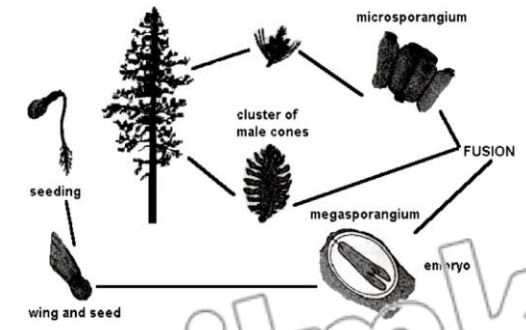


Chapter 9
Kingdom Plantae

9.1 CLASSIFICATION OF PLANTAE

For the sake of convenience organisms included in Plantae can be divided into two broad categories i.e. non-vascular (Bryophyta) and vascular (Tracheophyta) plants. Although this grouping is not according to any specific system of classification but it does reflect similarities and dissimilarities among various groups of plants. Each category is divided into sub-divisions, classes, sub-classes and other taxonomic ranks.

Divison: Bryophyta – (Non-Vascular Plants)		**Common Name**
Sub Division	Hepaticopsida	Liverworts
Sub Division	Musci Bryopsida	Mosses
Sub Division	Anthoceropsida	Hornworts
Division: Tracheophyta – (Vascular Plants)		**Common Name**
Sub Division	Psilopsida	Whisk ferns
Sub Division	Lycopsida	Club mosses
Sub Division	Sphenopsida	Horse tails
Sub Division	Pteropsida	Ferns and seed plants
Class	Filicineae	Ferns
Class	Gymnospermae	Naked-seeded plants
Class	Angiospermae	Flowering Plants

9.2 DIVISION BRYOPHYTA

Introduction

The first plants to colonize land were the bryophytes. They are generally thought to have evolved from green algae.

Habitat

The bryophytes are poorly adapted to life on land and are mainly confined to damp shady places.

Structure

- These plants are devoid of specialized conducting (xylem and phloem) tissues and strengthening tissues. Only the process of diffusion helps in the transportation of water and minerals as well as transportation of food and other substances.
- The plant body is with a proper cuticle, without cuticle or has a very thin one.
- They are said to be amphibians of the plant world because they cannot live away from water. They ***need water for reproduction.***
- They are ***flowerless.***

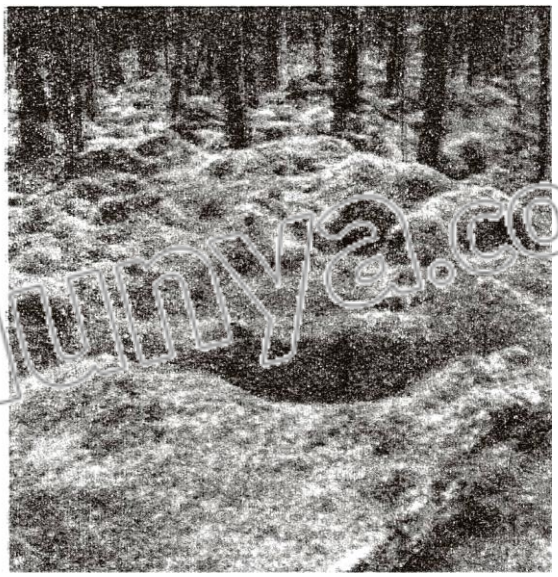


Fig: 9.1 A moss bug, lacking rigid supporting tissue, bryophytes are low profile plants they are most common in damp habitats.

- These plants show a regular ***heteromorphic (morphologically different) alternation of generation.***
- Gametophyte generation is dominant, independent and free living
  This may be thalloid as in many liverworts or is differentiated into structures resembling to stem, leaves and absorbing and anchoring organs, rhizoids, as in mosses and some liverworts. The gametophyte produces a sporophyte, which is a less conspicuous generation partially or totally dependent upon the gametophyte for its nutrition.
- The sporophyte generally consists of foot, seta and capsule.
- The sporophyte is diploid (2n) which produces in sporangia one kind of haploid spores (i.e. it is homosporous) by meiosis.
- The spores germinate and give rise to gametophyte which is also haploid.
- Multicellular male and female sex organs i.e. antheridia and archegonia respectively, are born on gametophyte either on same or different plants.
- These sex organs are multicellular and protected by a sterile covering of cells.
- Gametes are produced by mitosis.
- Male gametes produced within antheridia are called **antherozoids**; antherozoids are motile and always produced in large number.
- Female gametes formed within archegonia are termed as **eggs**.
- A single egg is formed in each archegonium.
- Fertilization takes place in water antherozoids (n) are attracted towards archegonia (n) chemotactically.
- A single antherozoid fuses with an egg (n) thus accomplishing fertilization which results in the formation of the diploid zygote (2n).
- The zygote is retained within the female sex organ (archegonium) for some time.
- After a resting period the zygote develops through mitotic divisions into a diploid embryo.
- The embryo ultimately develops into a sporophyte which is also diploid.
- The entire development of sporophyte thus takes place within the gametophyte plant body.
- Even when the sporophyte is fully developed it remains attached to the gametophyte for nourishment and protection because it does not obtain chloroplasts and is unable to perform photosynthesis.
- There is an alternation of generations in the life cycle of bryophytes i.e. multicellular haploid gametophytic (gamete producing) generation alternate with the multicellular diploid sporophytic (spore producing) generation.
- It is a very important phenomenon, which provides continuous genetic variabilities and selection for the best genetic make up for survival and adaptation in the changing environment.

Fig:9.2 Mosses often grow at wet places as seen here in a small water fall.

- In view of the above mentioned discussion, bryophytes can therefore be defined more precisely as plants with the distinguishing character as follows:
  "Vascular system absent; gametophyte dominant; sporophyte attached to gametophyte; homosporous."

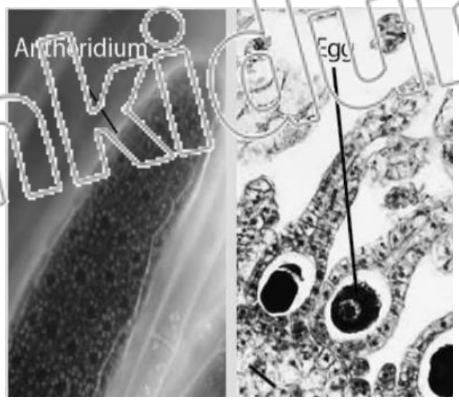


Fig: 9. 3 sex organs, male (antheridium) female (archegonium) of a bryophytic plant

9.3 ADAPTATIONS TO LAND HABITAT

In general, bryophytes developed the following adaptive characters for terrestrial environment.

Conservation of Water

- Formation of a ***compact multicellular plant body*** has helped in conservation of water by reducing cell surface area exposed to dry land conditions.
- Presence of ***cuticle*** further reduces loss of water by evaporation.

Development of Photosynthetic tissue

Development of photosynthetic tissue into special chambers for the absorption of carbon dioxide without losing much water and exposure to light.

Formation of Rhizoids

There is formation of special structures like rhizoids for absorption of water and anchorage.

Heterogamy

Heterogamy is evolved, forming non-motile egg containing stored food and motile sperms.

Protection of Gametes

Gametes are produced and protected by the special multicellular organs called antheridia and archegonia.

Retention of Embryo in Archegonia

Multicellular embryo is formed, which is retained and protected inside the female reproductive body during its development.

Alternation of Generations

Alternation of spore producing generation (sporophyte) with gamete-producing generation (gametophyte) enabled the plant to produce and test the best combinations for adapting to the versatile terrestrial conditions.

QUESTION RELATED TO ABOVE ARTICLE

Describe the adaptations of bryophytes to land habitat.
What adaptation made bryophytes able to live on land? (LHR 2019)
Give adaptive characters of bryophytes to land habitat. (FSD 2019)
How Bryophytes have adapted themselves to land habitat. (SWL 2019)
Describe land adaptations in bryophytes. (MTN 2019, LHR 2021)
How plants applied their different features to live successfully on land? (LHR 2022)

9.4 CLASSIFICATION OF BRYOPHYTES

Bryophytes are divided into three classes;

- Hepaticopsida
- Bryopsida
- Anthoceropsida

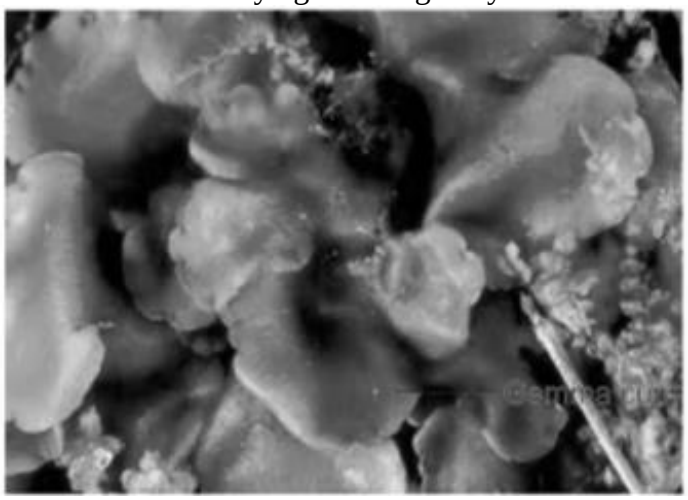
9.4.1 Hepaticopsida (Liverworts)

Introduction

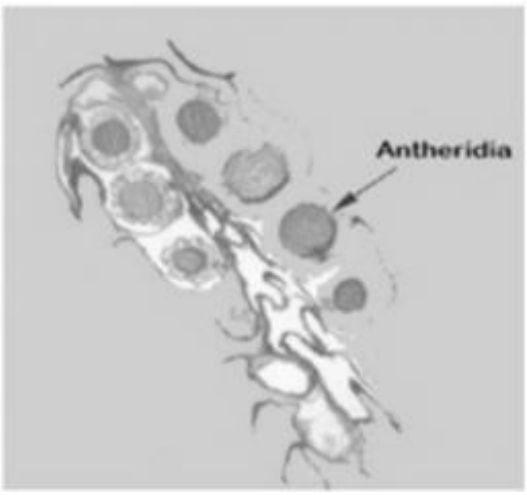
Bryophytes belonging to this class are called ***liverworts***. This class includes about ***900 species***. Liverworts are the simplest of all bryophytes.

Habitat

They are usually found on moist rocks and on wet soil. Since they live near water, so chances of drying out are greatly reduced.



(a)



(b)

Fig: 9.4 (a) *Marchantia*, a typical liverwort, the gemma cups function in asexual reproduction **(b)** *Porella*, a leafy liverwort showing lateral antheridia bearing branch.

Examples

Some common examples of liverworts are ***Marchantia*** and ***Porella.***

Features

Their main plant body is gametophyte.

Features of Gametophyte

Gametophyte is ***haploid***.

- It may be ***thalloid*** i.e. flat or ribbon-like usually dichotomously branched.
- It is attached to soil by means of ***rhizoids*** e.g. *Marchantia*. Other species tend to grow upright and are falsely leafy i.e. differentiated into false stem and leaves e.g. *Porella*.
- The ***sex organs*** develop on the upper surface of the thallus near the tips of the branches.
- Sometimes sex organs develop on special branches on gametophyte, called the ***antheridiophores*** and the ***archegoniophores*** as in *Marchantia*.

Features of Sporophyte

- Sporophyte is ***diploid***.
- It is ***dependent*** on gametophyte.

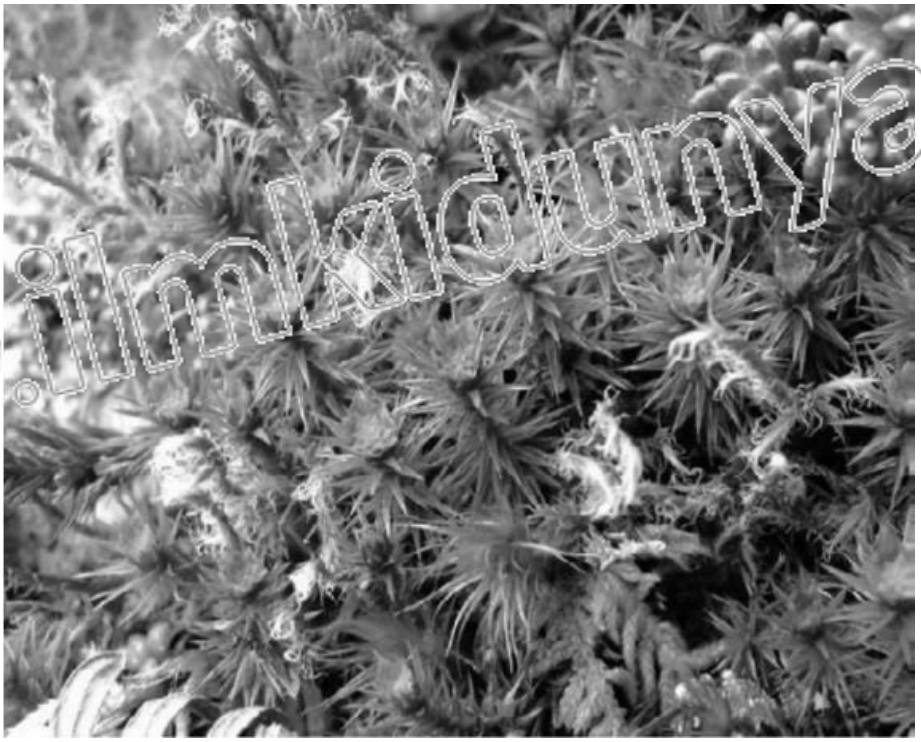


Fig: 9.5 A liverwort, *Marchantia* bearing sex organs antheridia and archegonia on special branches called antheridiophores and archegoniaphores.

