Contents

Bryophytes

The land plants or **Embryophytes** are placed in Embryophyta or **Metaphyta**. Plants of this group live primarily in terrestrial habitats, in contrast with the related green algae that are primarily aquatic. The embryophytes include trees, flowers, ferns, mosses, and various other green land plants.

- All of these plants are complex multicellular eukaryotes with specialized reproductive organs.
- With very few exceptions, embryophytes obtain their energy through photosynthesis (that is, by absorbing light); and they synthesize their food from carbon dioxide.
- Among the embryophytes, the simplest are Bryophytes which are generally known as **Mosses**.

Braun used the term Bryophyta for the first time in 1864. The branch of science that deals with Bryophytes is called Bryology.

- The first thing about the Bryophytes we should know is that they don't have a vascular tissue such as Xylem and Phloem, which we find in plants of higher orders.
- Due to this, they are also known as ***Atracheates*** which means no trachea.

In India, **S R Kashyap** did a commendable job in the studies of Bryphytes and that is why is called Father of Indian Bryology.

Bryophytes commonly grow close together in clumps or mats in damp or shady locations. They do not have flowers or seeds, and their simple leaves cover the thin wiry stems. Please note that in Bryophytes, the dominant phase of life is **not the plant itself but one of its phases in reproduction called gametophytes**. The only thing you need to remember is that gametophyte contains a single set of Chromosome and that is why the "**Bryophytes are in Haploid state in most of their lives**".

At certain times, mosses produce spore capsules, which may appear as beak-like capsules borne aloft on thin stalks.

These gametophyte produces male or female or both gametes (term used for sperms or ovum lower plants) by mitosis. When male and female gametes fuse, they make a diploid zygote, which develops by repeated mitotic cell divisions into a multicellular **Sporophyte**. This **Sporophyte is diploid** because it is a product of fusion of two haploid gametes. This Sporophyte is NOT independent in Bryophytes and needs to get nutritional support from the gametophyte.

Now, this diploid phase Sporophyte again produces sex cells via meiosis, which are called spores. During making of spores, the chromosome pairs are separated once again to form single sets. The spores are therefore once again haploid and develop into a haploid gametophyte. This is how the lifecycle of a Bryophyte goes on.

Importance of Bryophytes

Now here are some more important points which you need to know about bryophytes:

- Bryophytes are called the "amphibians" of the plant kingdom. They can live on land but for reproduction and fertilization, need water essentially. Bryophyte are also the first land inhabitating plants.
- The Bryophytes were the first plants in which alternation of generation was seen for the first time in the embryophytes as Gametophyte → Mitosis → gametes →Sporophyte → Spores → Meiosis →Gametophytes.
- One of the famous Bryophyte is **Peat Moss**. Its botanical name is *Sphagnum*. It grows in swamps and damp areas. This is one of the most economically important Bryophyte. You must know that in World War I, it was used as "dressing cotton' for wounded soldiers. Peat is obtained from Sphagnum.
- Typically, a Bryophyte is 1-4 cms long but *Dawsonia* is a large and perhaps largest Bryophyte, which reaches up to 60-70 cm.
- Some Bryophytes living in water such as *Riccia fluitans*, *Ricciocarpus natans* and *Sphagnum*
- Some Bryophytes are saprophytes means they thrive on dead and decaying matter. Example is some species of *Buxbaumia*.
- Some Bryophytes are epiphytics means they live on another plants. Example is *Dendroceros*.
- *Physcomitrella patens* is increasingly used in biotechnology. Prominent examples are the identification of moss genes with implications for **crop improvement or human health** and the safe production of complex biopharmaceuticals in the moss bioreactor.

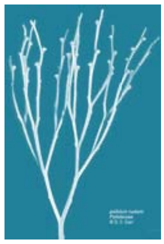
Pteridophytes

Pteridophytes are commonly known as **Ferns**. There are around 12,000 species of Ferns, many of them are generally used a **decoration / ornamental plants.** In the evolutionary stages, Ferns are next advanced level after Bryophytes.

As we read above the Bryophytes don't have the vascular tissues, but the Ferns have **BOTH xylem and phloem**, thus they are the **first vascular plants**. They have stems, leaves, and roots like other vascular plants.

- They differ from the advanced plants on the basis of the Reproduction procedures. They differ from gymnosperms and angiosperms as they **do not have neither flowers nor seeds**.

- As we read above that in case of the Bryophytes , the dominant phase of life is gametophytes. This reverses from Pteridophytes ONWARDS.
- This means that in Pteridophytes the dominant phase of life is Sporophyte. This Sporophyte is NOT only independent but also long lived.
- The plant, like the advanced plants is divided into root, stem and leaf. But some of the primitive Pteridophytes have false roots, means they cannot be called true roots. The stem is dichotomously branched which means two branches emerge from one branch as shown in the figure.
- The leaves can be small as well as big making them either microphyllous or megaphyllous. If leaves are small, the stem would be generally large and if leaves are big, the stem would be generally small.
- The Xylem and Phloem are the vascular tissues but they are primitive. This means that the Xylem lacks the Vessels and Phloem lacks the companion cells.



