Outline the classification of plants*
- *Illustrate the life cycles in plants*
- *Recognize the general characteristic features and reproduction of Algae*
- *Recognize the general characteristic features of Bryophytes*
- *Recognize the general characteristic features of Pteridophytes*
- *Describe the general characteristic features of Gymnosperms*
- *Recognize the salient features of Angiosperms*

Chapter Outline

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Traditionally organisms existing on the earth were classified into plants and animals based on nutrition, locomotion and presence or absence of cell wall. Bacteria, Fungi, Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms were included under plant group. Recently, with the aid of molecular characteristics. Bacteria and Fungi were segregated and placed under separate kingdoms. Botany is one of the oldest science in the world because its origin was from time immemorial as early men explored and identified plants for the needs of food, clothing, medicine, shelter etc., Plants are unique living entities as they are endowed with the power to harvest the light energy from the sun and to convert it to chemical energy in the form of food through the astounding reaction, **photosynthesis**. They not only supply nutrients to all living things on earth but sequester carbon-di-oxide during photosynthesis, thus minimizing the effect of one of the major green house gases that increase the global temperature. Plants are diverse in nature, ranging from microscopic algae to macroscopic highly developed angiosperms. There are mysteries and wonders in the plant world in terms of size, shape, habit, habitat, reproduction etc., Although plants are all made up of cells there exists high diversity in form and structure (Table 2.1).

2.1 Classification of Plants

Classification widely accepted for plants now include Embryophyta which is divided into Bryophyta and Tracheophyta. The latter is further divided into Pteridophyta and Spermatophyta (Gymnospermae and Angiospermae). An outline Classification of Plant Kingdom is given in Figure 2.1

2.2 Life Cycle Patterns in Plants

Alternation of Generation

Alternation of generation is common in all plants. Alternation of the haploid

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Table 2.1: Total Number of Plant groups in the World and India		
Plant group	**Number of known species**	
	World#	**India***
Algae	40,000	7,357
Bryophytes	16,236	2,748
Pteridophytes	12,000	1,289
Gymnosperms	1,012	79
Angiosperms	2,68,600	18,386

** Singh, P. and Dash, S.S. 2017-Plants discoveries 2016-New Genera, species and new records, BSI, India.*
 # Chapman, A.D. 2009. Number of living species in Australia and the world 2nd edition. Australian government, Department of environment, water Heritage and Arts.

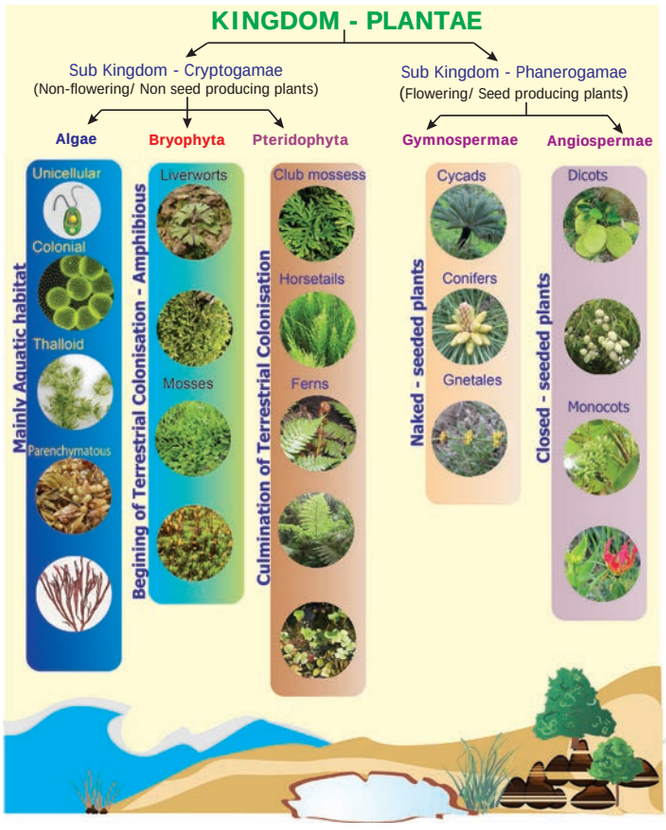

Figure 2.1: Classification of Plant Kingdom

gametophytic phase (n) with diploid sporophytic phase (2n) during the life cycle is called alternation of generation. Following type of life cycles are found in plants (Figure 2.2).

Haplontic Life Cycle

Gametophytic phase is dominant, photosynthetic and independent, whereas sporophytic phase is represented by the zygote. Zygote undergoes meiosis to restore haploid condition. Example: *Volvox*, *Spirogyra*.

Diplontic Life Cycle

Sporophytic phase (2n) is dominant, photosynthetic and independent. The gametophytic phase is represented by the single to few celled gametophyte. The gametes fuse to form zygote which develops into sporophyte. Example: *Fucus,* gymnosperms and angiosperms

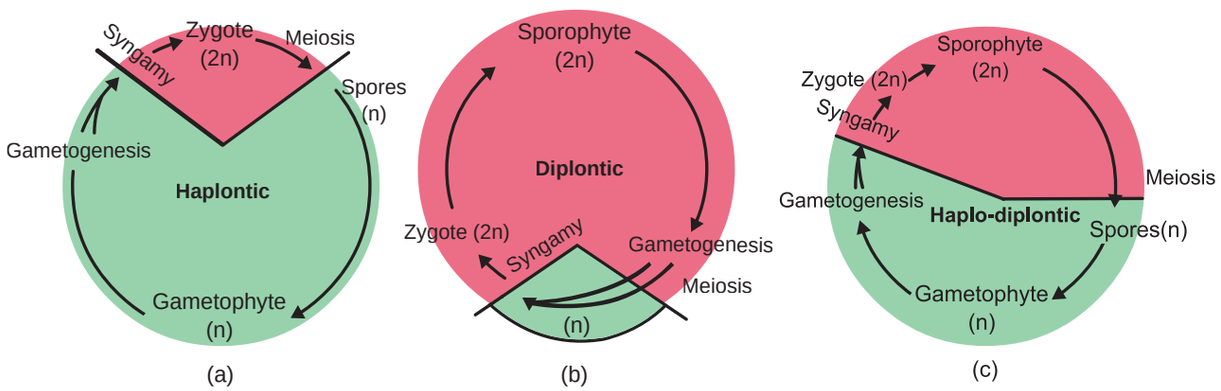

Figure 2.2: Life cycle patterns in plants a) Haplontic, b) Diplontic, c) Haplo-diplontic

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Haplodiplontic Life Cycle

This type of life cycle is found in bryophytes and pteridophytes which is intermediate between haplontic and diplontic type. Both the phases are multicellular. but they differ in their dominant phase.