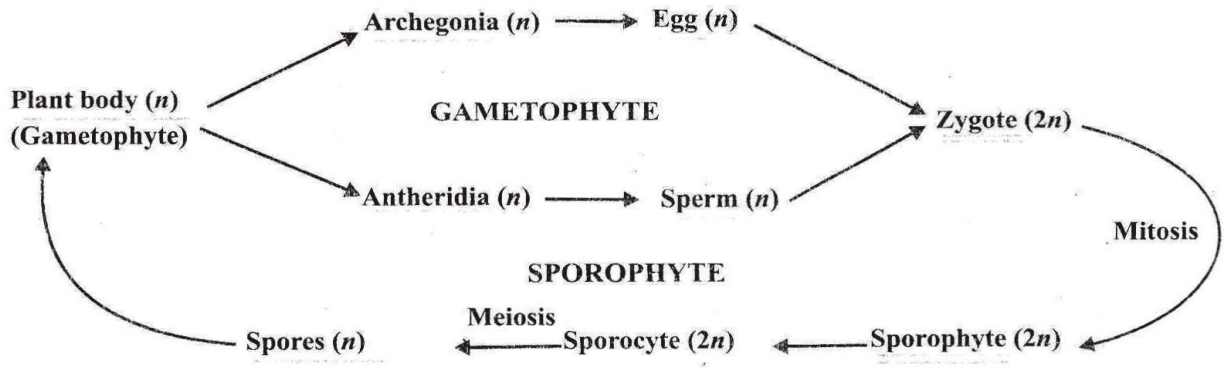


Fig: 9.6 Generalized life cycle of a Bryophyte showing alternation of generation.

9.4.2 Bryopsida

Introduction

Bryophytes belonging to this class are called ***mosses***. They usually grow to form cushions or mats.

Habitat

Like liverworts, most mosses inhabit damp places. In contrast to other bryophytes, they grow equally well in fairly dry places. However water is essential in the reproduction of mosses.

Examples

Some common examples are ***Funaria*** and ***Polytrichum.***

Alternation of Generation

Main generation is gametophyte.

Fig: 9.7 *Polytrichum*, a hair cup moss plant

Features of Gametophyte

- Gametophyte is haploid and always differentiated into structures, which resemble stem and leaves. Multicellular ***rhizoids*** are also present.
- Sexual reproductive organs, ***archegonia*** and ***Antheridia*** develop on the tips of different branches on the same plant as in *Funaria* on different plants as in *Polytrichum*.
- The archegonia and antheridia form clusters and are mixed with sterile hairs, forming a structure called ***paraphyses***.

Features of Sporophyte

- Diploid sporophyte produces haploid spores through meiosis.
- Spores of a moss, unlike of liverworts, develop into an alga like structure, the ***protonema***.
- Protonema produces a bud, from which a haploid moss plant (gametophyte) is formed.

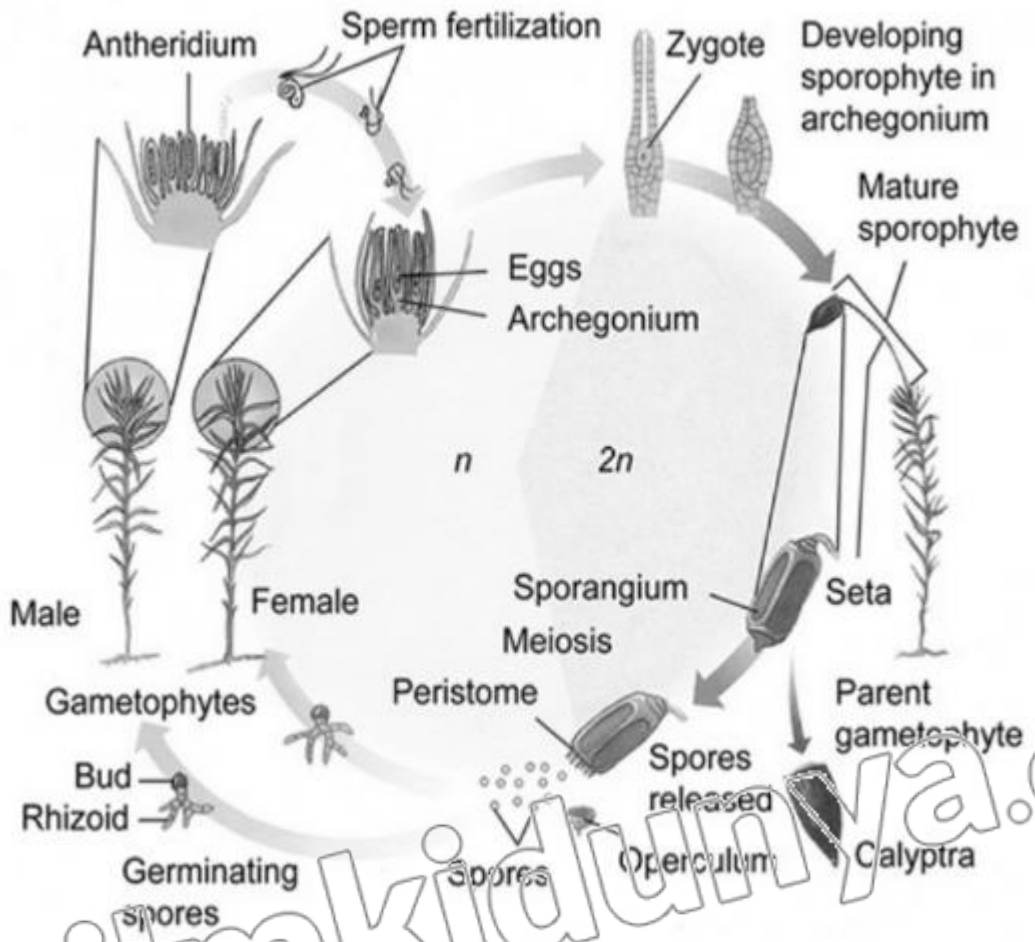


Fig. 9.8 Moss life cycle

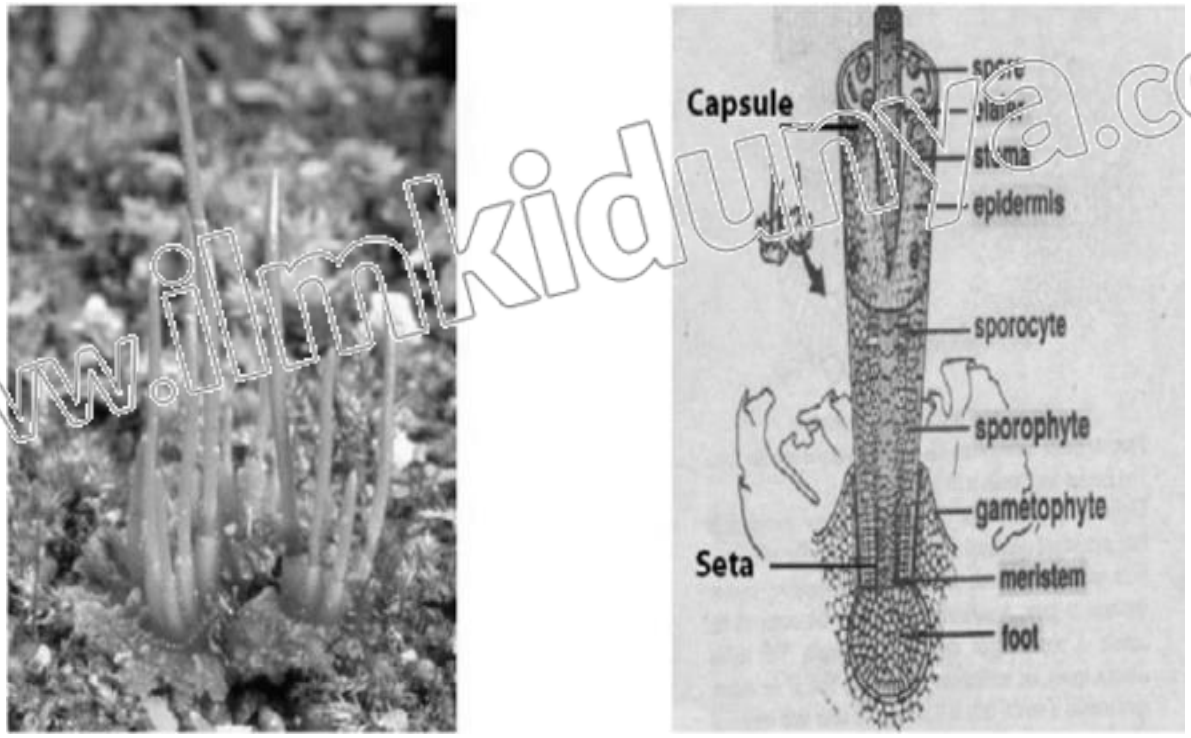
9.4.3 Anthocerotopsida (Hornworts)

Introduction

Bryophytes belonging to this class are called as ***hornworts***. This group is slightly advanced than Bryopsida and Hepaticopsida.

Example

One good example of Anthoceropsida is *Anthocerous*, which is also found in the hilly areas of Pakistan.



(a) **(b)**

Fig: 9.9 *Anthoceros*, a hornwort **(a)** Gametophyte with attached horn-shaped sporophyte **(b)** V.S. of sporophyte.

Features of Gametophyte

- Gametophyte is highly ***lobed*** and ***irregular*** in outline.
- Antheridia and archegonia are partially sunken in the gametophyte tissue.

Features of Sporophyte

- The Sporophyte exhibit many advanced characters due to which it can survive better on land as compared to other groups.
- Except for a little early stage of development, the sporophyte is not dependent upon gametophyte for nourishment and protection.
- It has ***stomata*** and ***chloroplast*** in epidermis and can thus photosynthesize its own food rather than obtaining it from gametophyte.
- It has a waxy ***cuticle*** to check excessive loss of water (desiccation).
- At the junction of foot and spore producing region, there is a band of ***meristematic tissue***. This tissue keeps on adding cells towards the spore-producing region during the formation, maturation and dispersal of spores from the opposite end. Due to fast growth rate of this meristematic tissue the sporophyte keeps on increasing in length for an indefinite period of time.

  Due to these characters, the sporophyte continues to survive as such even after the death and decay of the gametophyte.

QUESTION RELATED TO ABOVE ARTICLE

Describe the characteristics of liver worts.
Explain the life cycle of moss.
Write note on Anthoceropsida.

9.4.4 Alternation of Generations

- In the life history of liverworts, mosses and hornworts there are two distinct multicellular phases or generation.
- These generations are haploid ***gametophyte*** and diploid ***sporophyte***, which regularly alternate with each other.
- The gametophyte is the dominant generation because it is more conspicuous.
- It produces gametes called ***spermatozoids*** and egg, therefore called gamete-producing generation.
- A haploid spermatozoid fuses with a haploid egg to produced diploid ***oospore.***
- The oospore does not produce the gametophyte directly but produces a totally different plant called ***sporophyte.***
- The sporophyte in bryophytes is a less conspicuous generation, which is usually differentiate into ***foot, seta*** and ***capsule*** (also called ***sporogonium***).
- Spores develop within the capsule by reduction division (meiosis) from spore mother cells.
- The sporophyte produces spores and is, therefore called spore producing generation.
- The spore on germination does not develop into a sporophyte but gives rise to the gametophyte.
- Thus in the life history of a bryophytic plant, the two generations, the gametophyte and the sporophyte, regularly alternate with each other.
- The phenomenon of alternation of gametophyte and sporophyte in the life history of a plant is called alternation of generations.

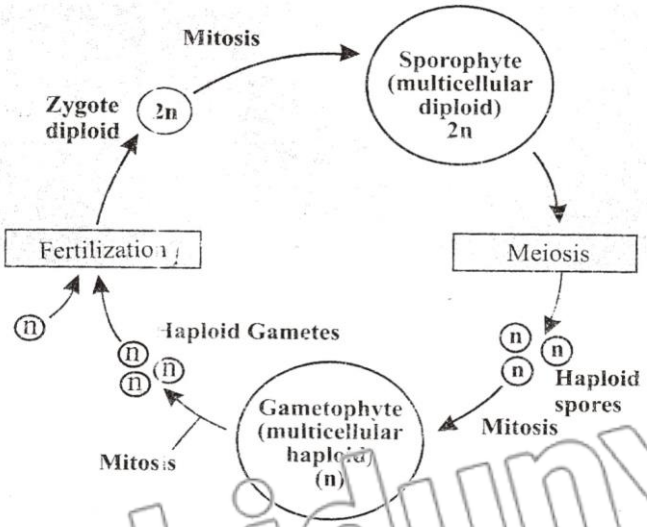


Fig: 9.10 Graphic representation of the alternation of gametophytic and sporophytic generation.

- It should be noted that the gametophyte or haploid stage begins with spores and ends at gametes, whereas the sporophyte begins with oospore and ends at spore mother cell.

9.4.4 (a) The Significance of Alternation of Generation

Some of the significantly important points of alternation of generation are as follows.

Source of genetic recombination

During the formation of spores from spore mother cells by meiotic division reshuffling of genes occurs. As a consequence, a great variety of spores with different genetic make-up are produced. These spores in turn produce gametophytes with different genetic combinations.