The reproduction in Ferns is generally asexual but they have sexual reproduction also. Sexual Reproduction causes the alternation of generations, characterized by a diploid Sporophyte and a haploid gametophyte phase. Unlike the gymnosperms and angiosperms, the **ferns' gametophyte is a free-living organism**.

Importance of Pteridophytes

- The Pteridophytes have vascular tissues and so have the Gymnosperms and Angiosperms. So they all together are called Vascular Plants or Tracheophytes or Tracheophyta.
- The smallest fern is *Azolla*. We must note that Azolla has the capability of Nitrogen Fixation and this has led to *Azolla* being widely used as a biofertiliser, especially in parts of southeast Asia. Indeed, the plant has been used to bolster agricultural productivity in China for over a thousand years.
- When rice paddies are flooded in the spring, they can be inoculated with Azolla, which then quickly multiplies to cover the water, suppressing weeds. The rotting plant material releases nitrogen to the rice plants, providing up to nine tonnes of protein per hectare per year.
- In addition to its traditional cultivation as a bio-fertilizer for wetland paddy (due to its ability to fix nitrogen), azolla is finding increasing use for sustainable production of livestock feed. Azolla is rich in proteins, essential amino acids, vitamins and minerals. Studies describe feeding azolla to dairy cattle, pigs, ducks, and chickens, with reported increases in milk production, weight of broiler chickens and egg production of layers, as compared to conventional feed. One FAO study describes how azolla integrates into a tropical biomass agricultural system, reducing the need for inputs.
- Osamunda regalis is known as Indian Royal Fern.
- *Dryopteris filix-mas* is used an anti-helminth means anti worm, used in Pharmacy.
- Parts of *Pteridium aquilinum* or *Pteridium esculentum*, are used as a cooked vegetable in Japan and are believed to be responsible for the high rate of stomach cancer in Japan. It is also one of the world's most important agricultural weeds, especially in the British highlands, and often poisons cattle and horses.

Gymnosperms

Gymnosperms are called so because they have naked seeds. Therefore, they are superior to Pteridophytes because they are **seed-bearing plants, while Pteridophytes don't have seeds**. They are **inferior to Angiosperms** or Flowering plants because **their ovules are in an unenclosed condition** means naked. In the flowering plants or Angiosperms, the ovules are covered. The plants in this group are the conifers, cycads, *Ginkgo,* and Gnetales. Since both angiosperms and gymnosperms have seeds, both of them are placed in **Spermatophytes**.

- Generally, the plants of Gymnosperms are woody trees, shrubs and climbers. Many of them are xerophytes means they can survive where there is no water such as deserts.
- **Gymnosperms have tap roots.** Tap roots are somewhat straight to tapering plant root that grows vertically downward. It forms a center from which other roots sprout laterally. One common example of Tap root in Angiosperms is Carrot. Please note that plants which have tap roots are difficult to relocate or transplant.
- The roots of many Gymnosperms have **symbiotic relations with algae or fungi (mycorrhiza)**. For example, the roots of Pinus have mycorrhizal relations with a fungus.
- The stem is erect and similar to advanced plants. It may or may not be branched. Leaves are **either green or brown.** The Xylem has bordered pits BUT there are NO vessels. Vessels in Xylem are found in ONLY Angiosperms. There are no companion cells in Phloem. Companion cells in Phloem is found in ONLY Angiosperms.

Life Cycle of Gymnosperms

The dominant phase of life is **Sporophyte as in all other vascular plants.** The gametophyte is relatively short-lived. Two spore types, microspores and megaspores, are, in general, produced in pollen cones or ovulate cones, respectively, which can be called male cones and female cones. Male cone is small and short-lived. Female cone is large and long-lived. A short-lived multicellular haploid, gamete-bearing phase (gametophyte) develops inside the spore wall. Pollen grains (microgametophytes) mature from microspores, and ultimately produce sperm cells; megagametophyte tissue develops in the megaspore of each ovule, and produces multiple egg cells. Thus, megaspores are enclosed in ovules (unfertilized seeds) and give rise to megagametophytes and ultimately to egg cells. During pollination, pollen grains are physically transferred between plants, from pollen cone to the ovule, being transferred by wind or insects. Whole grains enter each ovule through a microscopic gap in the ovule coat (integument) called the micropyle. The pollen grains mature further inside the ovule and produce sperm cells.

Two main modes of fertilization are found in gymnosperms. Cycads and Ginkgo have motile sperm that swim directly to the egg inside the ovule, whereas conifers and gnetophytes have sperm with no flagella that are conveyed to the egg along a pollen tube. After fertilization (joining of the sperm and egg cell), the zygote develops into an embryo (young Sporophyte). More than one embryo is usually initiated in each gymnosperm seed. Competition between the embryos for nutritional resources within polyembryonic seeds produces programmed cell death to all but one embryo. The mature seed comprises the embryo and the remains of the female gametophyte, which serves as a food supply, and the seed coat (integument).