In bryophytes dominant independent phase is gametophyte and it alternates with short-lived multicellular sporophyte totally or partially dependent on the gametophyte.

In pteridophytes sporophyte is the independent phase. It alternates with multicellular saprophytic or autotrophic, independent, short lived gametophyte(n).

2.3 Algae

Rain brings joy and life to various organisms on earth. Have you noticed some changes in and around you after the rain? Could you identify the reason for the slippery nature of the terrace and green patches on the wall of our home, green colour of puddles and ponds? Why should we clean our water tanks very often? The reason is algae. Algae are simple plants that lack true roots, true stems and true leaves. Two-third of our earth's surface is covered by oceans and seas. The photosynthetic plants called algae are present here. More than half of the total primary productivity of the world depends on this plant group. Further, other aquatic organisms also depend upon them for their existence.

M.O.Parthasarathy (1886-1963) 'Father of Indian Phycology'.

He conducted research on structure, cytology, reproduction and taxonomy of Algae. He published a Monograph on Volvocales. New algal forms like *Fritschiella, Ecballocystopsis, Charasiphon* and *Cylindrocapsopsis*. were reported by him.

Algae are autotrophs, and grow in a wide range of habitats. Majority of them are aquatic, marine (*Gracilaria,* and *Sargassum*) and freshwater (*Oedogonium,* and *Ulothrix*) and also found in soils (*Fritschiella,* and *Vaucheria*). *Chlorella* lead an endozoic life in hydra and sponges whereas *Cladophora crispata* grow on the shells of molluscs. Algae are adapted to thrive in harsh environment too. *Dunaliella salina* grows in salt pans (**Halophytic alga**). Algae growing in snow are called **Cryophytic algae**. *Chlamydomonas nivalis* grow in snow covered mountains and impart red colour to the snow (**Red snow**). A few algae grow on the surface of aquatic plants and are called **epiphytic algae** (*Coleochaete,* and *Rhodymenia*). The study of algae is called **algology** or **phycology**. Some of the eminent algologists include F.E. Fritsch, F.E. Round, R.E. Lee, M.O.Parthasarathy Iyengar, M.S. Randhawa, Y. Bharadwaja, V.S. Sundaralingam and T.V.Desikachary.

2.3.1 General Characteristic features

The algae show a great diversity in size, shape and structure. A wide range of thallus organisation is found in algae. Unicellular motile (*Chlamydomonas*), unicellular non-motile (*Chlorella*), Colonial motile (*Volvox*), Colonial non motile (*Hydrodictyon*), siphonous (*Vaucheria*), unbranched filamentous (*Spirogyra*), branched filamentous (*Cladophora*), discoid (*Coleochaete*) heterotrichous (*Fritschiella*), Foliaceous (*Ulva*) to giant kelps (*Laminaria* and *Macrocystis*). The thallus organization in algae is given in Figure 2.3.

Algae are eukaryotes except blue green algae. The plant body does not show differentiation into tissue systems. The cell wall of algae is made up of cellulose and hemicellulose. Siliceous walls are present in diatoms. In *Chara* the thallus is encrusted with calcium carbonate. Some algae possess algin, polysulphate esters of polysaccharides which are the sources for the alginate, agar agar and carrageenan. The cell has a

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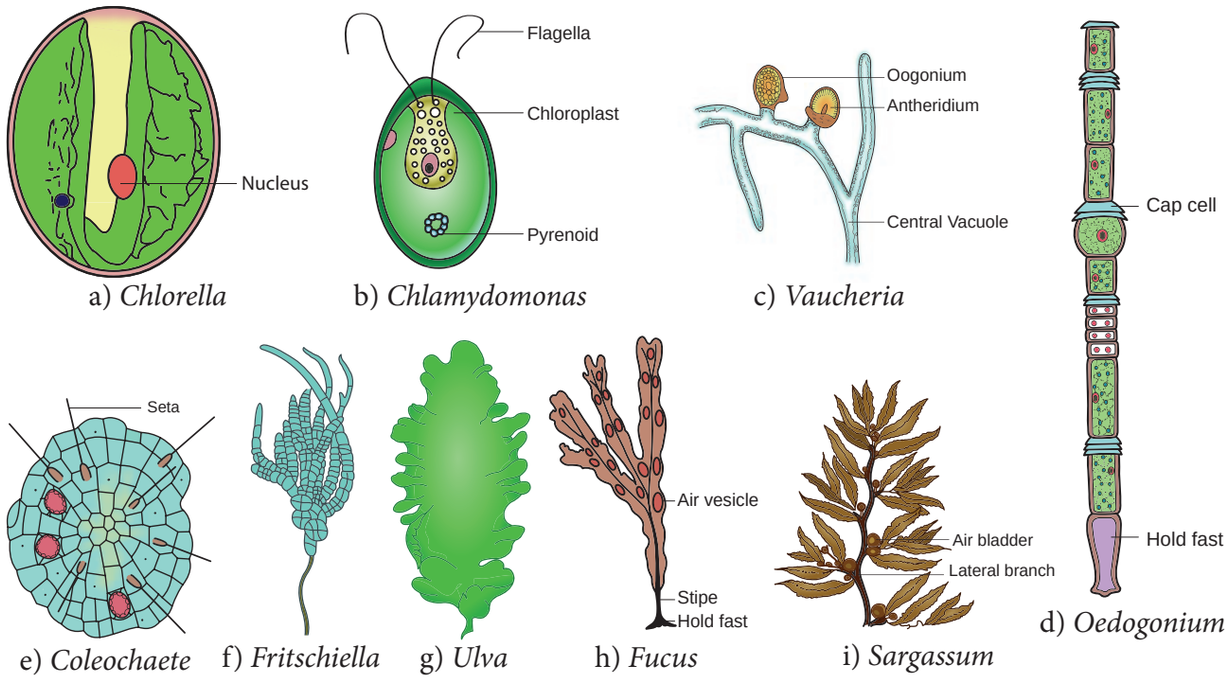
membrane bound nucleus and cell organelles like chloroplast, mitochondria, endoplasmic reticulum, golgi bodies etc., Pyrenoids are present. They are proteinaceous bodies found in chromatophores and assist in the synthesis and storage of starch. The pigmentation, reserve food material and flagellation differ among the algal groups.