Better chances of survival

The gametophyte with better genetic makeup will have a better chance for survival in the environment where they occur. On the other hand gametophytes with less advantageous characteristics will be eliminated. There is no reshuffling of genes during gametogenesis in the gametophyte as gametes are produced after mitosis. The oospore developing after fertilization now has a new genetic makeup as compared to the parent. This genetic variation passes to the new sporophyte which on maturity once again produces further genetic recombination which are transferred to the gametophyte. In this natural process the sporophyte thus provide a large amount of genetic variability and nature selects the best genetic combinations.

Evolution

On base of variations, natural selection acts on populations and thus cause evolution.

QUESTION RELATED TO ABOVE ARTICLE

Write down the significance of alternation of generations. (GRW 2018)

Define alternative of generation. Explain significance of Alternation of generation. (RWP 2019, 2021)

Why sporophytes and gametophytes alternate with each other? Give its significance. (RWP 2022, GRW 2022)

To what does alternation of generations refer in the plants? Describe Sporophyte and gametophyte. With which stage is an adult animal comparable? How are they reproductively dissimilar? (Exercise Question i)

9.5 DIVISION TRACHEOPHYTA

Tracheophytes are called ***vascular plants*** because of the presence of vascular tissue i.e. xylem and phloem. These are the successful group of land plants. They are able to adapt the rough land habitat most successfully and amongst them, the flowering plants today have dominated land habitat.

Reasons of Predominance

The evolution of following complex vegetative and reproductive characteristics enabled the vascular plants in general and flowering plants specifically to become predominant flora of land.

1. Root, stem and leaves.
2. Vascular systems in stem, roots and leaves.
3. Protected sporangia, leading to the evolution of seed.
4. Pollen tube for safe and water-independent transmission of male gamete to female gamete.
5. Flower and fruit.
6. Heteromorphic alternation of generation.

Divisions of Tracheophytes

The tracheophytes are further sub-divided into four sub-divisions i.e.

- Psilopsida.
- Lycopsida.
- Sphenopsida.
- Pteropsida.

9.5.1 PSILOPSIDA (PSILOPHYTA)

Introduction

Psilopsida is considered to be the earliest group of vascular plants. This group is also called as ***Psilophyta***.

Examples

Most of the representative of this group have become extinct, for example, ***Rhynia, Horneophyton, Psilophyton, Cooksonia.***

There are only two living genera ***Psilotum*** and ***Tmesipeteris.***

Features

Features of Sporophyte

- Sporophyte is ***rootless***.
- Its stem is differentiated into an underground ***rhizome*** and an aerial part. Both are dichotomously branched.
- The rhizome bears ***rhizoids***. Both rhizoid and rhizome perform function of root.
- The ***aerial branches*** are green, leafless and bear small veinless outgrowth, and carry out photosynthesis.
- Reproductive organs (***sporangia***), which develop at the tips of long or short branches, or on lateral sides of branches.
- ***Internal structure*** of stem is simple. Vascular tissue is narrow, central and solid without pith. Cortex is wide.

(a) **(b)**

Fig. 9.11 *Psilotum*
(a) Dichotomously leafless branches.
(b) The erect branches of another species, showing brown sporangia.

Features of Gametophyte

- The gametophyte is ***thalloid, colourless*** and ***underground***.
- Its cells contain a fungus, which provides food to the gametophyte and in turn gets protection from it. Thus they develop ***mycorrhizal association.***

9.5.1 (a) EVOLUTION OF LEAF

Leaf is photosynthetic organ of plant.

Plants before Evolution of Leaf

Early vascular land plants did not have true leaves or roots. They were small in size, with dichotomously branched erect smooth aerial parts and equally strong subterranean anchoring and absorpting rhizome.

Example

Rhynia had the same structural layout i.e. naked stem without leaves.

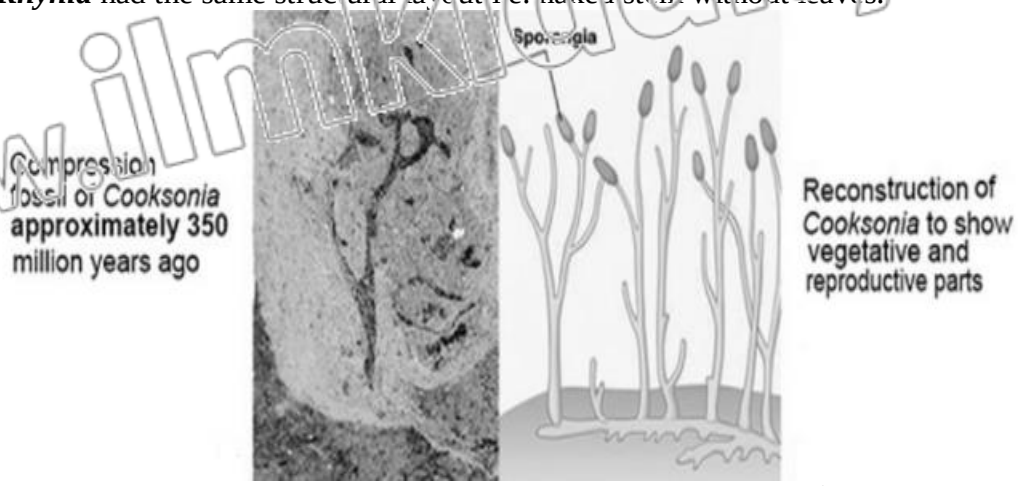


Fig: 9.12 *Cooksonia*: an early vascular plant bearing sporangia at the tips of the branches.

Types of Leaves

There are two important types of leaves;

- Microphylls
- Megaphylls

Microphyll

"Such type of leaf, which is small and has single undivided vein (vascular supply) is called microphyll."

Evolution of Microphyll

Rhynia-like plants started to form leaves as small scale like outgrowths. These outgrowths were not supplied with vascular bundles, therefore they were not regarded as true leaves.

Lycopods were the first plants that formed the true leaves and roots.

However in lycopods (e.g. ***Lycopodium***) the leaves are small in size. Each leaf has a single undivided vein and called as microphyll.

Megaphyll

"Large leaves having divided veins and veinlets with an expanded leaf blade or lamina are known as megaphylls."

Megaphylls are characteristic for ferns and seed plants.

Evolution of Megaphyll

It is suggested that evolution of megaphylls started from a dichotomous branching system in some primitive fern-like plants ***approximately 350 million years ago***.

It is assumed that evolution of a megaphyll included series of successive evolutionary steps. This process of evolution was very slow and gradual, which completed in more than ***15-20 million years***. These steps are as follows.

Overtopping

"It is an unequal development of various branches"

During this step, the dichotomously branched aerial portion of the stem showed unequal branching. Some branches remained short while others grew and expanded at a much faster pace. All these branches grew in different planes.

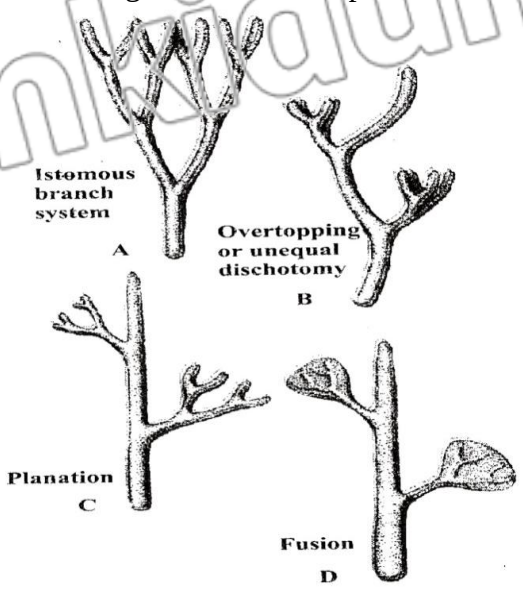


Fig: 9.13 Successive evolutionary steps in the evolution of leaf.

Planation

In this step there was arrangement of unequal dichotomies in one plane. This process is thus termed as planation.

Fusion/Webbing

During this step, the space between the overtopped dichotomous branches was occupied by a sheet of parenchyma cells, which connected these branches forming a flat lamina or leaf blade type of structure, having many dichotomously branched veins.

During course of revolution fusion of the vascular strands resulted in net or reticulate venation pattern.

Significance of Leaf

Leaves have increased surface area for absorption of light, thus caused increase in process of photosynthesis.

QUESTION RELATED TO ABOVE ARTICLE

Describe evolution of leaf and its importance in vascular plants.

Discuss different evolutionary steps in the evolution of maga phyll leaf. (DGK 2019)

Write down a note on evolution of leaf. (GRW 2021)

Describe in detail 'evolution of leaf. (LHR 2018, MTN 2021, RWP 2021)

How megaphylls evolved? Discuss their evolution in detail with the help of diagram. (DGK 2022)

What is the importance of seed in plants? Discuss significant events in evolution of seed (MTN 2022)

How dose evolution of microphyll differ from evolution of megaphyll? (FSD 2022)

Describe evolution of leaf and its importance in vascular plants. (Exercise Question iii)

9.5.2 LYCOPSIDA

Introduction

Lycopsids are not mosses but are called ***club mosses or spike mosses*** because their club/spike shaped strobili and small leaves (thought with vascular tissue) resemble mosses.

These are sometimes called ***ground pines*** because of their slight resemblance to the evergreen plants.

Fig: 9.14 *Lycopodium*: a club moss. The sporohylls are clustered at the tips of branches into club shaped structures called strobili

Example

Lycopodium and *Selaginella* are common examples. *Selaginella* resembles seed producing plants (spermatophytes) because of its heterosporic condition.

Features

Features of Sporophyte

The plants of Lycopsida have sporophytes differentiated into roots, stem and true leaves.

- The ***leaves*** are small and single veined also called microphylls. The arrangement of leaves is spiral or opposite.
- The ***sporangia*** develop singly on the upper side of the sporophylls, which may or may not be arranged to form strobili. Sporangia may be of one kind as in *Lycopodium* or of two kinds i.e. microsporangia and megasporangia as in *Selaginella*.
- In some Lycopsids such as *Lycopodium*, leaves and sporophylls are without a ***ligule*** (small outgrowth). In others, the ligule is present on the upper side of the sporophylls, near their base as in *Selaginella*. The Sporophytes are thus referred to as 'homosporous' and heterosporous' respectively. This condition is called homospory and heterospory respectively.

Features of Gametophyte

Gametophyte of lycopsida is mainly ***underground***.

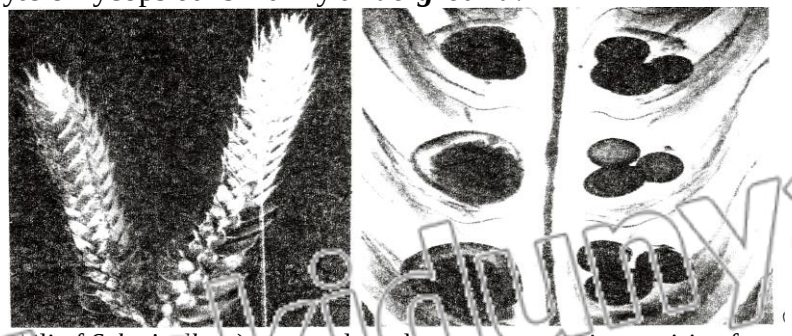


Fig: 9.15 Strobili of *Selaginella*: a) – two enlarged, compact strobili comprising four rows of sporophylls, b) longitudinal section of strobilus of *Selaginella* showing mega and microsporangia.

QUESTION RELATED TO ABOVE ARTICLE

Write a note on lycopsida. **(LHR 2017)**

9.5.3 SPHENOPSIDA

Introduction

Plants present in this group are called as ***horsetails***.

Example

Most common example is *Equisetum*.

Features

Features of Sporophyte

- Sporophyte is differentiated into stem, roots and leaves.
- Main ***stem*** is not smooth, it has large number of ridges and furrows.
- ***Leaves*** may be expanded or scale-like and are always arranged in whorls.
- Plants belonging to this group are also called ***arthrophytes*** because the whole plant body is composed of large number of joints. They represent nodes. Each node has whorl of branches.
- The ***sporangia*** are born on structures called sporangiophores, aggregated to form cones. Each sporangiophore has a slender stalk and an expanded disc at its free end. The sporangia appear on the underside of the disc.

Features of Gametophyte

Gametophyte is ***thalloid*** and grows upon clayed soil and on mud.

Fig: 9.16 Representative of three of the subdivisions of vascular plants **(a)** club moss *Lycopodium* **(b)** A horsetail, *Equisetum* **(c)** A tree fern.

9.5.4 PTEROPSIDA

Pteropsida is divided into three classes;

- Filicinae
- Gymnospermae
- Angiospermae

The class Filicineae contains seedless plants foliar sporangia (sporangia attached to fronds. The leaves are called fronds. When the frond is immature and young, it is coiled, this pattern of development is called circinate vernation. It is an important character of this group.

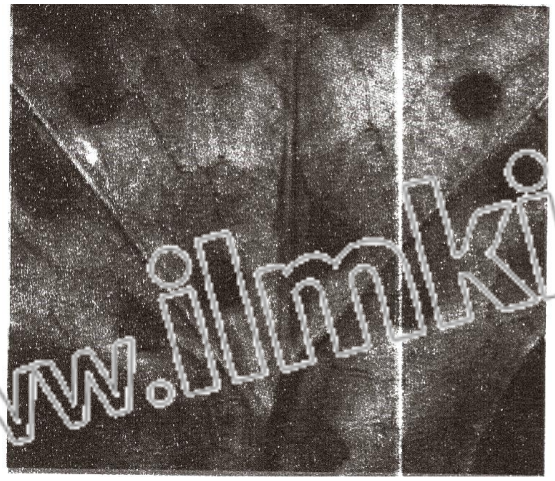


Fig: 9.17 A frond bearing sporangia attached To the underside of the leaf.