Importance of Gymnosperms

- Coast Redwood of California, which we know as the tallest plant / trees of the world are Gymnosperms. Its botanical name is *Sequoia sempervirens spp. gignatica*. The height is 420 fits and they are long living plants can live up to 1200-1800 years. The plant is an important timber.
- Many Gymnosperms are called the "living fossils". This is because many of them represent the one of the few, if not the only, surviving members of a taxonomic group, with no close living relatives. Well known example of a living fossils are Cycas and Ginkgo Biloba, a tree which is literally in a class by itself. Like many other living fossils, Ginkgo is also remarkably similar anatomically to older relatives in the fossil record.
- **Canada balsam** is obtained from *Abies balsamea*, a Gymnosperm. This is the resin of the plant, very sticky, colorless and odorless. It has high optical quality and was used once upon a time in making the invisible-when-dry glue for glass. Similarly, it was used as a glue for prisms. Today it is used to fix the scratches in the glasses and also in cough syrups.
- **Ephedrine**, which is used in Medicines as stimulant, appetite suppressant, concentration aid, decongestant, and to treat hypotension associated with anaesthesia, is obtained from *Ephedra distachya*, which is also a Gymnosperm. It has been used in the treatment of asthma and bronchitis for centuries. Please note that Ephedra is a naturally growing Gymnosperm in Rajasthan.
- **Sago** is a major staple food for the lowland peoples of New Guinea and the Moluccas. It is traditionally cooked and eaten in various forms, such as rolled into balls, mixed with boiling water to form a paste, or as a pancake. Sago is often produced commercially in the form of "pearls". Sago pearls can be boiled with water or milk and sugar to make a sweet sago pudding. It is obtained from *Cycas revoluta* and *Metroxylon.* Please note that **Sabudana,** which is used as a staple food in India, particularly in Hindu rituals and Vratas is NOT obtained by Cycas BUT is obtained from **tapioca roots which is an Angiosperm of family Euphorbiacae.**
- **Chilgoza** is obtained from *Pinus gerardiana*, known as the Chilgoza Pine. Chilgoza is one of the most important cash crops of tribal people residing in the Kinnaur district of Himachal Pradesh, which seems to be the only place in India where Chilgoza pines are found.
- Cedar wood is obtained from many species of the Gymnosperms. Similarly Chir wood is obtained from Chir Pine or *Pinus longifolia*. The Pinus species of Gymnosperms contain the "winged pollen grains". Pinus aristata is oldest living Gymnosperm.

Angiosperms

Angiosperms, flowering plants, or **Magnoliophyta**, are the most advanced, most diverse and most dominant group of land plants. They are seed-producing plants like the gymnosperms and can be distinguished from the gymnosperms by a series of derived characteristics such as flowers, endosperm within the seeds, and the production of fruits that contain the seeds. They have developed from Gymnosperms over the period and replaced them as most dominant group of plants some 100 million years ago.

- **Benefit of Flowers:** Due to Flowers, Angiosperms were able to adapt a wider range of ecological niches, making them largely dominate terrestrial ecosystems.
- **Reduced Male and Female Parts:** Instead of cones in Gymnosperms, the Angiosperms have stamens, reduced male parts and an enclosed ovule. The Stamens are much lighter than the

corresponding organs of gymnosperms and have contributed to the diversification of angiosperms through time with adaptations to specialized pollination methods. In some advanced species, the Stamens were modified to prevent self-fertilization, enabling further diversification.

- **Dominant Sporophyte:** The main plant of Angiosperms is a Diploid Sporophyte which is divided into roots, stems and leaves. The male gametophyte in angiosperms is significantly reduced in size compared to those of gymnosperm seed plants. The smaller pollen decreases the time from pollination — the pollen grain reaching the female plant — to fertilization of the ovary; in gymnosperms, fertilization can occur up to a year after pollination, whereas, in angiosperms, the fertilization begins very soon after pollination. The shorter time leads to angiosperm plants' setting seeds sooner and faster than gymnosperms, which is a distinct evolutionary advantage.
- **Double Fertilization:** Double Fertilization is a rule on Angiosperms. This means that the Fertilization in Angiosperms involves the joining of a female gametophyte (megagametophyte, also called the embryo sac) with two male gametes (sperm). It begins when a pollen grain adheres to the stigma of the carpel, the female reproductive structure of a flower. The pollen grain then takes in moisture and begins to germinate, forming a pollen tube that extends down toward the ovary through the style. The tip of the pollen tube then enters the ovary and penetrates through the micropyle opening in the ovule. The pollen tube proceeds to release the two sperm in the megagametophyte. One sperm fertilizes the egg cell and the other sperm combines with the two polar nuclei of the large central cell of the megagametophyte. The haploid sperm and haploid egg combine to form a diploid zygote, while the other sperm and the two haploid polar nuclei of the large central cell of the megagametophyte form a triploid nucleus (some plants may form polyploid nuclei). The large cell of the gametophyte will then develop into the endosperm, a nutrient-rich tissue which provides nourishment to the developing embryo. The ovary, surrounding the ovules, develops into the fruit, which protections the seeds and may function to disperse them. **Please note that in Double Fertilization, five nuclei are involved.**

Generally, the endosperm formation begins after fertilization and before the first division of the zygote. Endosperm is a highly nutritive tissue that can provide food for the developing embryo, the cotyledons, and sometimes the seedling when it first appears.

Please note that **Endosperm which is formed after fertilization is Triploid** (3n). This is a major difference with Gymnosperms because in Gymnosperms, the Endosperm is always Haplod (n).