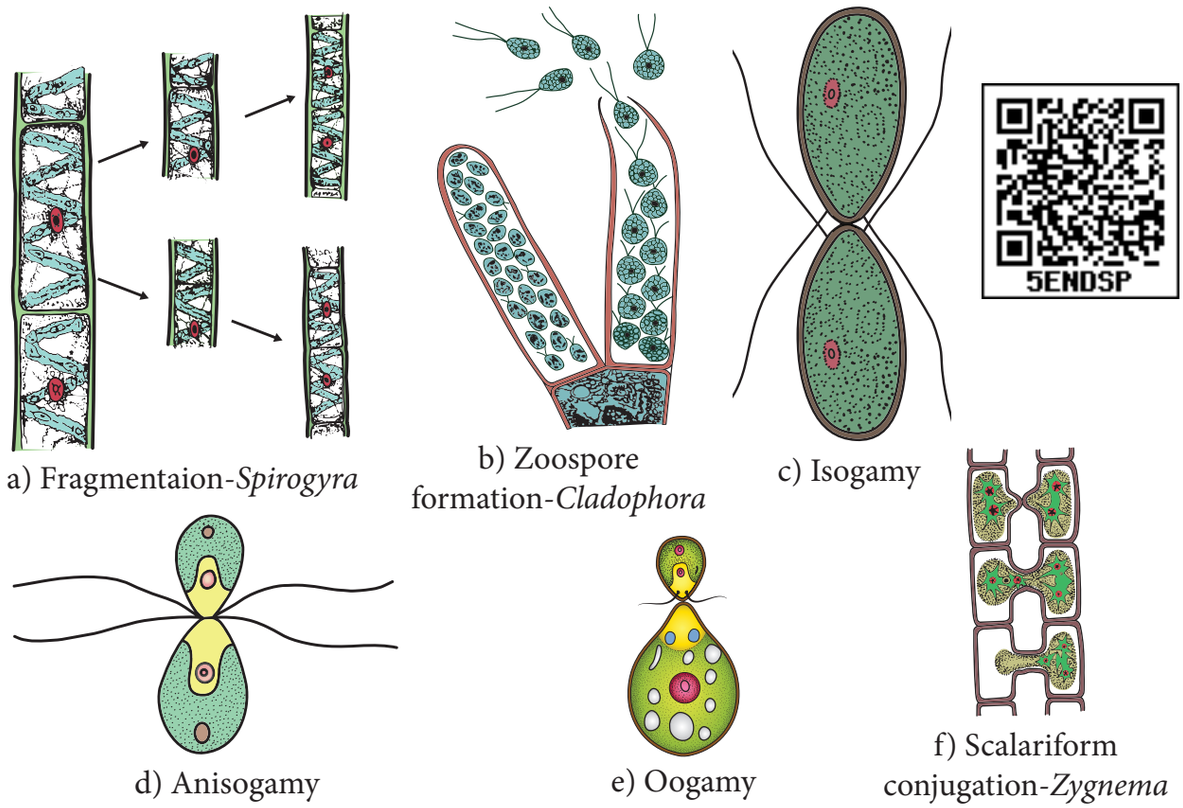
Algae reproduces by vegetative, asexual and sexual methods (Figure 2.4). Vegetative reproduction includes fission (In unicellular forms the cell divides mitotically to produce



a) *Chlorella* b) *Chlamydomonas* c) *Vaucheria* d) *Oedogonium*

e) *Coleochaete* f) *Fritschiella* g) *Ulva* h) *Fucus* i) *Sargassum*

Figure 2.3: Thallus organization in Algae



a) Fragmentaion-*Spirogyra* b) Zoospore formation-*Cladophora* c) Isogamy

d) Anisogamy e) Oogamy f) Scalariform conjugation-*Zygnema*

Figure 2.4: Reproduction in Algae

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two daughter cells Example: *Chlamydomonas)*; Fragmentation (fragments of parent thallus grow into new individual Example: *Ulothrix*) budding (A lateral bud is formed in some members like *Protosiphon* and helps in reproduction) bulbils, (a wedge shaped modified branch develop in *Sphacelaria*) akinetes (Thick walled spores meant for perennation and germinates with the advent of favourable condition Example: *Pithophora*) and Tubers (Structures found on the rhizoids and the lower nodes of *Chara* which store food materials).

Asexual reproduction takes place by the production of zoospores motile spores (*Ulothrix, Oedogonium*) aplanospore (thin walled non motile spores Example: *Vaucheria*); autospores (spores which look similar to parent cell Example: *Chlorella*); hypnospore (thick walled aplanospore – Example: *Chlamydomonas nivalis*) and Tetraspores (Diploid thallus of *Polysiphonia* produce haploid spores after meiosis).

Sexual reproduction in algae is of three types 1. Isogamy (Fusion of morphologically and Physiologically similar gametes Example: *Ulothrix*) 2. Anisogamy (Fusion of either morphologically or physiologically dissimilar gametes Example: *Pandorina*) 3. Oogamy (Fusion of both morphologically and physiologically dissimilar gametes. Example: *Sargassum*). The life cycle shows distinct alternation of generation.

The Oldest recorded alga is Grypania, which was discovered in the banded iron formations of northern Michigan and dated to approximately 2100Ma

2.3.2. Classification

F.E. Fritsch proposed a classification for algae based on pigmentation, types of flagella, reserve food materials, thallus structure and reproduction. He published his classification in the book "The structure and reproduction of the Algae"(1935). He classified algae into 11 classes namely Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenophyceae, Phaeophyceae, Rhodophyceae, Cyanophyceae.

The salient features of Chlorophyceae, Phaeophyceae and Rhodophyceae are given below.