Fig: 9.18 Ferns. A ostrich fern growing on a Forest floor. See the coiled immature and Young fronds ready to uncoil.

9.5.4.1 CLASS FILICINAE

Introduction

Plants present in this group are commonly called ***ferns***.

Features

- They are ***worldwide*** in distribution and are especially abundant in tropics.
- They are mostly ***shade and moisture loving plants***. Few are able to live under dry conditions. They grow on hills and in plains.
- Some are ***epiphytic*** and grow on the bark of trees.
- They vary greatly in ***size***.
- They contain ***foliar sporangia*** (sporangia attached to leaves), such leaves are called fronds. When the frond is immature and young, it is coiled, this pattern of development is called ***circinate vernation***.

Examples

Important ferns are ***Dryopteris, Pteridium, Adiantum*** and ***Pteris*** etc.

9.5.4.1 (a) Adiantum (Maiden-Hairfern)

Introduction

It is one of the most common example of fern, belonging to class Filicinae.

Habitat

It usually grows along moist walls, water courses and drains.

Structure

- It is small ***herb*** consisting of stem, roots and leaves.
- ***Stem*** is short, thick, underground, usually branched, horizontally growing rhizome.
- ***Rhizome*** is protected by brownish scales called ramenta and covered by persistent leaf basis.
- Fibrous ***adventitious roots*** arise from the lower side of the rhizome.
- ***Compound leaves or fronds*** arise from the upper side of rhizome. Young leaves show circinate vernation.
- The ***stipe*** (stalk) and rachis of leaf are black, smooth, and shiny (hence called maiden hair fern).
- The ***leaflets*** (pinnae and pinnules-leaflets of second order) show dichotomous venation.
- ***Sori*** (groups of sporangia) are born on the underside of reflexed lobes of the margins of leaflets and are protected by bent margins of the leaflets, forming false indusium.

Life Cycle

Life cycle of Adiantum shows heteromorphic alternation of generation, in which;

- Sporophyte being dominant.
- Gametophyte small and reduced but separate and independent.

Structural Features of Sporophyte

Different structural features are as follows:

- The diploid Sporophyte produces number of sori. The sori are green but when ripe they become dark brown.
- Each sorus consists of a number of sporangia covered by false indusium. The leaves bearing sporangia are called sporophylls.
- Each sporangium is slightly flattened, biconvex body (capsule) born on a multicellular stalk. The capsular wall consists of a single layer of flat, thin walled cells. The edge of the capsule is made of two parts i.e. annulus and stomium.
- The annulus occupies three fourth of the edge. Annular cells have their radial and inner walls thickened.
- The stomium occupies one fourth of the edge. The stomial cell are thin walled.

Conversion of Sporophyte into Gametophyte

Inside the sporangia, haploid spores are produced by reduction division (meiosis) of diploid megaspore mother cells.

The annulus of the sporangium contracts in dry weather, the stomial cells being thin-walled rupture and spores are dispersed by wind.

When a spore falls on a moist soil, it germinates at a suitable temperature and produces a haploid gametophyte or prothallus.

Structural Features of Gametophyte

Different structural features are as follows:

- The ***prothallus*** is an autotrophic, small, flat, heart-shaped structure.
- At anterior end of the prothallus is a ***notch*** in which lies the growing point. Its size is about one-third of an inch at its longest diameter.
- It is horizontally placed on the soil and has unicellular ***rhizoids*** on its lower surface towards the posterior end. The rhizoids fix the prothallus to the soil and absorb nutrients for it.
- It is composed of rounded thin walled ***cells***. The margin of the prothallus is one-cell thick but the middle part is many-cell thick and is cushion-like.
- It is ***monoecious*** i.e. male and female sex organs appear on the underside of the same prothallus. In the mature prothallus, archegonia occur near the notch and the antheridia are scattered among the rhizoids.
- The ***archegonium*** consists of a ventor and a neck. The ventor contains the egg or oosphere and is embedded in the cushion of the thallus.

Conversion of Gametophyte into Sporophyte

Each antheridium produces numerous spermatozoids which are spirally coiled and multiciliated. They reach the archegonium by swimming in water. Fertilization occurs and an oospore is formed. The oospore forms the Sporophyte. Young Sporophyte is first attached to the gametophyte but later becomes independent.

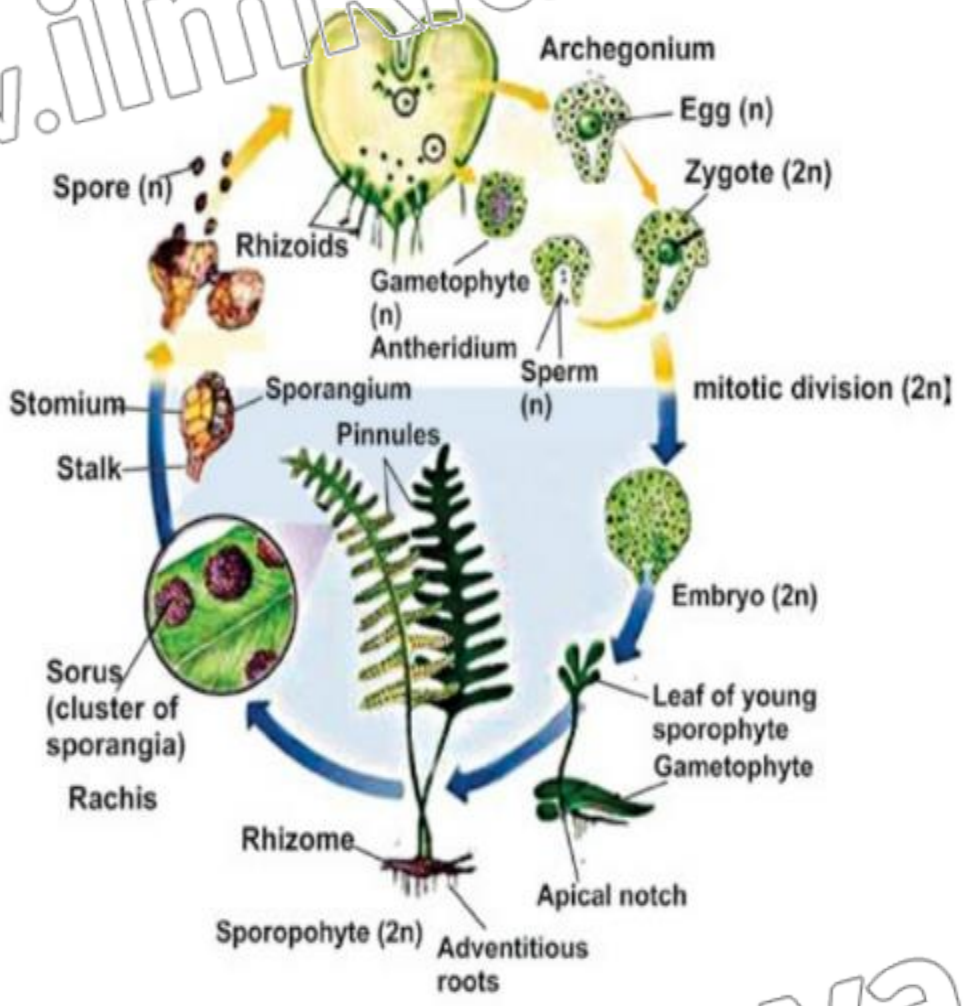


Fig: 9.19 Life history of *Adiantum*

QUESTION RELATED TO ABOVE ARTICLE

Explain in detail Psilopsida.

Explain in detail Lycopsida.

Explain in detail Sphenopsida.

Discuss life cycle of Maiden-hairfern. **(GRW 2019)**

Discuss the life Cycle of Adiatum. **(LHR 2018, MTN 2018, DGK 2019)**

9.6 EVOLUTION OF SEED HABIT

Seed plants (spermatophytes) predominate over non-seeded vascular plants.

One of the most significant events in the history of land plants was the development of seed habit. It was an important change in the reproductive system of the vascular plants, which occurred approximately ***390 million years ago***. First complete seed appeared approximately ***365 million years ago*** during late Devonian period.

- Technically a seed may be defined as a ***fertilized ovule***.
- An ***ovule*** is an integumented indehiscent megasporangium.
- ***Integuments*** are specialized protective coverings around megasporangium, which vary in number.

All seed producing plants are called spermatophytes. Various steps involved in the evolution of seed habit are as follows:

1. Evolution of heterospory.
2. Retention and germination of megaspore within the megasporangium.
3. Development of protective layers around megasporangium.
4. Reduction to a single functional megaspore per sporangium.
5. Development of an embryo sac within the sporangium
6. Modification of distal end of megasporangium for pollen capture.

1) Evolution of Heterospory

- Primitive vascular land plants produced one kind of spores, a condition called ***homospory***. All groups of land plants up to pteridophytes are homosporous.
- During early phase of evolution some plant groups started producing two different types of spores, the smaller ones called microspores and the larger ones called megaspores. This condition is called ***heterospory***.

➢ The ***microspores*** produced inside microsporangia germinated to form male gametophyte or the ***microgametophyte***.
➢ ***Megaspore*** germinated to form female gametophyte or ***megagametophyte***.

2) Retention and Germination of Megaspore within the Megasporangium

- During the usual reproductive cycle in the heterosporous vascular land plants, the megaspore used to be shed and dispersed soon after their formation in order to germinate into female gametophyte.
- In some plants (e.g. *Selaginella*) the megaspore was not allowed to escape from megasporangium immediately after its formation.
- In others, megaspore was permanently retained within the megasporangium. Here, within the confined wall of megasporangium, the megaspore germinated to form egg containing female gametophyte.

3) Development of Protective Layers around Megasporangium

Some branch like structures of Sporophyte surrounding the megasporangium fused around megasporangium to form protective envelope or integument. The megasporangium tightly locked by integuments became totally indehiscent. This important change led to the evolution and formation of ovule, which is nothing but an integumented indehiscent megasporangium. In this way more protection was accorded to the egg-containing apparatus in terrestrial environment.

4) Reduction to a Single Functional Megaspore per Sporangium

Each megaspore mother cell within a megasporangium used to produce four functional megaspores.

- If these megaspores germinate to produce four viable female gametophytes. There may have been a competition for space and food among the four gametophytes.
- Early vascular plants adopted a new strategy i.e. only one megaspore was selected for the further development into a healthy female gametophyte while the remaining three were aborted.

5) Development of an Embryo Sac within the Sporangium

The single healthy megaspore retained with the megasporangium germinated to form an egg containing female gametophyte called an embryo sac.

6) Modification of Distal End of Megasporangium for Pollen Capture

When most of the structural and functional changes leading to the development of seed habit were completed, another important modification took place in the megasporangium, which was now integumented, indehiscent and permanently attached to the Sporophyte. The distal end of the megasporangium became modified for capturing pollen (microspore containing male gametophyte).

Pollen after being trapped in the distal cavity of the megasporangium produced pollen tube, which carried male gametes deep into the embryo sac to fertilize the egg, forming a zygote, which forms an embryo. The megasporangium (ovule) after fertilization is transformed into a seed, the integuments becoming the seed coats. The seed offers maximum degree of protection to a developing embryo under the unfavourable terrestrial environment. The development and evolution of seed habit was a great success and a giant leap, which ultimately enabled plants to colonize land permanently.

QUESTION RELATED TO ABOVE ARTICLE

Discuss various steps involved in the evolution of seed habit.

Write main steps of evolution of seed.

Discuss at least four steps for the evolution of seed habit. (DGK 2021)

Describe the evolution of leaf. (BWP 2021)

What is the importance of seed in plants? Discuss significant events in evolution of seed.

(MTN 2022)

Relate heterospory and modification of megasporangium with adaptation of seed habit in spermatophytes. (SGD 2022)

What is a seed? Why is the seed a crucial adaptation to terrestrial life?

(Exercise Question ii)

Discuss evolution of seed and its significance. (Exercise Question iv)

9.7 CLASS GYMNOSPERMAE

Introduction

'Gymno' means ***'naked'*** and ***'spermae'*** means ***'seed'***.

Thus the term gymnospermae means ***'naked-seeded plants'***.

Characteristics

- Gymnosperms are ***one of the successful groups*** of seed plants, which are worldwide in distribution.
- They constitute about ***one-third*** of the world's forests.
- The gymnosperms are ***heterosporous plants***, which produce seeds but no fruits. The two kinds of spores are microspores and megaspores, which develop on microsporophylls and megasporophylls respectively.
- The ***ovules*** in these plants are usually borne on the exposed surfaces of the fertile leaves (megasporophylls). These ovules, unlike those of angiosperms are not enclosed but lie naked on the surface of fertile leaves.
- They show ***regular heteromorphic alternation of generations***. They have independent, dominant sporophyte but less conspicuous, dependent gametophyte. The female gametophyte is permanently retained within the ovule.
- The megasporophylls bearing ovules are not folded and joined at the margins to form an ovary.