- Pollination can be self-pollination or cross-pollination. Insects (Entomophily) can facilitate the pollination, similarly can Wind (anemophily), Water (Hydrophily), Animals (Zoophily).
- Pollination taking place in a single flower is called self pollination, while pollination taking place between two flowers is called cross pollination. If the cross pollination is between flowers of a same plant, it will be called Geitonogamy, while if it takes place between two separate plants, it will be called as Xenogamy.
- In some plants, the flowers are bisexual and closed called Cleistogamous. Here only self pollination takes place.

Classification: Monocots and Dicots

Angiosperms are classified into two categories –

1. **Monocotyledonae (monocot):** In the seed of monocotyledonaeic plant, one cotyledon is found. The roots of these plants are not developed. The plant flower has three parts or its multiples. In the vascular pool, **cambium doesn't exist**. So, they don't so secondary growth. Today, at least more than 50,000 monocot species are known. **Monocot leaves are much longer than they are broad and their veins usual run in the same direction**. Some examples are grasses, bamboo, sugarcane, cereals, bananas, palms, lilies, orchids etc.
2. **Dicotyledonae (dicot)** : In the seed of dicotyledonaeic plant **two cotyledons** are found. In the vascular pool cambium exists. The flower of the plant has multiples of four or five petals. They show **secondary growth**. While the monocots have only one seed leaf in the embryo, the dicots have two seed leaves. Dicots have veins forming a network in their leaves. Dicots have almost all the hardwood tree species, pulses and the most fruits, vegetables, species beverage crops and ornamental flowering plants.

Roots

Roots of Angiosperms always move opposite to the sunlight towards the land. There are no root nodes and internodes as that in stems of these plants. The soft parts of roots and root hairs absorb water and mineral salts from the soil. The root transports water and mineral salts to the stem and ultimately to the leaves. Some roots like of carrot, radish etc. store foods and in contingency plants use these foods. The roots are of following types:

1. **Tap root**: The radical of such root develops itself and forms a main root and such roots exist in dicotyledonous plants.
2. **Conical shape:** This type of root is thickened towards base but thin near the side of the plant. Example-carrot.
3. **Napiform:** This type of root is extremely thickened and becomes inflated spherical at the base (bottom) but it becomes extremely thin at the top of the plant. Examples-turnip, beet root etc.
4. **Fusiform :** This type of root is inflated in the middle portion, while towards bottom and top it becomes thinned. Example is Radish.
5. **Pneumatophores :** This type of root is found in salty soil of the sea and for the respiratory activities it undergoes towards negative geotropic. Examples are Rhizophora, etc.

Adventitious Roots

Adventitious roots develop necessity if circumstances. All I wanted to say is that these develop to avoid stress or fight with the problem of nutrition deficiency or to get sufficient oxygen, or avoid too much oxygen. One more important work of these roots is to help in vegetative propagation in many plants. This ability of plant stems to form adventitious roots is utilized in commercial propagation by cuttings. Understanding of the physiological mechanisms behind adventitious rooting has allowed some progress to be made in improving the rooting of cuttings by the application of synthetic auxins as rooting powders and by the use of selective basal wounding.

The first thing about the Adventiuous roots you must note is that **they develop near the existing vascular tissue,** so that they can connect to the xylem and phloem. There are several kinds of modifications such as:

1. **Tuberous roots** are without any definite shape; example: Sweet Potato.

2. **Fasciculated root** (tuberous root) occur in clusters at the base of the stem; example: asparagus, dahlia.
3. **Nodulose roots** become swollen near the tips; example: turmeric.
4. **Stilt roots** arise from the first few nodes of the stem. These penetrate obliquely down in to the soil and give support to the plant; example: maize, sugarcane.
5. **Prop roots** give mechanical support to the aerial branches. The lateral branches grow vertically downward into the soil and acts as pillars; example: banyan.
6. **Climbing roots** these roots arising from nodes attach themselves to some support and climb over it; example: money plant.

Modifications of adventitious roots

Roots	Examples
Fibrous root	Onion
Leafy root	Briophylem
Climbing root	Betel leaf, pothos
Buttress root	Terminolia
Sucking root	Cuscuta
Respiratory root	Juicia
Epiphytic root	Orcede
Aerial root	Orcede
Assimilatory root	Tinspora
Parasitic root	Kascutta
Moniliform root	Grapes, bitter guard
Nodulose root	Mango turmeric
Prop root	Banyan tree
Stilt root	Maize, sugarcane
Fasciculated root	Dahlia

Types of stems

On the basis of the position of the soil, stems are of three types:

- **Underground stem:** The branch or part of the stem which intruses inside the soil is called underground stem. These stems store the food in the stem, node, internode, bud and scale leaf are found. Examples- banana, potato, colocasia etc.
- **Sub aerial stem :** If a few part of stem is inside the soil and rest is in air then such stem is called subaeriala stem. Examples-Grass root, water plant, etc.
- **Aerial stem** : The stem which is completely confined and localized in air and entirely outside from the soil then it is called aerial stem. In this type of stem branches, leaves, node, internodes, buds flower-fruit etc are found. Examples-Grapes, lemons, roses etc.