Chlorophyceae

The members are commonly called **'Green algae'**. Most of the species are aquatic(Fresh water-*Spirogyra*, Marine -*Ulva*). A few are terrestrial(*Trentipohlia*). Variation among the shape of the chloroplast is found in members of algae. It is cup shaped (*Chlamydomonas*), discoid (*Chara*), girdle shaped, (*Ulothrix*), reticulate (*Oedogonium*), spiral (*Spirogyra*), stellate (*Zygnema*) and plate like (*Mougeoutia*).

Chlorophyll 'a' and Chlorophyll 'b' are the major photosynthetic pigments. Storage bodies called pyrenoids are present in the chloroplast and store starch. They also contain proteins. The cell wall is made up of inner layer of cellulose and outer layer of pectin. Vegetative reproduction takes place by means of fragmentation and asexual reproduction is by the production of zoospores, aplanospores and akinetes. Sexual reproduction is present and may be isogamous, anisogamous or oogamous. Examples for this group of algae includes *Chlorella, Chlamydomonas, Volvox, Spirogyra, Ulothrix, Chara* and *Ulva.*

Phaeophyceae

The members of this class are called **'Brown algae'**. Majority of the forms are found in marine habitats. *Pleurocladia* is a fresh water form. The thallus is filamentous (*Ectocarpus*) frond like (*Dictyota*)or may be giant kelps (*Laminaria* and *Macrocystis*). The thallus is differentiated into leaf like photosynthetic

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part called fronds, a stalk like structure called stipe and a holdfast which attach thallus to the substratum.

The Pigments include Chlorophyll a, c, Carotenoids and Xanthophylls. A golden brown pigment called fucoxanthin is present and it gives shades of colour from olive green to brown to the algal members of this group. Mannitol and Laminarin are the reserve food materials. Motile reproductive structures are present. Two laterally inserted unequal flagella are present. Among these one is whiplash and another is tinsel. Although sexual reproduction ranges from isogamy to oogamy, Most of the forms show oogamous type. Alternation of generation is present (isomorphic, heteromorphic or diplontic). Examples for this group include *Sargassum, Laminaria, Fucus* and *Dictyota.*

Rhodophyceae

Members of this group include '**Red algae**' and are mostly marine. The thallus is multicellular, macroscopic and diverse in form. *Porphyridium* is the unicellular form. Filamentous (*Goniotrichum*) ribbon like (*Porphyra*) are also present. *Corallina* and *Lithothamnion* are heavily impregnated with lime and form coral reefs. Apart from chlorophyll a, r-phycoerythrin and r-phycocyanin are the photosynthetic pigments. Asexual reproduction takes place by means of monospores, neutral spores and tetraspores.

The storage product is floridean starch. Sexual reproduction is oogamous. Male sex organ is spermatangium which produces spermatium. Female sex organ is called carpogonium. The spermatium is carried by the water currents and fuse with egg nucleus to form zygote. The zygote develops into carpospores. Meiosis occurs during carpospore formation. Alternation of generation is present. Examples for this group of algae include *Ceramium, Polysiphonia, Gelidium, Cryptonemia* and *Gigartina.*

2.3.3 Economic Importance

The Economic importance of Algae is given in Table 2.2

Table 2.2: Economic importance of Algae

Name of the Algae	Economic importance
Beneficial activities	
Chlorella, Laminaria, Sargassum, Ulva, Enteromorpha	Food
Gracilaria, Gelidiella, Gigartina	Agar Agar – Cell wall material used for media preparation in the microbiology lab. Packing canned food, cosmetic, textile paper industry
Chondrus crispus	Carrageenan – Preparation of tooth paste, paint, blood coagulant
Laminaria, Ascophyllum	Alginate – ice cream, paints, flame proof fabrics
Laminaria, Sargassum, Ascophyllum, Fucus	Fodder
Diatom (Siliceous frustules)	Diatomaceous earth– water filters, insulation material, reinforcing agent in concrete and rubber.
Lithophyllum, Chara, Fucus	Fertilizer
Chlorella	Chlorellin -Antibiotic
Chlorella, Scenedesmus, Chlamydomonas	Sewage treatment, Pollution indicators
Harmful activity	
Cephaleuros virescens	Red rust of coffee

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DO YOU KNOW?

A green alga *Botryococcus braunii* is employed in Bio-fuel production.

Algae in Health care

Kelps are the rich source of Iodine *Chlorella* is used as single cell Protein (SCP).

Dunaliella salina an alga, growing in salt pan is complement to our health and provide β carotene.

DO YOU KNOW?

A Productive Cultivation in Sea

Algae like *Kappaphycus alvarezii, Gracilaria edulis* and *Gelidiella acerosa* are commercially grown in the sea for harvesting the phycocolloids.

Sea Palm It is *Postelia palmaeformis* a brown alga.

2.4 Bryophytes

Amphibians of Plant Kingdom

In the previous chapter, we noticed a wide range of thallus organization in Algae. Majority of them are aquatic. The development of heterotrichous habit, development of parenchyma tissue and dichotomous branching in some algae supports the view that colonization of plants in land occurred in the past. Bryophytes are simplest and most primitive plant groups descended from alga – like ancestors. They are simple embryophytes. Let us learn about the structure and reproduction of these primitive land plants called Bryophytes in detail.

Bryophytes are simplest land inhabiting cryptogams and are restricted to moist, shady habitats. They lack vascular tissue and hence called **'Non- vascular cryptogams'**. They are also called as **'amphibians of plant kingdom'** because they need water for completing their life cycle.

Shiv Ram Kashyap (1882-1934)

Father of Indian Bryology. He published a book- 'Liverworts of Western Himalayas and Punjab Plains' He identified new genera like *Atchinsoniella, Sauchia, Sewardiella* and *Stephansoniella.*

2.4.1 General characteristic features

- The plant body of bryophyte is gametophyte and is not differentiated into root, stem and leaf like structure.
- Most of them are primitive land dwellers. Some of them are aquatic (*Riella, Ricciocarpus*).
- The gametophyte is conspicuous, long lived phase of the life cycle. Thalloid forms are present in liverworts and Hornworts. In Mosses leaf like, stem like structures are present. In Liverworts thallus grows prostrate on the ground and is attached to the substratum by means of rhizoids. Two types of rhizoids are present namely smooth walled and pegged or tuberculate. Multicellular scales are also present. In Moss the plant body is erect with central axis bearing leaf like expansions. Multicellular rhizoids are present. The structure and reproduction in Bryophytes is given in Figure 2.5.
- Vascular tissue like xylem and phloem are completely absent, hence called 'Non vascular cryptogams'.
- Vegetative reproduction takes place by the formation of adventitious buds (*Riccia fluitans*) tubers develop in *Anthoceros.* In some forms small detachable branches