Classification of Gymnosperms

The important genera of gymnosperms are:

- *Cycas* (Sago-palm)
- *Pinus* (Pines)
- *Taxus* (Yew)
- *Picea* (Hemlock)
- *Cedrus* (Deodar)
- *Ginkgo* etc.

Fig: 9.20 (a) *Cycas* tree-habit and general Organography

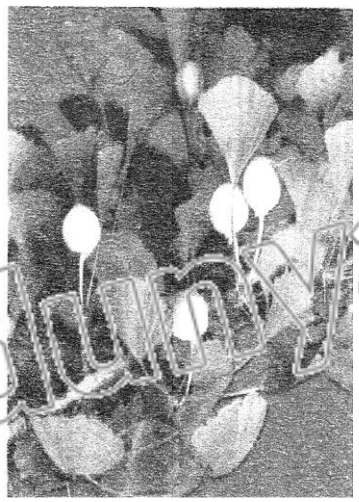


Fig: 9.20 (a) *Ginkgo biloba*

QUESTION RELATED TO ABOVE ARTICLE

Write a note on class gymnoperae. **(LHR 2021, MTN 2021)**

Write a detailed note on class gymnoperae. **(DGK 2021)**

9.7.1 *Pinus*-Life Cycle

Introduction

Pinus is a ***conifer***, which belongs to class gymnospermae. Conifers are heterosporous.

Life Cycle

In the life cycle of *Pinus*, the dominant diploid sporophytic generation alternates with inconspicuous gametophyte generation. The main plant body is Sporophyte.

Steps of Life Cycle with Characteristic Features

Formation of Cones

Male and female cones are produced on same plant.

- ***Male cones*** are small in size and produced in clusters on an axis.
- ***Female cones*** are large and conspicuous.

Formation of Megagametophyte

The megasporangium is located on female cone. Each female cone is composed of large number of spirally arranged scale leaves (megasporophylls), which are woody in texture. At the base of each scale is an ovule. An ovule is actually a megasporangium, which is protected by two integuments.

Each megasporangium has a single diploid megaspore mother cell. The megaspore mother cell divides meiotically to produce four haploid megaspores.

The functional megaspore (n) undergoes mitosis to produce female gametophyte or an embryo sac. The embryo sac contains one to several archegonia. The archegonia contain the female gamete or an egg.

Formation of Microgametophyte

Microspore are formed in microsporangia, which are present on microsporophylls. The microspore germinates within its own wall to form a small inconspicuous male gametophyte (microgametophyte) by meiosis.

Such a microspore of seed plants that contains the microgametophyte or male gametophyte including the gametes is called a ***pollen grain***.

Pollination

Pollen grain in *Pinus* has two wings attached to its lateral sides. Pollens are produced in great number and are carried by wind. Due to wings pollen can float in air for a longer period of time and can travel long distances.

During pollination the pollen land directly on the ovules.

Fertilization

Only few pollens are able to germinate to form pollen tubes through which male gametes are transferred to the embryo sac for fertilization.

More than one egg can be fertilized to form several zygotes, but one zygote usually survives to form a single embryo. After fertilization the ovule becomes the seed.

Germination of New Sporophyte Plant

- The seed contains an embryo along with some stored food material. The seed upon germination gives rise to a new sporophyte plant.
- In the life cycle of pinus, the dominant diploid sporophytic generation alternates with inconspicuous haploid gametophyte generation.

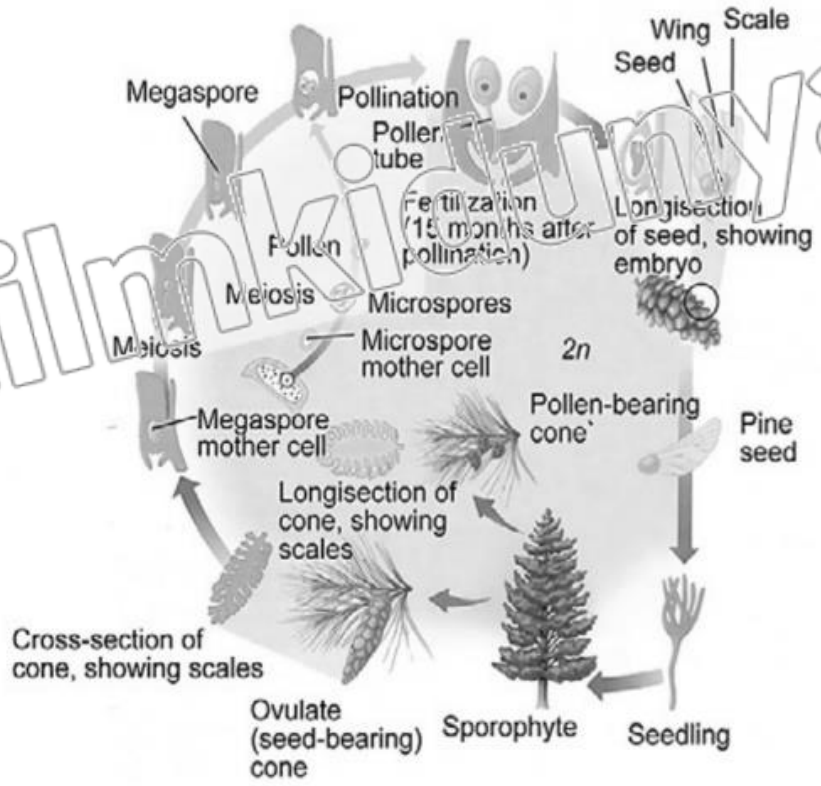


Fig: 9.21 Life Cycle of *Pinus*

QUESTION RELATED TO ABOVE ARTICLE

Give life cycle of *Pinus*.

9.8 CLASS ANGIOSPERMAE

Introduction

'Angio' means ***'close'*** and ***'sperm'*** means ***'seed'***.

The term 'angiosperms' literally means ***'enclosed seeded plants'***.

Features

- Angiosperms make up ***235,000*** of the 360,000 known species of plants.
- They are ***heterosporous***, autotrophic plants.
- They are ***most abundant and most successful*** of all the plants on the earth.
- They produce ***flowers, fruits and seeds***.
- In these plants, fertile leaves bearing ovules are folded and joined at the margins to form ***ovaries***. The ovary after fertilization is changed into a fruit containing seeds.

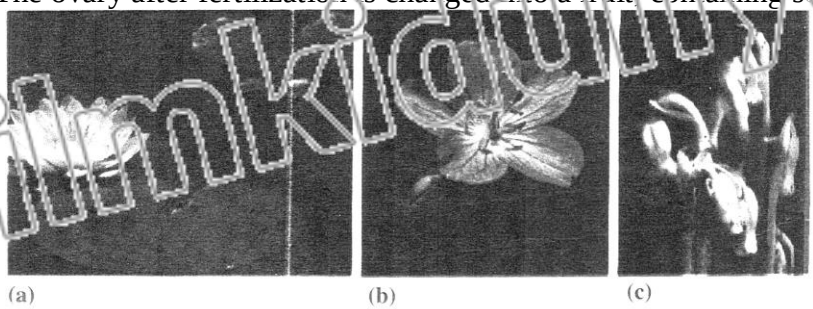


Fig 9.22: Some of the remarkable diversity of angiosperms is shown in these photograph The species shown here are Dicots **(a)** fragrant water lily, **(b)** wild geranium, **(c)** Indian pipe a parasite, an angiosperm that lacks chlorophyll.

9.8.1 Life Cycle of an Angiospermic Plant

Introduction

Angiospermic plants show ***heteromorphic alternation of generations***.

Features

- The adult plant is ***diploid Sporophyte*** mostly differentiated into roots, stem and leaves.
- At maturity, Sporophyte plant produces flowers.
- A ***flower*** is a modified shoot, which consists of a pedicel, thalamus (torus) and floral leaves (sepals, petals, stamens and carpals). Thalamus and floral leaves, especially the stamens and carpals, are so modified, that they do not even look like stem and leaves respectively.
- The ***sepals*** and ***petals*** are non-essential or non-reproductive parts. Sepals protect the inner parts while petals attract insects for pollination. When the pollination is over, the sepals usually and petals always fall off.
- ***Stamens*** and ***carpels*** are the essential or reproductive parts of the flower. The stamen consists of a filament and an anther. It is male reproductive part of flower.

  The carpal consists of a basal broader part, the ovary, the style and the terminal part of the style, the stigma. Carpal is female reproductive part of flower.

Life Cycle

Different steps occurring through life cycle of angiosperms are as follows.

Formation of Megagametophyte

The ovary contains ovule, which consists of an integument (covering) and tissue the nucleus present inside.

Inside ovule, a megaspore cell is present, which on meiosis produces four haploid megaspores (n).

One remaining functional megaspore divides by mitosis to form eight cells. Two groups of three cells each, move towards opposite poles. Remaining two central cells join to form diploid fusion nucleus.

Out of three cells present near micropyle, one is egg (central).

This seven celled structure (containing egg and fusion nucleus) is called female gametophyte (megagametophyte).

Megaspore Mother Cell ⟹ Four Megaspores ⟹ Functional Megaspore ⟹ Egg + Diploid Fusion Nucleus + Synergids + Antipodals

Formation of Pollen Grain

Inside pollen sac, several microspores are produced by meiosis. Each microspore consists of two nuclei, generative and tube nucleus. This microspore is also called as pollen grain.

Pollination

During pollination, pollen grain is transferred from anther of stamen to stigma of carpal.

Formation of Microgametophyte

After pollination, pollen grain germinates to form pollen tube.

The generative nucleus of the microspore divides by mitosis to form two male gametes. At this stage of development, the pollen grain is called male gametophyte.

9.8.1 a) Double Fertilization

The pollen tube grows through the style, enters the ovule and then reaches the female gametophyte. Here it discharges the male gametes (sperms).

- One of the sperms (n) fuses with egg (n) to form zygote (2n) also called oospore, which develops into an embryo.

- Other sperm (n) fuses with diploid fusion nucleus (2n) endosperm nucleus (3n), which develops into a multicellular nutritive tissue, the endosperm.

"Such type of fertilization in which one sperm fuses with the egg and other with fusion nucleus is called double fertilization, which is characteristic feature of flowering plants".

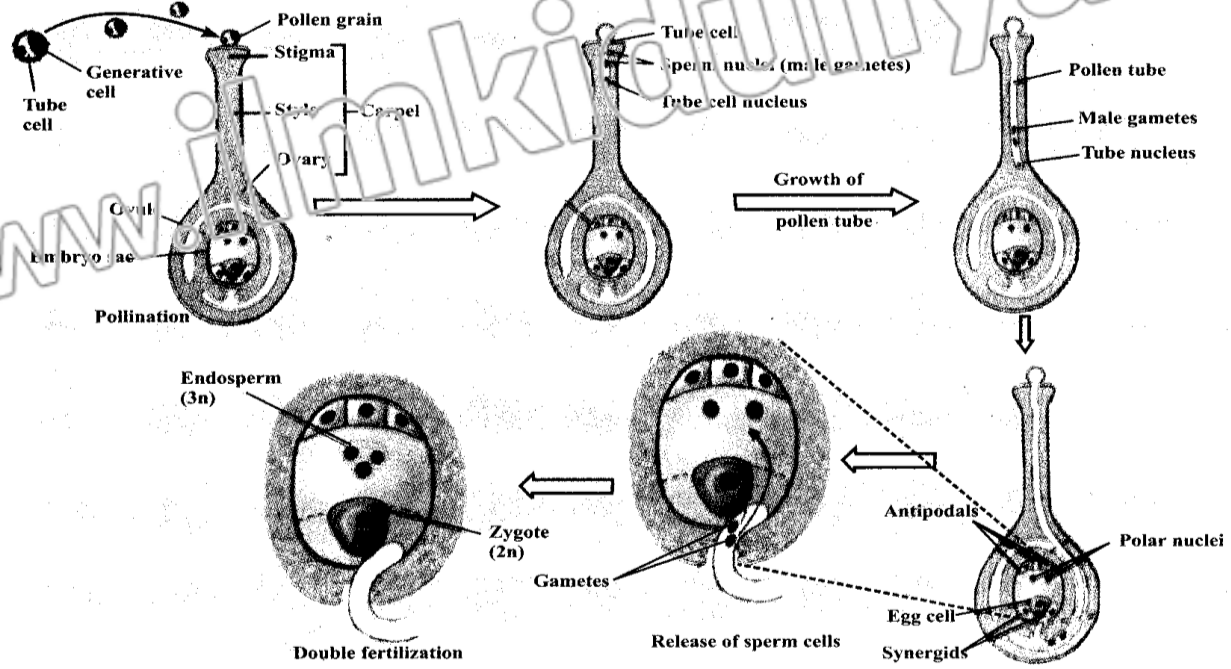


Fig: 9.23 Life Cycle of on angiospermic plants.

9.8.1. b) Seed Formation

After double fertilization, the integuments of the ovule form testa and tegmen and ovary wall develops into the fruit coat.

Germination of New Sporophyte Plant

Seeds usually undergo a period of rest and then under suitable conditions, germinate and produce a seedling, which gradually changes into a sporophyte.

QUESTION RELATED TO ABOVE ARTICLE

What are details of double fertilization?
Explain the life cycle of flowering plant in detail.
Write down a note on life cycle of angiospermic plant. (GRW 2021)
Write life cycle on an Angiospermic plant. (SWL 2021)
In what way do the flowering plants differ from the rest of the seed plants? What is the stigma? Is fertilization in angiosperms direct or indirect? From what tissue does angiosperm fruit develop? (Exercise Question v)

9.8.2 Classification of Angiosperms

The class of angiosperms is divided into two sub-classes:

- Monocotyledonae (with one cotyledon)
- Dicotyledonae (with two cotyledon)

According to the number of cotyledons in the embryo.