Modifications of stems

To perform some specific works, stems sometimes do exclusive works other than common work then shapes and sizes of the stems are changed and it is called modifications of stems. Usually there exists three types of modifications in the stems-

Underground modifications:

In the diverse conditions, underground stems store their food inside the stems and become thickened and tuberous. There are various types of modifications occur in underground stem-

- ✓ Stem tuber- Potato
- ✓ Bulb – Onion, garlic, tulips, lilies etc.
- ✓ Corm – Gladiolus, crocus, saffron etc.
- ✓ Rhizome—Ginger, turmeric, arrow root etc.

Sub aerial modifications :

There are various types of modifications exists in such types of stem-'

- ✓ Runner – Grass root, mereilia etc.
- ✓ Stolon – Mint, jasmine, straberi etc.
- ✓ Offset – Water plant, pestia etc.
- ✓ Sucker – Roses, gilly flower etc.

Aerial modifications :

There also occur various types of aerial modifications-

- ✓ Stem tendril – Grape.
- ✓ Stem thorn – Lemon, roses, jujube, plum or Chinese date.
- ✓ Phylloclade – Cactus.
- ✓ Bublis – Ruscus.

Leaf

Leaves prepare food for the plants. Respiratory activities are performed by the leaves through stomata. Leaves perform the vascular and execratory activities of foodstuffs. Leave help in performing conducive reproduction and pollination. Some leaves work to store food-stuffs.

Modification of leaves:

Leaves undergo through various modifications like the following—

- ✓ **Leaf spines :** In this class of modification leaves transform into spines. Examples-Cactus, lemon etc.
- ✓ **Floral leaves :** In this class of modification floral activities like calyx, corolla etc are performed by the leaves.
- ✓ **Bract :** In this class of modification leaves become colored and fascinate the insects towards themselves.
- ✓ **Scaly leaves:** Sometimes leaves modified themselves to protect buds and other soft organs of the plant, called scaly leaves. Sometimes scaly leaves also store the food-stuffs. Example-Garlic, onion, etc.
- ✓ **Leaf root :** In this class of modification, leaves transform into roots. Example- Briophylem etc.
- ✓ **Leaf tendril :** In this class of modification leaves take the form of tendrils. Example-Pea plant.
- ✓ **Storage leaves :** In this class of modification leaves store foodstuffs and become thickened and tuberous.
- ✓ **Picher :** In this class leaves accommodate to trap the insects and modified themselves in the form of bags. Example-Pitcher plant.
- ✓ **Bladder :** In this class of modification, leaves transform themselves in the form of bladder to trap the aquatic insects like utriculeria etc.

- ✓ **Leaf hooks :** In this class of modification leaves turn like nails. Example-bignonia etc.
- ✓ **Phyllode :** Australian acacia etc.

Flower

A Flower is a composite system of **modified leaves and knots**, which directly participates in the reproductive activity and produces fruits and seeds. Usually a flower is composed from four modified leaves which are attached to the thickened receptacle thalamus. This receptacle thalamus has four types of cycle- calyx, corolla, androecium and gynoecium.

The flower which have all four cycles is called complete flower, while if any cycle be absent then it is called incomplete flower. The organelles calyx and corolla and called auxiliary organelles, while androecium and gynoecium and called necessary organelles.

- ✓ **Calyx :** This is an extremely cycle of the flower and it is green colored cycle of sepals. The main work of calyx is to protect the soft parts of buds and performs photosynthesis. In some flowers, it becomes colored and its main function to fascinate insects for the pollination.
- ✓ **Corolla :** This is the second cycle of the flower which is confined inside the organelle calyx. Corolla is mainly composed from 2-6 petals and it is also colored whose main function to fascinate insects for the pollination.
- ✓ **Androecium :** This is the third cycle of sepals which is the made from stamens. The stamen is the male sex organ of the flower. Each and every stamen has its three parts-
    1. Filament
    2. Anther
    3. Connective
- ✓ **Gynoecium :** This is the central part (fourth cycle) of the flower and it is the female sex organ of the flower. Each and every gynoecium is made from one or more carpels and it produces females ovule. The carpel is made from three components- ovary, style and stigma.
- ✓ **Ovary :** Above the pedicel, there exists a thickened tuberous structure called ovary and inside of there exists some very small knots like structure and these are called ovules. In these ovules female embryo sac exists and in the various plants and number of ovules are fixed.
- ✓ **Style** : This is basically the upper lengthened and thinned part above the ovary.
- ✓ **Stigma :** This is the uppermost sticky part of the style.

Please note that the vital component of androecium is basically stamen and in which pollen grains are found in pollen sac.

Some Important Points

- ✓ The edible portion of the coconut is endosperm.
- ✓ In some dicots, cotyledons absorb entire store foodstuffs from endosperm and due to it endosperm is completely destroyed and these seeds are called **non-endospermic**. Example-Pea, gram, beans etc.
- ✓ In some plants without fertilization, fruits are produced through ovary and the process of this non-fertilization is called **parthenocarpy** and **such fruits are seedless**. Examples-banana, papaya, orange, grapes, etc.