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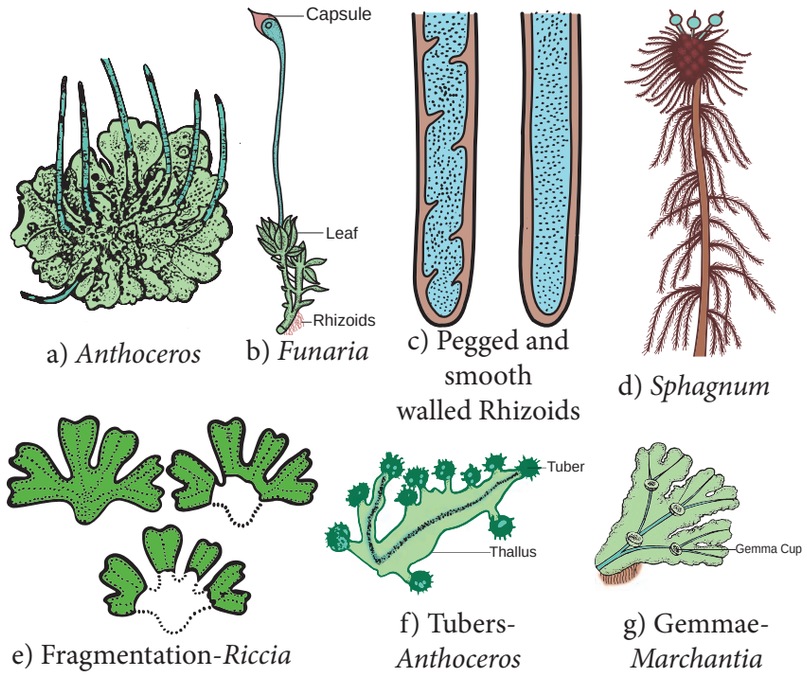

a) *Anthoceros* b) *Funaria* c) Pegged and smooth walled Rhizoids d) *Sphagnum*

e) Fragmentation-*Riccia* f) Tubers-*Anthoceros* g) Gemmae-*Marchantia*

Figure 2.5: Structure and reproduction in Bryophytes

or brood bodies are formed, they help in vegetative reproduction as in *Bryopteris fruticulosa*. In *Marchantia* propagative organs called gemmae are formed and help in reproduction.

- Sexual reproduction is oogamous. Antheridia and Archegonia are produced in a protective covering and are multicellular.
- The antheridia produces biflagellate antherozoids which swims in thin film of water and reach the archegonium and fuse with the egg to form diploid zygote.
- Water is essential for fertilization.
- The zygote is the first cell of the sporophyte generation. It undergoes mitotic division to form multicellular undifferentiated embryo. The embryogeny is exoscopic (the first division of the zygote is transverse and the apex of the embryo develops from the outer cell). The embryo divides and give rise to sporophyte.
- The sporophyte is dependent on gametophyte.
- It is differentiated into three recognizable parts namely foot, seta and capsule.
- Foot is the basal portion and is embedded in the gametophyte through which water and nutrients are supplied for the sporophyte. The diploid spore mother cells found in the capsule region undergoes meiotic division and give rise to haploid spores. Bryophytes are homosporous. In some sporophytes elaters are present and help in dispersal of spores (Example: *Marchantia*). The spores germinate to produce gametophyte.
- The zygote, embryo and the sporogonium constitute sporophytic phase. The green long living haploid phase is called gametophytic phase. The haploid gametophytic phase alternates with diploid sporophyte and shows heterologous alternation of generation.

Proskauer in the year 1957 classified Bryophytes into 3 Classes namely

i. **Hepaticopsida** (*Riccia, Marchantia, Porella* and *Riella*)

ii. **Anthocerotopsida** (*Anthoceros* and *Dendroceros*)

iii. **Bryopsida** (*Funaria, Polytrichum* and *Sphagnum*).

2.4.2 Economic importance

Dead thalli of *Sphagnum* gets accumulated and compressed, hardened to form peat. In northern Europe (Netherlands)peat is used as fuel in commercial scale. Apart from this nitrates, brown dye and tanning materials are derived from peat. *Sphagnum*

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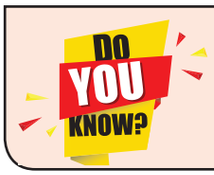
and peat are also used in horticulture as packing material because of their water holding capacity. *Marchantia polymorpha* is used to cure pulmonary tuberculosis. *Sphagnum*, *Bryum* and *Polytrichum* are used as food. Bryophytes play a major role in soil formation through succession and help in soil conservation.



Buxbaumia aphylla and *Cryptothallus mirabilis* are saprophytic bryophytes

2.5 Pteridophytes

Seedless Vascular Cryptogams

From the previous section, we are aware of the salient features of amphibious plants called bryophytes. But there is a plant group called pteridophytes which are considered as first true land plants. Further, they were the first plants to acquire vascular tissue namely xylem and phloem, hence called vascular cryptogams. Club moss, horsetails, quill worts, water ferns and tree ferns belong to this group. This chapter deals with the characteristic features of Pteridophytes.