- The plants included in the Monocotyledonae are called **Monocotyledonous plants or Monocots.**
- The plants included in the Diocotyledonae are called **Dicotyledonous plants** or **Dicots**.
- A few distinguishing characters of the two classes are given below.

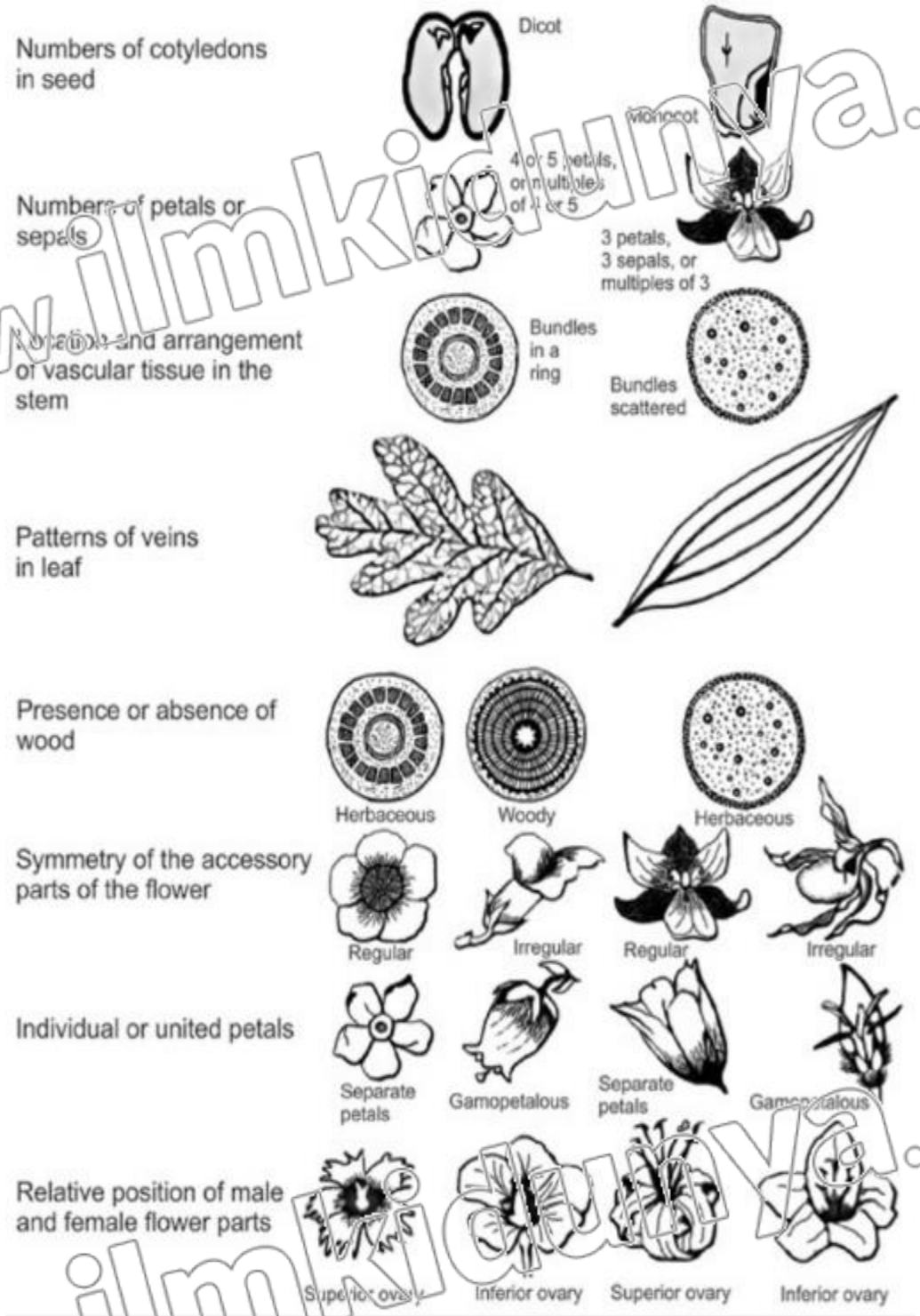


Fig. 9.4 Comparison of Dicot and Monocot

QUESTION RELATED TO ABOVE ARTICLE

Describe the differentiation between monocotyledon and dicotylendon plants. (Any four differences) (GRW-2017)

What two classes comprise the angiosperms? How do the two classes structurally differ from one another? Which class derived the other? Explain, Dicotyledons are considered to be derived from monocotyledons. (Exercise Question vi)

9.8.3 ANGIOSPERMIC FAMILIES

Some angiospermic families are described below:

1. Rosaceae (Rose family)
2. Solanaceae (potato family)
3. Fabaceae (Pea family)
4. Caeselpiniaceae (Cassia family)
5. Mimosaceae (Acacia family)
6. Poaceae (Grass family)

9.8.3.1 ROSACEAE (Rose Family)

Introduction

- It is also called ***rose family***.
- This family contains nearly ***100 genera*** and ***2000 species*** and is distributed over most of the earth.
- ***In Pakistan***, 29 genera and about 213 species are reported.

Familiar Plants

Pyrus (pear), ***Rosa*** (rose), ***Malus*** (apple), ***Fragaria*** (strawberry) etc.

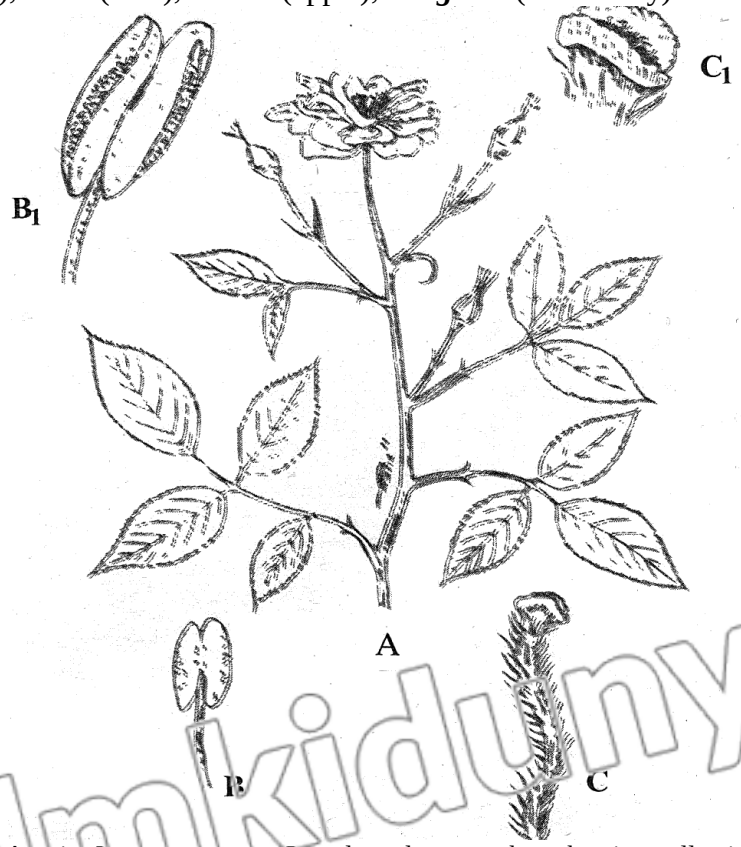


Fig: 9.25 Rosaceae: A-twig, B-young stamen; B_1-enlarged open anther, showing pollen in it; C-style hairy and stigma bilabiate; C_1- enlarged bilabiate stigma.

Vegetative Characters

- ***Plants*** are trees, shrubs and herbs.
- ***Stem*** of shrubby plants usually have spines.
- ***Leaves*** are alternate, rarely opposite, simple or compound, with paired stipules, which are sometimes attached to the petiole. Spines may also occur on the rachis.

Floral Characters

- ***Inflorescence*** is variable, solitary or may be racemose or cymose cluster.
- ***Flowers*** mostly bisexual, actinomorphic, often perigynous to some degree, usually showy and scented.
- ***Calyx*** consists of 5 sepals rarely 4, which are united at the base.
- ***Corolla*** consist of 5 petals or multiple of 5, which are free, rosaceous, large and showy.
- ***Androecium*** consists of numerous stamens, sometimes only 5 or 10.
- ***Gynoecium*** is of one to numerous separate carpals or variously united, ovary generally superior, sometimes inferior.
- ***Placentation*** is basal, when the carpal is one or apocarpous, but axile when the carpals are many and syncarpous (fused).

Economic Importance

Economic importance of this family is great in providing the pleasure and welfare to mankind. The members of this family are important in temperate regions for fruit and ornamentals. Perhaps they rank third in commercial importance in the temperate zone among the families of flowering plants.

Some economically important points are as follows.

Production of Fruits

Important fruits are apple, pear, peach, almond, apricot, strawberry etc.

Use as Ornamentals

A large number of plants are ornamental and are grown in gardens for their beautiful and scented flowers. The most widely cultivated genus for decorative purpose is *Rosa* (rose). Roses which have been grown in gardens since ancient times are now numbered in thousands.

Many other genera are also grown for their beautiful flowers in the parks and gardens.

Use as Wood and Walking Sticks

The branches of *Cretaegus* provide excellent walking sticks and wood. The wood of *Pyrus pastia* is used for making tobacco pipes.

Production of Different Substances

- In Asian countries, the petals of common rose usually called gulabs are used in making 'gulkand'.
- These petals are also used in extraction of an essential oil (rose oil) used as perfume.
- When distilled with water, the petals of rose give rose-water or 'Ark-e-Gulab', which is used for curing eye diseases and for many other purposes.

9.8.3.2 SOLANACEAE: Night shade or potato family

Introduction

- It is also called ***potato family***.
- It is family of about ***90 genera*** and ***2000 species*** of tropical and temperate distribution.
- ***In Pakistan***, 14 genera and about 52 species are reported.

Familiar Plants

Solanum tuberosum (potato), ***Nicotiana tabacum*** (tobacco), ***Lycopersicum esculentum*** (tomato) and ***Capsicum frutescens*** (red pepper).

Fig 9.26 Solanaceae: *Solanum nigrum*, A-twig, B-Flower C-fruit, D-seed

Vegetative Characters

- ***Plants*** including in this family are herbs, shrubs, sometimes trees or vines.
- ***Stem*** is hairy or prickly.
- ***Leaves*** are alternate or rarely becoming opposite in the floral region. They are simple, petiolate, rarely sessile.

Floral Characters

- ***Inflorescence*** is typically axillary cyme or combination of cymes, sometimes helicoids or axillary umbellate cyme.
- ***Flowers*** are mostly bisexual, usually actinomorphic or weakly zygomorphic, hypogynous, usually pentamerous.
- ***Calyx*** consists of 5 united sepals, which are usually persistent.
- ***Corolla*** consists of 5 united petals, which are rotate to tubular.
- ***Androecium*** consists of 5 free stamens but inserted on corolla (epipetalous). Rarely stamens 4 and didynamous (arranged in two whorls of 2 each).
- ***Gynoecium*** is a compound pistil of 2 united carpals. Ovary is obliquely placed, superior, bilocular or imperfectly 4-locular by false septum.
- ***Placentation*** is axile.

Economic Importance

Members of the family Solanaceae provide drugs and food, some are weedy, some are poisonous and others are handsome ornamentals.

Use as Food

- The most important plant in the family is *Solanum tuberosum* (potato-white or Irish potato). In Ireland, people are completely dependent on potatoes.
- ***Lycopersicum esculentum*** (tomato), the favourite home garden vegetable, was once believed to be poisonous.
- The fruits of ***Capsicum annum*** and ***Capsicum frutenscens*** are rich in vitamin C and A and are used as condiment.
- ***Physalis*** (ground-cherry produces an edible fruit enclosed in a bladder like persistent calyx, the husk, giving the name husk tomato.

Medicinal Importance

Many members of this family yield powerful alkaloids e.g. *Atropa belladona, Datura* which are rich in atropin and daturine respectively are used medicinally.

Use as Ornamentals

Many plants are cultivated in the gardens for their beautiful flowers, these include *Petunia, Nicotiana, Cestrum* and *Solanum* etc.

9.8.3.3 FABACEAE: (Papilionaceae) Pea family

Introduction

- It is also called ***pea family or Papilionaceae***.
- It is a family with about ***400 genera*** and ***9000 species***.
- Members of this family occur all over the world, but particularly in the warm temperate regions.
- ***In Pakistan***, about 82 genera and about 587 species have been reported.

Familiar Plants

Lathyrus odoratus (sweet pea), ***Arachis hypogea*** (peanut), ***Cicer arietinum*** (chick Pea) and ***Dalbergia sisso*** (shisham).

Fig: 9.27 Fabaceae (Papilionaceae): *Seastania sesbar*; A-twig; B-flower; B1 standard verilium; C-fruit a legume; D-carpel

Vegetative Characters

- ***Plants*** are herbs, shrubs and trees.
- ***Stem*** is herbaceous or woody or climber by tendrils (wiry, coiled thread-like structures).
- ***Leaves*** are compound or rarely simple, sometimes partially or completely modified into tendrils, alternate, stipulate. Stipules are mostly leafy.