Fruit

The fruit is usually formed in the ovary of the plant and pericarp is formed from the mature ovary walls. But in the formation of some fruits like apple, jack fruit etc, *calyx, corolla, thalamus etc participate and such fruits are called* **false fruits.**

Usually pericarp has three layers outermost layer is called **epicarp**. Middle Layer is called **mesocarp**, while innermost layer is called endocarp. **Please note that Coconut coir is Mesocarp.**

Types of fruit :

On the basis of fertilization of the flower there are two types of fruits-

- **True fruit –** The fruit forms in the ovary of the flower by the process of fertilization and zygote formation is called true fruit.
- **False fruit :** When fruit formation occurs other than ovary and flowers organelles like calyx, corolla, thalamus etc take place then it is called false fruit. Examples- Apple, jack fruit, pear etc.

But in angiosperms too much diversities are found in their fruits, thus on macro level there are three classes in them.

- **Simple fruit** – bean, mustard, mango, lemon etc.
- **Aggregate fruit-** strawberry, lotus, raspberry, custard apple etc.
- **Composite fruit-** jack fruit, mulberry, banyan, fig etc.

Some common Fruits and their edible parts. **This list is important.**

Fruits	Edible parts
Mango	Mid. Pericarp
Apple	Thalamus
Pear	Thalamus
Tomato	Pericarp and perisperm
Litchi	Pulpy aerial
Coconut	Endosperm
Guava	Pericarp
Ground nut	Seed leaves and embryo
Wood apple	Mesocarp and endocarp
Grape	Pericarp
Jack fruit	Sepals, bract, seeds
Wheat	Endosperm and embrya
Coriander	Thalamus and seeds
Custurd apple	Pericarp
Water chest nut	Seed leaves
Lemon	Juicy pore
Chinese date	Epicarp and mesocarp
Mulberry	Bract, sepals and seeds

Stomata :

There exist various tiny openings (called pores) on the surface of the skin of stems and leaves called stomata which are surrounded by two kidney shaped **guard cells.** In a leaf the number of stomata vary from 14 to $1040mm^2$. These stomata **exchange the moisture and help in transpiration activities** in the plants.

Annual rings

The branch of botany under which annul a rings of the plant are studied is called dendrochronolgy. By the elevation of number of annual rings in the plants or trees, the ages of the plants or trees are estimated exactly.

- Please note that dendrochronolgy is applicable only to a period of a few thousand years and only in the few areas where old wood samples have been preserved, radiocarbon dating can date events up to sixty thousand years old.

How does it work?

Due to the chronological, climatic changes the core activities of the cambium of any plant that of any place is regularly changed. In spring season this **activity is increased,** while in the winter season it is decreased, consequently distinct annual rings form which is the indicative parameter of the year growth.

Secondary growth

Whenever plant is small almost tissues are composed from meristematic tissue, called **primary tissue**. But specially in dicotyledonaeic plants, as the ages pass, **some new cells access to these plants and these new cells appear as permanent parenchyma tissues of meristematic nature**, called secondary tissue. Due to these secondary tissue the organs (roots, stems) of the plants become thickened, called secondary growth.

- Secondary growth takes place in **dicot plants only because of presence of cambium and cork cambium in the secondary tissues.** Thus in monocot plants **secondary growth do not take place because of lack of cambium**.
- Please note that as long as the vascular cambium continues to produce new cells, the stem or root will **continue to grow in diameter**. In woody plants, this process produces wood. But it is NOT always necessary that only woody plants show the secondary growth. Some plants such as Tomato , which is non-woody also show secondary growth.

Photosynthesis

The `food' for **plants is sunlight**, **water and air (carbon dioxide and oxygen)**. Plants have the amazing ability to harvest energy from the sun using chlorophyll and convert it in to chemical energy.

They then utilize it to produce carbohydrates such as sugars and starch (`photosynthesis'). These carbohydrates serve as chief energy source for almost all living beings in the world, including plants themselves. Nutrients such as nitrogen, phosphorus, potassium and other micronutrients are taken up by plants in very simple forms and used directly.

Plant cells oxidize the sugars to release carbon dioxide and energy and utilize the energy to drive reactions for normal functions of the cell.

In addition, cells use carbohydrates and derived products as building blocks for proteins and lipids (fat). Carbohydrates, proteins and lipids are the chief components of several sub-cellular organelles (parts of a cell).

Photosynthesis is the process through which the food is prepared by the plant from chlorophyll, carbon dioxide (CO_2) and water (H_2O) in the presence of sunlight. Thus, the living cells of the plant by the help of chlorophyll and sunlight absorb CO_2 from atmosphere and then in the presence of water (H_2O) carbohydrate is formed. The chemical involve in the photosynthesis is –

$$6CO_2 + 12H_2O \text{ ---------- } C_6H_{12}O_6+6H_2O+6O_2$$

The above reaction happens in presence of sunlight and can be written generally as follows:

Carbon dioxide + electron donor + light energy → carbohydrate + oxidized electron donor

- *Photosynthesis occurs in two stages. In the **first stage, light-dependent** reactions or light reactions capture the energy of light and use it to make the energy-storage molecules ATP and NADPH. During the second stage, the light-independent reactions use these products to capture and reduce carbon dioxide.*
- *Most organisms that utilize photosynthesis to produce oxygen use visible light to do so, **although there are plants which use infrared radiation** too.*

Here are some more details about the two stages of the Photosynthesis:

- **Photochemical reaction:** This process (reaction) **occurs in the grana** of the chlorophyll and the reaction involves is called **hill reaction.** In this process water (H_2O) disassociates and forms H+ and electron and for this decomposition of water (H_2O) energy is obtained from light. Ultimately, APT and NADPH are emancipated in the form of energy.
- **Chemical dark reaction :** This process (reaction) occurs in the **stroma of the chlorophyll** and for this reaction **energy is supplied by the photochemical reaction** and that's why it is called dark reaction. In this reaction, the produced energy in the forms APT and NADPH are utilized in the synthesis of carbohydrates from CO_2.