Pteridophytes are the vascular cryptogams and were abundant in the Devonian period of Palaeozoic era (400 million years ago). These plants are mostly small, herbaceous and grow well in moist, cool and shady places where water is available. The photographs for some pteridophytes are given in Figure 2.6.


a) *Lycopodium* (club moss)


b) *Equisetum* (Horse tail)


c) *Azolla* (Water fern)

Figure 2.6: Pteridophytes

2.5.1 General characteristic features of Pteridophytes:

- Plant body is sporophyte (2n) and it is the dominant phase. It is differentiated into root, stem and leaves.
- Roots are adventitious.
- Stem shows monopodial or dichotomous branching.
- Leaves may be microphyllous or megaphyllous.
- Stele is protostele but in some forms siphonostele is present (*Marsilea*)
- Tracheids are the major water conducting elements but in *Selaginella* vessels are found.
- Sporangia, spore bearing bag like structures are borne on special leaves called sporophyll. The Sporophylls get organized to form cone or strobilus. Example: *Selaginella*, *Equisetum* .
- They may be **homosporous** (produce one type of spores-*Lycopodium*) or **Heterosporous** (produce two types of spores-*Selaginella)*. Heterospory is the origin for seed habit.
- Development of sporangia may be **eusporangiate** (development of sporangium from group of initials) or **leptosporangiate** (development of sporangium from single initial).
- Spore mother cells undergo meiosis and produce spores (n).
- Spore germinates to produce haploid, multicellular green, cordate shaped independent gametophytes called prothallus.
- Fragmentation, resting buds, root tubers and adventitious buds help in vegetative reproduction.
- Sexual reproduction is oogamous. Sex organs, namely antheridium and archegonium are produced on the prothallus.
- Antheridium produces spirally coiled and multiflagellate antherozoids.
- Archegonium is flask shaped with broad venter and elongated narrow neck. The

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venter possesses egg or ovum and neck contain neck canal cells.

- Water is essential for fertilization. After fertilization a diploid zygote is formed and undergoes mitotic division to form embryo.
- Pteridophytes show **apogamy** and **apospory.**

Reimer (1954) proposed a classification for pteridophytes. In this classification, the pteridophytes are divided into five subdivisions. 1. Psilophytopsida 2. Psilotopsida 3. Lycopsida 4. Sphenopsida 5. Pteropsida. There are 19 orders and 48 families in the classification.

The success and dominance of vascular plants is due to the development of

- Extensive root system.
- Efficient conducting tissues.
- Cuticle to prevent desiccation.
- Stomata for effective gaseous exchange.

2.5.2 Economic Importance

The Economic importance of Pteridophyte is given in Table 2.3.

Table 2.3: Economic importance of Pteridophyte

Pteridophyte	Uses
Rumohra adiantiformis (leather leaf fern)	Cut flower arrangements.
Marsilea	Food
Azolla	Biofertilizer.
Dryopteris filix–mas	Treatment for tapeworm.
Pteris vittata	Removal of heavy metals from soils - Bioremediation
Pteridium sp.	Leaves yield green dye.
Equisetum sp.	Stems for scouring.
Psilotum, Lycopodium, Selaginella, Angiopteris, Marattia	Ornamental plants

2.5.3 Types of Stele

The term stele refers to the central cylinder of vascular tissues consisting of xylem, phloem, pericycle and sometimes medullary rays with pith (Figure 2.7).

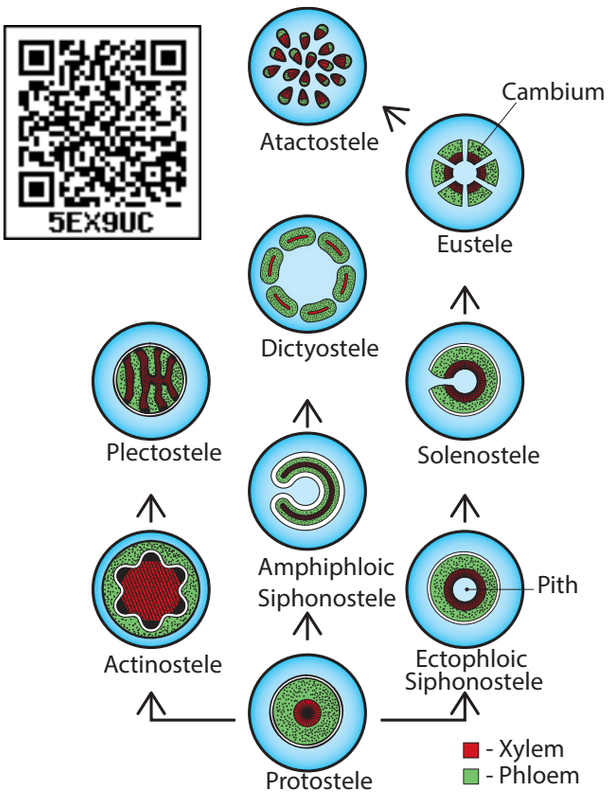

Figure 2.7: Types of Stele

There are two types of steles

1. Protostele 2. Siphonostele

1. Protostele:

In protostele phloem surrounds xylem. The type includes Haplostele, Actinostele, Plectostele, and Mixed protostele.

(i) **Haplostele**: Xylem surrounded by phloem is known as haplostele. Example: *Selaginella.*

(ii) **Actinostele**: Star shaped xylem core is surrounded by phloem is known as actinostele. Example: *Lycopodium serratum.*

(iii) **Plectostele**: Xylem plates alternates with phloem plates. Example: *Lycopodium clavatum.*

(iv) **Mixed prototostele**: Xylem groups uniformly scattered in the phloem. Example: *Lycopodium cernuum.*

2. Siphonostele:

In siphonostele xylem is surrounded by phloem with pith at the centre. It includes Ectophloic siphonostele, Amphiphloic siphonostele, Solenostele, Eustele, Atactostele and Polycylic stele.

(i) Ectophloic siphonostele: The phloem is restricted only on the external side of the xylem. Pith is in centre. Example: *Osmunda.*

(ii) Amphiphloic siphonostele: The phloem is present on both the sides of xylem. The pith is in the centre. Example: *Marsilea*.

(iii) Solenostele: The stele is perforated at a place or places corresponding the origin of the leaf trace.

(a) Ectophloic solenostele – Pith is in the centre and the xylem is surrounded by phloem Example *Osmunda*.

(b) Amphiphloic solenostele – Pith is in the centre and the phloem is present on both sides of the xylem. Example: *Adiantum pedatum*.

(c) Dictyostele – The stele is separated into several vascular strands and each one is called meristele. Example: *Adiantum capillus-veneris*.

(iv) Eustele: The stele is split into distinct collateral vascular bundles around the pith. Example: Dicot stem.

(v) Atactostele: The stele is split into distinct collateral vascular bundles and are scattered in the ground tissue. Example: Monocot stem.

(vi) Polycyclicstele: The vascular tissues are present in the form of two or more concentric cylinders. Example: *Pteridium*.

2.6 Gymnosperms

Naked seed producing Plants

Michael Crichton's Science Fiction is a book transformed into a Film of Steven Spielberg (1993) called **Jurassic Park**. In this film you might have noticed insects embedded in a transparent substance called amber which preserves the extinct forms. What is amber? Which group of plants produces Amber?