Floral Characters

- ***Inflorescence*** is racemose or solitary axillary.
- ***Flowers*** are bisexual, zygomorphic, bracteate, pedicellate, perigynous, pentamerous and papilionaceous.
- ***Calyx*** consists of 5 sepals, more or less united in a tube, mostly hairy.
- ***Corolla*** consists of 5 petals, papilionaceous, usually clawed, dissimilar.
- The upper posterior petal is large and conspicuous and is called ***standard or vexillium***.
- 2 lateral ones are free called ***wings***.
- 2 anterior inner most that fuse to form a boat-shaped structure called ***keel or carina***.
- ***Androecium*** consists of 10 stamens, mostly diadelphous (united by their filaments in two groups), 9 fused to form a sheath round the pistil, while 10^{th} posterior one is free.
- ***Gynoecium*** consists of one carpal with one locule. Ovary is superior, style is long and slightly bent.
- ***Placentation*** is marginal.
- ***Fruit*** is usually a legume or pod, showing a great variety of form in various species.

Economic Importance

The family is of considerable importance as a source of high-protein food, oils and forage as well as ornamentals and other uses. Some economically important points are as follows:

Use as Food

Pulses belonging to this family are used as food. Some important and common species of pulse yielding plants are gram, pea, and bean. These pulses are rich in protein contents.

Forage for Animals

Medicago sativa (Alfafa) is one of the world's best forage crop for horses. ***Melilotus*** and ***Trifolium*** are also cultivated as main fodder crops.

Timber Plants

Many trees of this family provide excellent timber for building, furniture and fuel. Main timber plants are *Butea*, *Dalbergia* etc.

Production of Different Substances

- Seeds of ***Arachis hypogea*** (peanut) are edible and are also used for extraction of peanut oil, which after hydrogenation is used as vegetable oil.
- Indigo dyes are obtained from ***Indigofera tinctoria*** and yellow dyes from flowers of ***Butea monosperma*.**
- The red and white seed of *Abrus precatorious* are used by jewelers as weights called 'ratti'.

Production of Medicines

Many plants of this family are important for medicines. These include

- ***Glycyrrhiza glabra*** for cough and cold
- ***Clitoria ternatea*** is used against snake bite.

Ornamental Plants

Some important ornamental plants include *Lathyrus, Lupinus, Clitoria, Butea* etc.

9.3.4 CAESALPINIACEAE: Cassia family

Introduction

- It is also called as ***Cassia family***.
- This family includes about ***152 genera*** and ***2300 species***.
- ***In Pakistan***, the family is represented by 16 genera and about 60 species.

Familiar Plants

Tamarindus indica*, *Cassia fistula (amaltas), ***Bauhinia veriagata*** (kachnar), ***Cassia*** etc.

Fig: 9.28 Caesalpiniaceae: *Cassia senna*; A twig, B-flower; C-fruit

Vegetatice Characters

- ***Plants*** are mostly trees and shrubs, some are woody climbers, rarely herbs.
- ***Stem*** is erect, woody, herbaceous or climbing.
- ***Leaves*** are compound, pinnate, very rarely simple stipulate.

Floral Characters

- ***Inflorescence*** is axillary or terminal raceme or panicle or spikes, rarely cymose, showy.
- ***Flowers*** are bisexual, zygomorphic, rarely actinomorphic and perigynous.
- ***Calyx*** consists of 5 sepals, free or connected at base, often coloured.
- ***Corolla*** consists of 5 petals, which are free.
- ***Androecium*** consists of 10 stamens or fewer, rarely numerous, free or variously united.
- ***Gynoecium*** consists of a simple pistil (1-carpal). Ovary is superior, unilocular, stigma is simple.
- ***Placentation*** is marginal.
- ***Fruit*** is legume.

Economic Importance

The family is of great importance. Some plants are ornamental, some have medicinal importance, and a few have food and other values.

Use as Medicine

- The leaves of ***Cassia alata*** are used to cure ring worm and skin diseases.
- ***Cassia senna*** **and** ***Cassia obovata*** are cultivated for the leaves, which yield the drug Senna, which is the base for a laxative.
- Oil extracted from the seeds of ***Cynometera cauliflora*** is applied externally for skin diseases.

Ornamental Plants

Common ornamental plants are ***Bauhinia variegata*** (kachnar), ***Cassia fistula*** (amaltas), ***Parkinsonia*** etc.

Use as Food

- The leaves and flower buds of ***Bauhinia variegata*** are used as vegetables.
- The acidic fruit of ***Tamarindus indica*** are edible and are rich in tartaric acid.

Production of Different Substances

- The bark of ***Bauhinia*** and ***Tamarindus indica*** is used in tanning.
- The heartwood of ***Haematoxylon*** (Longwood) yields the dye, Haematoxylin.

9.8.3.5 MIMOSEAE: Mimosa or Acacia Family

Introduction

- It is also called ***Mimosa or Acacia family***.
- It is a family of about ***56 genera*** and ***2800 species***.
- ***In Pakistan***, it is represented by 11 genera and 49 species, of these only 4 genera and 18 species are native and rest are introduced.

Familiar Plants

Acacia nilotica, Albizzia lebbek, Mimosa pudica (touch me not), ***Prosopis glandulosa, P. cineraria.***

Fig: 9.29 Mimosaceae: *Prosopsis cineraria*; A-twig, B-inflorescence; C-flower; -D-fruits

Vegetative Characters

- Mostly ***plants*** are trees or shrubs, rarely climbers or herbs. Most of them are xerophytes.
- ***Stem*** is mostly woody.
- ***Leaves*** are pinnate by compound, alternate and stipulate, stipules modified into thorns.

Floral Characters

- ***Inflorescence*** is spike-like or head or umbel, rarely racemose or globos umbels.
- ***Flowers*** are bisexual, actinomorphic, hypogynous to slightly perigynous and bracteate.
- ***Calyx*** usually consists of 5 sepals which are generally fused, toothed or lobed.
- ***Corolla*** consists of 5 petals, which are free or fused and lobed.
- ***Androecium*** consists of 5 to numerous stamens, which are free or adnate to the base of corolla.
- ***Gynoecium*** consists of a simple pistil of 1 carpal, ovary unilocular, superior. Ovules are many.
- ***Placentation*** is marginal.
- ***Fruit*** is legume, dehiscent or indehiscent.

Economic Importance

Production of Wood

Many trees of this family including species of ***Acacia***, ***Albizzia*** and ***Xylia*** provide commercially important wood, which is used for construction purpose or for furniture or as a fuel. The wood of ***Albizzia lebbek*** is used in cabinet work and railway carriage.

Production of Different Substances

- Arabic gum is obtained from ***Acacia nilotica*** and ***A. sensegal*.**
- Katha, a dye, is obtained from ***Acacia catechu*.**

Medicinal Importance

- The tender leaves of ***Acacia nilotica*** are used as blood purifier.

Ornamental Plants

- Some common garden plants grown for their beautiful flowers are ***Mimosa pudica*** and ***Acacia melanoxylon*.**
- A few species of *Prosopis* are planted in the arid zones for breaking the wind pressure.

9.8.3.6 POACEAE: (Gramineae) Grass Family

Introduction

- It is also called as ***gramineae or grass family***.
- It is distributed throughout the world wherever vascular plants can survive.
- It includes ***600 genera*** and ***10,000 species***.
- ***In Pakistan***, it is represented by 158 genera and 492 species.

The traditional family name Gramineae takes its name from the Latin Grammar, which was used as a 'generic' name for certain grasses.

Familiar Plants

Triticum vulgare (wheat), ***Zea mays*** (corn), ***Avena sativa*** (oats), ***Oryza sativa*** (rice), ***Bambusa*** (bamboo), ***Saccharum officinarum*** (sugar cane) etc.

Vegetative Characters

- ***Plants*** are annual or perennial herbs.
- ***Stem*** is jointed, usually hollow at the internodes, closed at the nodes.
- ***Leaves*** are solitary at the nodes, sometimes crowded at the base of the stem, alternate, exstipulate, ligulate, mostly sessile, leaf-base mostly sheathing, simple.

Floral Characters

Inflorescence is mostly compound, composed of units called spikelets,

- These are variously arranged (indense clusters as in wheat compound spike or loosely on branched axis-panicle as in spikelets etc).
- Each ***spikelet*** consists of ***bracts***.
- These bracts are arranged along a slender axis called ***rachilla***.
- There are two lower bracts called ***glumes***, which are empty. Other two bracts, ***lemma*** enclosing a flower and opposed by a hyaline scale called ***palea***.
- The whole (lemma, palea and flower) is termed as ***floret***.
- The glumes or lemmas often bear one or more stiff bristles called ***awns***.
- This basic pattern of spikelet structre is consistent throughout the family. Spikelets of grasses vary widely in different genera, particularly as to number of fertile florets in each and deposition of sexes with them.

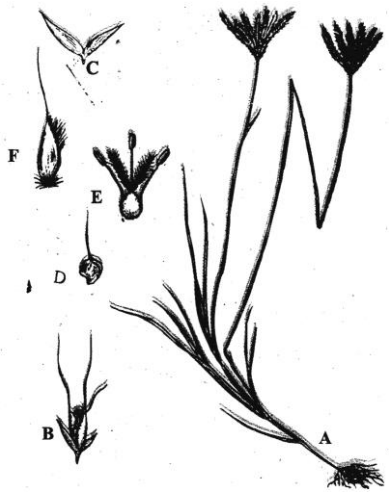


Fig. 9.30 Poaceae (Gramineae): *Chloris barbata*; A-Habit; B-spikelet; C-gulumes; D-fertile lamma, E-flower; F-fruit;

- ***Flower*** is usually bisexual, sometimes unisexual, small and inconspicuous, sessile, bracteate, incomplete, zygomorphic, hypogynous.
- ***Perianth*** is absent or represented by 2, rarely 3, minute hyaline or fleshy scales called lodicules.
- ***Androecium*** consists 1 to 6 stamens, usually 3 with delicate filaments.
- ***Gynoecium*** consists a compound pistil of 3 united carpals, stigmas usually large and feathery.
- ***Fruits*** are grains or caryopsis (caryopsis a dry, indehiscent fruit in which fruit wall, pericarp' is completely fused with seed coat).

Economic Importance

Economically family Poaceae has greater importance than any other family of flowering plants. It has great economic importance to both man and animals.

Use as Food

Cereals and millets, which constitue the chief food stuff of mankind, belongs to this family.

Plants providing food for man are ***Triticum vulgare*** (wheat), ***Avena sativa*** (oats), ***Zea mays*** (corn), ***Oryza sativa*** (rice), ***Hordeum vulgare*** (barley), ***Secale cereale*** (rye), ***Penisetum typhoideum***, ***Sorghum vulgare*** etc.

Sugar is obtained from the juice of ***Saccharum officinarum*** (sugar cane).

Use as Fodder

Most of the fodder crops, which are equally important to domestic animals, belong to this family.

The dried stem and leaves of the cereal crops are used as fodder for the cattle.

Production of Different Substances

- Certain grasses yield aromatic oils e.g. ***Cymbopogon citratus*** (lemon grass), which yield lemon grass oil. It is used in perfumes and soap industry and for making infusions.
- Some species of grasses are used in making papers.
- Ethyl alcohol and many other kind of beverages are also prepared from cereals e.g. whisky from rye, barley, corn and rum molasses from sugar cane.
- Fibers obtained from leaves of ***Saccharum munja***, which is used in making ropes.

Use of Bamboo

- ***Bambusa*** (bamboo) are used as building material for the thatching huts, making boats, carts, pipes etc. and the split stem are woven into mats, baskets, fans, hats, course umbrella.
- Leaves are also given to horses as a cure of cough and cold etc.

QUESTION RELATED TO ABOVE ARTICLE

Explain the floral characters of family Solanacea.

What are the floral characters of family Poaceae and discss its economic importance.

Give economic importance of family Poaceae (LHR 2019, SGD 2019, FSD 2021)

How family poaceae is economically important for human? (BWP 2022)

KEY POINTS

Technical Terms of plant:

Herb:

An annual green small sized plant is called herb. They have soft and usually green stem e.g. radish.

Shrub:

The woody green plant whose main stem cannot be distinguished from its branches is called shrub. Its size is less than 6 feet.

Tree:

It is perennial green woody plant with a distinct upright (straight) stem of 6 feet or more is called tree.

Annual:

A plant which survives only one season like wheat is called annual plant.

Biennial:

A plant which survives in two growing seasons like radish is called biennial plant.

Perennial:

A plant which survives many seasons like trees is called perennial plant.

Rhizome:

A horizontal underground stem which store food is called rhizome e.g. Ginger

Technical terms of Leaves:

Sessile:

Leaves without stalk (petiole) are called sessile.

Petiolate:

Leaves with stalk are called petiolate.

Arrangement of leaves on stem:

It may be

Opposite:

It this case, two leave arise on the same point on stem at opposite direction.

Alternate:

In this case, leaves are arranged alternatively (one leave on one side other on the other side and so on) on stem.

Stipules:

The pair of lateral outgrowths present at base of petiole of leaf is called stipules. A leaf with stipules is called **stipulate** and a leaf without stipule is called **ex–stipule.**

Adnate Stipule:

In this case, the stipules fuse with the petiole to form a winged shaped petiole.