Factors influencing photosynthesis

- **Light :** The process of photosynthesis **only occurs for violet, blue and red light**, while it doesn't occur for **ultraviolet, green, yellow and infrared light**. For the low intensity light photosynthetic activity is maximum, but as the intensity of the light increases photosynthetic activity decreases.
- **Temperature :** As the process of photosynthesis is the complex chemical reaction of the various enzymes and these enzymes only being normal to participate in the chemical reaction up to a moderate and optimum temperature. Thus photosynthetic activity increase from 0°C to 37°C but 37°C onwards such activity decreases abruptly.
- **Carbon dioxide (CO_2)**: Up to a definite level on increasing the concentration of CO_2, photosynthetic activity increases, but after the certain limit, the increase of its concentration does not affect the photosynthetic activity.
- Water (H_2O): Due to the lack of water, the photosynthetic activity abruptly decreases because of steep fall of the rate of evaporation. In fact the pores of the plant leaves become partially closed and ultimately the translocation of CO_2 is disrupted through the leaves.
- The metal magnesium is found in the chlorophyll of plant leave and in the nucleus of the chlorophyll on atom of the magnesium exists. The chemical substance chloroplast is called the nucleus of the photosynthesis.

Plant hormones

The plant hormones are prepared by the apical meristem, younger mature leaves and transported through the **vascular tissue phloem** to the other organs of the plants. The plant hormones are the natural organic substances whose presence of very small amount only influences the inner activities of the plants sharply and substantially.

There are various types of plant hormones.

Auxins :

- Most fundamental plant hormone, whose impacts were first seen by Darwin in 1880, but was first described by the Dutch scientist **Frits Went**. Kenneth V. Thimann isolated this phytohormone and determined its chemical structure as **indole-3-acetic acid**. Went and Thiman then co-authored a book on plant hormones, *Phytohormones,* in 1937.
- It's a weak **organic acid** which actively participates in the cell division and the cell elongates consequently thus plants growth occurs. Auxin participates in ***phototropism, geotropism, hydrotropism*** and other developmental changes. The uneven distribution of auxins, due to environmental cues such as unidirectional light or gravity force, results in **uneven plant tissue growth.** And generally Auxin governs the form and shape of plant body, direction and strength of growth of all organs and their mutual interaction
- Helps in stems growth and thus called growth inhibitor, which acts like controller or regulator of roots and column growth.

Please note that Auxin also works in controlling the leaves and fruits **abscission**. Sometimes due to larger concentration of this hormone in the stems, fruits fall before ripening.

Heliotropism in Sunflower

Please note that heliotropic flowers track the sun's motion across the sky from East to West. In Sunflower, the young buds and leaves show these phenomena but the mature flowers permanently face East. The Auxin hormone plays a role in Heliotropism. Auxin works on the side of the stem opposite the Sun. The direction of the head lags behind the Sun's position by about 12 degrees, or a time of 48 minutes. The motion is performed by motor cells in a flexible segment just below the flower, called a pulvinus. The motor cells are specialized in pumping potassium ions into nearby tissues, changing their turgor pressure. The segment flexes because the motor cells at the shadow side elongate due to a turgor rise. Further, also note that Heliotropism is a response to blue light. If we use a transparent glass, which blocks blue light, the sunflower will stop response to sun's direction.

During the night, the flowers may assume a random orientation, while at dawn they turn again towards the East where the sun rises. The Botanical name of Sunflower is Helianthus annus, where Helianthus is from the Greek *helios* "sun" and *anthos* "flower."

Applications of Auxin

Agent Orange

- Used in high doses, Auxin stimulates the production of ethylene. Excess ethylene (also native plant hormone) can inhibit elongation growth, cause leaves to fall (leaf abscission), and even kill the plant. This is why, Auxin is used as a herbicide. Some synthetic auxins such as 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were sold as herbicides. Please note that the Dicot plants are more susceptible to Auxin than the Monocot plants. 2, 4D was used as Agent Orange, a defoliant used extensively by American forces in the Vietnam War. The 2,4-dichlorophenoxyacetic acid was actually first widely used herbicide in the world and it actually is still the most widely used herbicide in the world since.

Artificial parthenocarpy

- The help of auxins hormones can produce seedless fruits. If some Auxin applied on the flower of the plants then without fertilization and without seeds formation ovary wall becomes tuberous and forms the fruit. This is called the artificial parthenocarpy. This technique is used today in the production of seedless fruits like tomato, apple, grapes etc.

- By the more concentration of this hormone in the roots the natural growth is abruptly decrease but the branches of roots are enhanced.