Amber is a plant secretion which is an efficient preservative that doesn't get degraded and hence can preserve remains of extinct life forms. The amber is produced by ***Pinites succinifera***, a Gymnosperm.

In this chapter we shall discuss in detail about one group of seed producing plants called **Gymnosperms**.

Gymnosperms (Gr. Gymnos = naked; sperma= seed) are naked seed producing plants. They were dominant in the Jurassic and Cretaceous periods of Mesozoic era. The members are distributed throughout the temperate and tropical region of the world

2.6.1 General characteristic features

- Most of the gymnosperms are evergreen, woody trees or shrubs. Some are lianas (*Gnetum*)
- The plant body is sporophyte and is differentiated into root, stem and leaves.
- A well developed tap root system is present. Coralloid roots of *Cycas* have symbiotic association with blue green algae. In *Pinus* the roots have mycorrhizae.
- The stem is aerial, erect and branched or unbranched (*Cycas*) with leaf scars.
- In conifers two types of branches namely branches of limited growth (Dwarf shoot) and Branches of unlimited growth (Long shoot) is present.
- Leaves are dimorphic, foliage and scale leaves are present. Foliage leaves are green, photosynthetic and borne on

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branches of limited growth. They show xerophytic features.

- The xylem consists of tracheids but in *Gnetum* and *Ephedra* vessels are present.
- Secondary growth is present. The wood may be **Manoxylic** (Porous, soft, more parenchyma with wide medullary ray -*Cycas*) or **Pycnoxylic** (compact with narrow medullary ray-*Pinus*).
- They are heterosporous. The plant may be monoecious (*Pinus*) or dioecious (*Cycas*).
- Microsporangia and megasporangia are produced on microsporophyll and megasporophyll respectively.
- Male and female cones are produced.
- Anemophilous pollination is present.
- Fertilization is siphonogamous and pollen tube helps in the transfer of male nuclei.
- Polyembryony (presence of many embryo) is present. The naked ovule develops into seed. The **endosperm** is haploid and develop before fertilization.
- The life cycle shows alternation of generation. The sporophytic phase is dominant and gametophytic phase is highly reduced. The photograph of some of the gymnosperms is given in Figure 2.8

Sporne (1965) classified gymnosperms into 3 classes, 9 orders and 31 families. The classes include i) Cycadospsida ii) Coniferopsida iii) Gnetopsida.

a) *Taxus* b) *Ginkgo*

Figure 2.8: Gymnosperms

2.6.2 Comparison of Gymnosperm with Angiosperms

Gymnosperms resemble with angiosperms in the following features

- Presence of well organised plant body which is differentiated into roots, stem and leaves.
- Presence of cambium in gymnosperms as in dicotyledons.
- Flowers in *Gnetum* resemble the male flower of the angiosperm. The zygote represent the first cell of sporophyte.
- Presence of integument around the ovule.
- Both plant groups produce seeds.
- Pollen tube helps in the transfer of male nucleus in both.
- Presence of eustele.

The difference between Gymnosperms and Angiosperms were given in Table 2.4.

Table 2.4: Difference between Gymnosperms and Angiosperms

S.No	Gymnosperms	Angiosperms
1.	Vessels are absent [except Gnetales]	Vessels are present
2.	Phloem lacks companion cells	Companion cells are present
3.	Ovules are naked	Ovules are enclosed within the ovary
4.	Wind pollination only	Insects, wind, water, animals etc., act as pollinating agents
5.	Double fertilization is absent	Double fertilization is present
6.	Endosperm is haploid	Endosperm is triploid
7.	Fruit formation is absent	Fruit formation is present
8.	Flowers absent	Flowers present

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2.6.3 Economic importance of Gymnosperms

Table 2.5: Economic importance of Gymnosperms

S.No	Plants	Products	uses
1.	*Cycas circinalis, Cycas revoluta*	Sago	Starch used as food
2.	*Pinus gerardiana*	Roasted seed	Used as a food
3.	*Abies balsamea*	Resin (Canada balsam)	Used as mounting medium in permanent slide preparation
4.	*Pinus insularis, Pinus roxburghii*	Rosin and Turpentine	Paper sizing and varnishes
5.	*Araucaria* (Monkey's puzzle), *Picea* and *Phyllocladus*	Tannins	Bark yield tannins and is used in Leather industries
6.	*Taxus brevifolia*	Taxol	Drug used for cancer treatment
7.	*Ephedra gerardiana*	Ephedrine	For the treatment of asthma, bronchititis
8.	*Pinus roxburghii*	Oleoresin	Used to make soap, varnishes and printing ink
9.	*Pinus roxburghii, Picea smithiana*	Wood pulp	Used to make papers
10.	*Cedrus deodara*	wood	Used to make doors, boats and railway sleepers
11.	*Cedrus atlantica*	oil	Used in perfumery
12	*Thuja, Cupressus, Araucaria, and Cryptomeria*	whole plant	Ornamental plants/Floral Decoration

Palaeobotany in India

The National wood fossil park is situated in Tiruvakkarai, a Village of Villupuram district of Tamil Nadu. The park contains petrified wood fossils approximately 20 million years old. The term 'form genera' is used to name the fossil plants because the whole plant is not recovered as fossils instead organs or parts of the extinct plants are obtained in fragments. Shiwalik fossil park-Himachal Pradesh, Mandla Fossil park-Madhya Pradesh, Rajmahal Hills–Jharkhand, Ariyalur – Tamilnadu are some of the fossil rich sites of India.

Some of the fossil representatives of different plant groups are given below

Fossil Algae - *Palaeoporella*, *Dimorphosiphon*

Fossil Bryophytes – *Naiadita, Hepaticites, Muscites*

Fossil Pteridophytes – *Cooksonia, Rhynia,, Baragwanthia, Calamites*

Fossil Gymnosperms – *Medullosa, Lepido-carpon, Williamsonia, Lepidodendron*

Fossil Angiosperms – *Archaeanthus, Furcula*

Prof. Birbal Sahni (1891-1949)

Father of Indian Palaeobotany. He described Fossil plants from Rajmahal Hills of Eastern Bihar. *Pentoxylon sahnii*, *Nipanioxylon* are some of the form genera described by him. Birbal Sahni Institute of Palaebotany is located in Lucknow.