Simple Leaf:

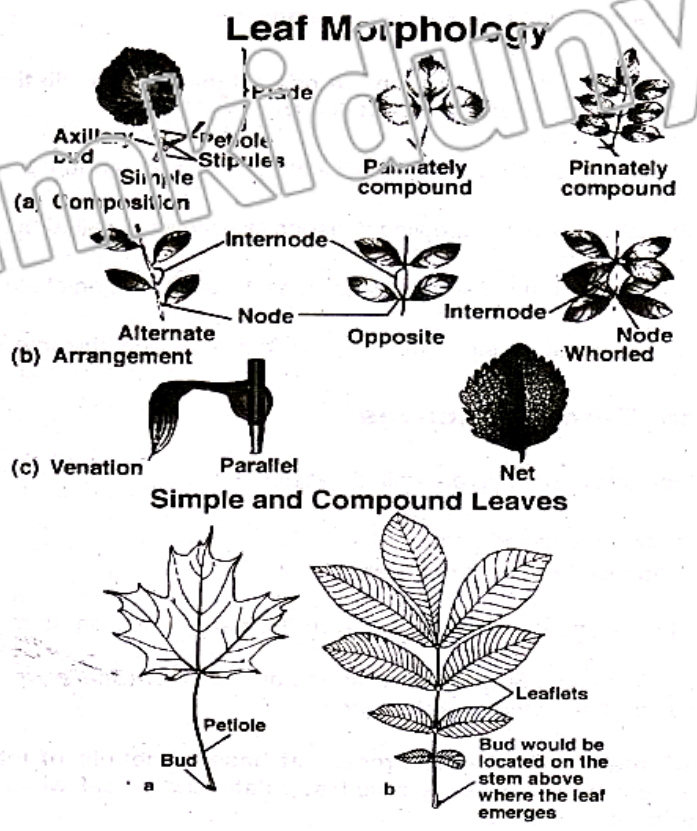
The lamina of simple leaf form one piece and it is not divided into small leaflets.

Compound leaf:

In this case, the lamina is divided into small leaflets. A compound leaf is composed of a fix number of leaflets.

Pinnate leaf:

Pinnate leaf has a single midrib. All the lateral veins arise from this single midrib. **[Opposite Palmate].**



Pinnate compound leaf:

When the leaflets of a compound leaf arise from the sides of the rachis, the leaf is said to be pinnate compound leaf, e.g. leaf of rose.

Ligule:

It is small single outgrowth at the base of lamina of leaf. It is directed upwardly. The leaves with ligule are called ligulate, e.g. Wheat.

Inflorescence:

Group of flower is called inflorescence. It is of two types:-

Racemose:

In this case, the main axis (stem) continues to grow and develop lateral flowers. It may be:

(1) Terminal raceme:

When Racemose inflorescence is present at top of the stem.

(2) Panicle:

A branched raceme is called panicle.

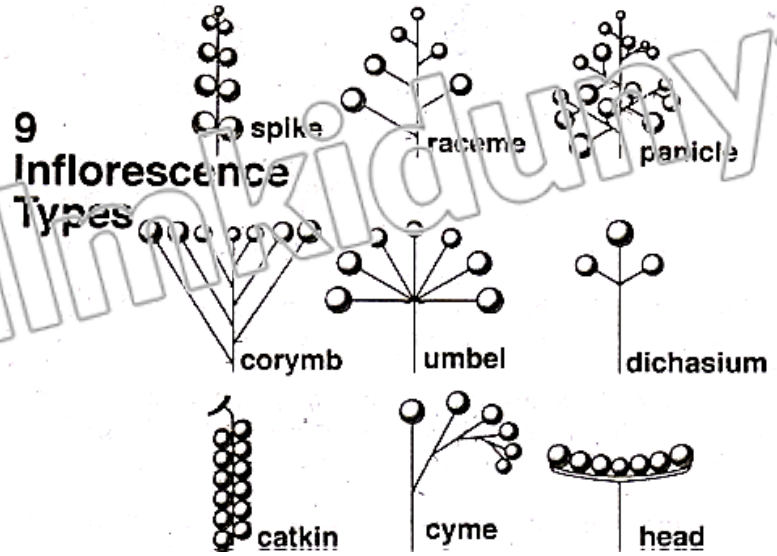
(3) Spike:

In this case, the flowers in racemose inflorescence are sessile (without pedicel). Sometime the spike has many small units called **Spikelets.**

(4) Umbel:

In this case, the main axis is so short that flowers appear to be arised form the same point. When umbel is present in rounded shape it is called

Globose umbel:



Cymsoe:

(1) Axillary cyme:

In this case the braches are present on the same side the main axis and the main axis seem straight with lateral braches. It is called **Axillary umbellate cyme,** the flowers are present in clusters and they have Axillary cyme inflorescence, e.g. onion.

(2) Helicoid:

In this case, the new braches arise alternatively on the main axis (first on one direction and the other on the opposite direction and so on).

Solitary:

The single flower is called solitary. It is called **Axillary solitary,** when it is present at lateral side of the stem. It is called terminal solitary, when it is present at tip of the stem.

Technical terms of Flowers:

Monosexual:

When one of stamen or carpel is present.

Bisexual:

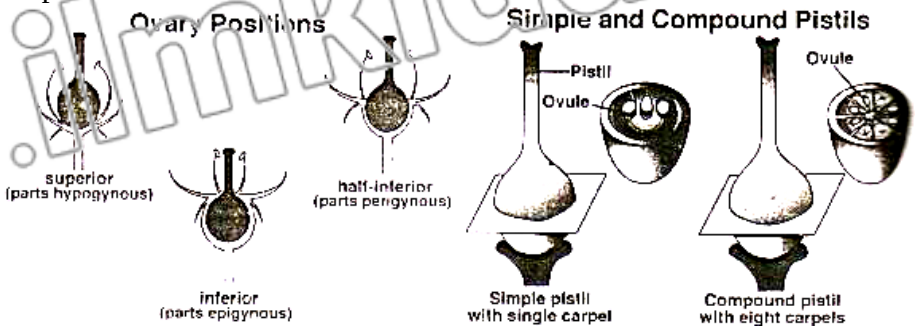
When both stamen and carpel are present.

Actinomorphic:

When a flower can be cut into two equal halves by more than one plane, it is called Actinomorphic flower.

Zygomorphic:

When a flower can be cut into two equal halves by only one plane, it is called zygomorphic flower.



Bract:

Bract is a special leaf in the axil of which flower arises. The flower with bract are called bracteate and without bract are called ebracteate.

Hypogynous:

In this case, the thalamus (upper part of pedicel) is convex. The carpel attach at the tip. The stamen, sepals are inserted below the gynoecium on the side. So ovary is superior.

Perigynous:

In this case, the thalamus is flattened. Ovary is present in the centre. The stamens, sepals, petals are inserted on the rim of the disc around the gynoecium. So ovary is superior.

Persistent sepals:

If sepals do not fall after the opening of flower, they are called persistent sepals.

Epipetalous stamen:

It the stamens are attached with the petals, they are called epipetalous.

Adelphous:

It he stamens are fused by their filaments, this condition is called Adelphous.

Placentation:

The attachment of ovule in the ovary is called placentation. There are different types of placentation.

(1) Basal:

In this case, the ovule is attached at the base of ovary.

(2) Axile:

In the case there is a central axil (rod) inside the ovary. The ovule attach on this axil.

(3) Marginal:

In this case the ovules are attached on the inner wall of the ovary.

Simple pistil:

In this case, the carpels are not fused.

Compound pistil:

In this case, one or more carpels are fused.

Unilocular overy:

In this case, the ovary has single chamber.

During the past few decades biologists have been trying to classify living organisms into various groups which could logically reflect their similarities and dissimilarities at various levels.

The groups were supposed to foreshadow the natural relationships among living organisms and their mode of origin. Such a system of classification is called ***Phylogenetic System of Classification*.**

Main Features of Kingdom Plantae

Kingdom Plantae mainly includes organisms which are;

- Eukaryotic
- Autotrophic
- Multicellular
- Non-motile
- Developing from embryos
- Having cell wall outer to cell membrane, which is composed of cellulose?

There are about 360,000 known species of plants

EXERCISE

Q 1

Fill in the Blanks.

i) The sporophyte is _____ and _____ generation and the gametophyte is _____ and _____.

ii) The motile asexual reproductive cells are characteristics of _____ and are called _____.

iii) The sexual reproduction is said to be oogamous or heterogamous if the two fusing gametes are _____.

iv) In the stem of monocotyledons, the bundles are _____ while in the stem of dicotyledons, they are _____.

v) The double fertilization is the characteristic feature of _____.

vi) Stem, roots and leaves are the _____ parts and flowers, fruits and seeds are the _____ parts of the plant.

vii) _____ is the phenomenon of the production of two kinds of spores in the plants.

viii) The naked-seeded plants are included in the group _____.

Ans

i) Diploid, Dominant, Haploid, Reduced
ii) Sporophyte, Spores
iii) Different
iv) Scattered, in rings
v) Angiosperms
vi) Non-reproductive, Reproductive
vii) Heterospory
viii) Gymnospermae

Q.2. Short Questions

Q.1 (a) How are ferns better adapted to life on land than liverworts and mosses?

Liverworts and mosses are non-vascular while ferns are vascular plants. Vascular tissue is involved in support and transport of material.

(b) Which of the following are nutritionally self-supporting?

1. Mature liverwort and moss gametophyte.

2. Mature liverwort and moss sporophyte.

Q.2 (a) The chances of survival and development of wind-blown pollen grains are much less than those of spores of Adiantum. Comment on this statement.

Wind-blown pollen grains are widely dispersed and mostly are lost due to unfavourable conditions while spores of adiantum usually fall on nearby moist place and germinate.

(b) Account for the fact that megaspores are large and microspores are small.

Megaspore is seven-cell structure while microspore is two-cell structure.

(c) What important advances have angiosperms made towards the seed plant habit?

There are two important adaptations.

- Seed enclosed in fruits.
- Double fertilization

Q.3 Write a note on alternation of generations.

Ans: Alternation of Generations:

The mechanism by which a multicellular, diploid, sporophyte generation alternates with another multicellular, haploid, gametophyte generation is called alternation of generations.

In Land Plants:

it is heteromorphic alternation of generations.

Q.4 What is the importance of the following?

(a) Seed

In higher vascular plants, seed is involved in formation of new Sporophyte. In some cases, it is also used as food.

(b) Double Fertilization
Double fertilization ensures formation of fruit and maximum supply of food for nourishment of developing embryo.

(c) Heterospory
It is production of different spores and is most successful type of reproduction in plants.

Q.5 Pick and match the following.

Column I	Column II	Answer
i) Fern Sporophyte	Involves vegetative parts of plants	i) Is a diploid generation
ii) The moss plant	Is the first cell of Sporophyte	ii) Is gametophytic generation
iii) The gamete	Is the last cell of gametophyte	iii) Are haploid cells
iv) The spores	Are asexual reproductive cells	iv) Are asexual reproductive cells
v) Vegetative reproduction	Are haploid cells	v) Involves vegetative parts of plants
vi) The oospore	Is gametophytic generation	vi) Is the last cell of gametophyte
vii) The gamete	Is a diploid generation	vii) Is the first cell of gametophyte
viii) The spore mother cell	Is the first cell of gametophyte	viii) Divided by reduction division to form haploid spores
ix) The spore	With naked seeds	ix) Is the first cell of Sporophyte
x) Gymnosperms are the plants	Divided by reduction division to form haploid spores	x) With naked seeds

Q.6 Sketch and label fertile pinnule and sporangium of Adiantum. (Answer Missing)

Q. 3. Encircle the correct answer from the multiple choices.

i) All bryophytes (mosses, liverworts and hornworts) share certain characteristics. These are:
(a) Reproductive cells in protective chambers and a waxy cuticle.
(b) A waxy cuticle, true leaves and reproductive cells in protective chambers.
(c) Vascular tissue, true leaves and a waxy cuticle.
(d) Reproductive cells in protective chambers and vascular tissues.

ii) A heterosporous plant is one that:
(a) Produces a gametophyte that bears both sex organs.
(b) Produces microspores and megaspores in separate sporangia, giving rise to separate male and female gametophytes.
(c) Is a seedless vascular plant.
(d) Produces two kinds of spores, one asexually by mitosis and one type by meiosis.

iii) The male gametophyte of an angiosperm is the:
(a) Anther
(b) Embryo sac
(c) Microspore
(d) Germinated pollen grain

iv) Important terrestrial adaptations that evolved exclusively in seed plants include all of the following except:
(a) Pollination by wind or animal instead of fertilization by swimming sperms
(b) Transfer of water through vascular tissues
(c) Retention of the gametophyte plant within the Sporophyte
(d) Protection and nourishment of the embryo within the seed

Answers Key:

i	**a**
ii	**b**
iii	**d**
iv	**d**

Q .4. Extensive Questions.

i) To what does alternation of generations refer in the plants? Describe Sporophyte and gametophyte. With which stage is an adult animal comparable? How are they reproductively dissimilar?

Ans: (See article 9.4.4)

ii) What is a seed? Why is the seed a crucial adaptation to terrestrial life?

Ans: (See article 9.6)

iii) Describe evolution of leaf and its importance in vascular plants.

Ans: (See article 9.5.1 a)

iv) Discuss evolution of seed and its significance.

Ans: (See article 9.6)

v) In what way do the flowering plants differ from the rest of the seed plants? What is the stigma? Is fertilization in angiosperms direct or indirect? From what tissue does angiosperm fruit develop?

Ans: (See article 9.8)

vi) What two classes comprise the angiosperms? How do the two classes structurally differ from one another? Which class derived the other? Explain, Dicotyledons are considered to be derived from monocotyledons.

Ans: (See article 9.8.2)