2.7 Angiosperms

In the previous section, the characteristic features of one of the spermatophyte called Gymnosperms were

discussed. Spermatophytes also include plants bearing ovules enclosed in a protective cover called ovary, such plants are called Angiosperms. They constitute major plant group of our earth and are adapted to the terrestrial mode of life. This group of plants appeared during the early cretaceous period (140 million years ago) and dominates the vegetation on a global scale. The sporophyte is the dominant phase and gametophyte is highly reduced.

2.7.1 Salient features of Angiosperms

- Vascular tissue (Xylem and Phloem) is well developed.
- Flowers are produced instead of cone
- The Ovule remains enclosed in the ovary.
- Pollen tube helps in fertilization, so water is not essential for fertilization.
- Double fertilization is present. The endosperm is triploid.
- Angiosperms are broadly classified into two classes namely Dicotyledons and Monocotyledons.

2.7.2 Characteristic features of Dicotyledons and Monocotyledons

Dicotyledons

Morphological features

Reticulate venation is present in the leaves. Presence of two cotyledons in the seed. Primary root radicle persists as tap root.

Flowers tetramerous or pentamerous.

Tricolpate (3 furrow) pollen is present.

Anatomical features

- Vascular bundles are arranged in the form of a ring in stem.
- Vascular bundles are open (Cambium present).
- Secondary growth is present.

Monocotyledons

Morphological features

Parallel venation is present in the leaves. Presence of single cotyledon in the seed. Radicle doesn't persist and fibrous root is present.

Flowers trimerous.

Monocolpate (1 furrow) Pollen is present.

Anatomical features

- Vascular bundles are scattered in the stem
- Vascular bundles are closed (Cambium absent).
- Secondary growth is absent.

Current Angiosperm Phylogeny Group (APG) System of classification doesn't recognize dicots as a monophyletic group. Plants that are traditionally classified under dicots are dispersed in several clades such as early Magnolids and Eudicots.

Summary

Plant Kingdom includes Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms

The life cycle in plants fall under three types 1. Haplontic,2. Diplontic and 3. Haplodiplontic

Algae are autotrophic, chlorophyll bearing organisms. The Plant body is not differentiated into root like, stem like or leaf like structures. A wide range of thallus organization is found in algae. They reproduce vegetatively through fragmentation, tuber and akinete formation. Zoospores, autospores and hypnospores are produced during asexual reproduction and sexual reproduction occurs through isogamy, anisogamy and oogamy.

Bryophytes are the simplest land plants. They are called amphibians of plant kingdom or nonvascular cryptogams. The plant body is gametophyte. The sporophyte depends upon gametophyte. Conducting tissues like xylem and phloem is absent. Vegetative reproduction takes place through fragmentation, formation of adventitious bud and gemmae. Sexual reproduction is oogamous. Water is essential for fertilization.

Pteridophytes are also called vascular cryptogams. The plant body is sporophyte

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and is long lived, which is differentiated into root, stem and leaves. They may be homosporous or heterosporous. The sporangia with spores are found in sporophylls. The sporophylls organise to form cones or strobilus. The spores germinates to produce haploid, multicellular heart shaped independent gametophyte called prothallus. Sexual reproduction is oogamous. The life cycle shows alternation of generation.

The term stele includes central cylinder of vascular tissues comprising xylem, phloem, pericycle, endodermis and pith . There are two major types of stele namely protostele and siphonostele.

Gymnosperms are naked seed producing plants. The plant body is sporophyte and it is the dominant phase. Coralloid roots are found in *Cycas*. The roots of *Pinus* possess mycorrhizal association. Two types of branches called long shoot and dwarf shoot are present. Stem shows secondary growth. Spores are produced in cones. Pollen tube helps in fertilization. The endosperm is haploid. Alternation of generation is present

Angiosperms are highly evolved plant group and their ovules remain enclosed in an ovary. A wide range of habit is present. These include trees, shrubs, herbs, climbers, lianas. Double fertilization is present. The endosperm is triploid. They are classified into dicotyledons and monocotyledons.

Evaluation

1. Which of the plant group has gametophyte as a dominant phase?
   a. Pteridophytes
   b. Bryophytes
   c. Gymnosperm
   d. Angiosperm
2. Which of following represents gametophytic generation in pteridophytes?
   a. Prothallus
   b. Thallus
   c. Cone
   d. Rhizophore
3. The haploid number of chromosome for an angiosperm is 14, the number of chromosome in its endosperm would be
   a. 7 b. 14 c. 42 d. 28
4. Endosperm in gymnosperm is formed
   a. At the time of fertilization
   b. Before fertilization
   c. After fertilization
   d. Along with the development of embryo
5. Differentiate halpontic and diplontic life cycle.
6. What is plectostele? give example.
7. What do you infer from the term pycnoxylic?
8. Mention two characters shared by gymnosperms and angiosperms.
9. Do you think shape of chloroplast is unique for algae. Justify your answer?
10. Do you agree with the statement 'Bryophytes need water for fertilization'? Justify your answer.

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ICT Corner

Different forms of plants

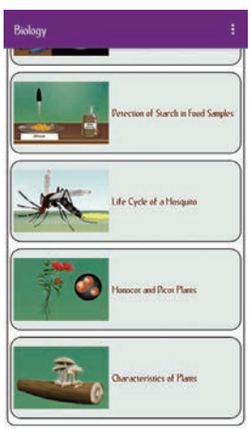
Is all the **plants** are same?

Steps

- Scan the QR code or go to google play store
- Type online labs and install it.
- Select biology and select Characteristics of plants
- Click theory to know the basic about Characteristics of plants
- Register yourself with mail-id and create password to access online lab simulations

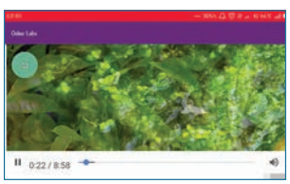
Activity

- Select video and record your observations of different forms of plant group.



Step 1

Step 2



Step 3

Step 4

URL:

https://play.google.com/store/apps/details?id=in.edu.olabs.olabs&hl=en

Alternate web:

http://www.phschool.com/atschool/phbio/active_art/plant_life_cycle/plantlifecycle.swf

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* Pictures are indicative only

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