Gibberellins

Gibberellic acid (or Gibberellin A3, GA, and (GA3) was first recognized in 1926 by a Japanese scientist, **Eiichi Kurosawa**, studying bakanae, the "foolish seedling" disease in rice.

It was first isolated in 1935 by Teijiro Yabuta, from fungal strains (*Gibberella fujikuroi*) provided by Kurosawa. Yabuta called the isolate gibberellin. Its chemical formula is $C_{19}H_{22}O_6$. When purified, it is a white-to-pale-yellow solid.

Functions & Applications

- Gibberellins are involved in the natural process of breaking dormancy and various other aspects of germination.
- Before the photosynthetic apparatus develops sufficiently in the early stages of germination, the stored energy reserves of starch nourish the seedling. Usually in germination, the breakdown of starch to glucose in the endosperm begins shortly after the seed is exposed to water.
- Gibberellin affects decomposition of plants and helps plants grow if used in small amounts, but eventually plants develop tolerance for it.
- Gibberellic acid stimulates the cells of **germinating seeds to produce mRNA molecules** that code for hydrolytic enzymes.
- Since GA regulates growth, applications of very low concentrations can have a profound effect while too much will have the opposite effect.
- By the *use of this plant hormone the time taken in blossoming the flowers and the fruit formation time can be reduced.*
- This plant hormone breaks the stagnation and comes into play in the seeds and provokes to sprout them.
- Gibberellins have been proved to motivate the activities of cambium in wood plants.
- Through the comprehensive spread of this hormone the production of fruits and flowers can be achieved up to an optimum level.
- Via the specific use of this hormone seedless fruits can be produced.

Cytokinin

Cytokinins or CKs are a group of chemicals that influence cell division and shoot formation. They were called kinins in the past when the first cytokinins were isolated from yeast cells. Because cytokinin promotes plant cell division and growth, it is commercially utilized by produce farmers to increase the yield of a crop. A study showed a 5-10% increase in cotton yield under drought conditions when cytokinin was applied to the seedlings

Ethylene

In the form of hormone, ethylene was invented in 1962 by Burg.

- Ethylene is the only natural gaseous hormone, which is a growth controller or regulator, and this hormone is synthesized in almost organs of the plants.
- Ethylene forms through the **Yang Cycle** from the breakdown of **methionine,** which is in all cells

- Ethylene has very limited solubility in water and does not accumulate within the cell but diffuses out of the cell and escapes out of the plant.
- Its effectiveness as a plant hormone is dependent on its rate of production versus its rate of escaping into the atmosphere.
- Ethylene affects fruit-ripening: Normally, when the seeds are mature, ethylene production increases and builds-up within the fruit, resulting in a climacteric event just before seed dispersal.

Functions & Applications

- Ethylene is used as the fruit ripening hormone.
- By the use of this hormone the number of the female flowers can be increased.
- This hormone promotes the growth activities in stems, embryonic development in the male flowers etc.
- This hormone also provokes the abscission activities of leaves, flowers and fruits.

How does calcium carbide ripen mangoes?

For reasons of safe transportation of fruits, mangoes, bananas etc are picked before they ripen fully. Slightly green harvested mangoes are subjected to small containers of Calcium Carbide (CaC2) with a plastic covering. CaC_2 reacts with the moisture in the air to release **acetylene (or ethyne) gas**, *which* is a ripening hormone. Industrial-grade calcium carbide contains arsenic and phosphorus, and its use for ripening is illegal in many countries. One can distinguish the artificially ripenened fruit by the uniform skin colour in fruits like tomato, mango, papaws, etc and in the case of banana, yellow colour fruit with dark green stem.

We are advised not to keep banana inside the refrigerator. Why?

We should know that while many fruits are stabilized by refrigeration, most tropical and subtropical fruits (bananas in particular) exhibit chilling injury. Chilling injury can result in great losses in the quality and shelf life of the fruit. Fruits and vegetables subject to chilling injury includes banana, lemon, lime, eggplant, tomato, avocado, cucumber, pineapple, jackfruit and papaya.
Banana is one of the most sensitive fruits because it develops injury below about 12° C. Apparently, cold hardy fruits, such as apple and pear, are not affected as they evolved tolerance to chilling temperatures. The blackening of the banana skin is caused by the frelease of enzyme, polyphenoloxidase (PPO) as well as Ethylene. PPO is an oxygen-dependent enzyme, which polymerises naturally occurring phenols in the banana skin into polyphenols similar in structure to melanin formed in suntanned human skin. Ethylene is produced as a gaseous hormone in banana. Ethylene diffuses into the fruit and hastens the process of ripening. It is yellow when the fruit is ripe and turns black with the production of more and more ethylene. The large number of enzymes of Kreb's cycle converts citric acid, mallic acid and oxalic acid into glucose in a banana, to make it sweet during the process of ripening. When the banana is kept in the refrigerator, the enzymatic reactions are stopped by the cold but the production of ethylene hormone continues.

Abscisic Acid

Abscisic acid owes its names to its role in the abscission of plant leaves. In preparation for winter, ABA is produced in terminal buds and slows plant growth and directs leaf primordia to develop scales to protect the dormant buds during the cold season. ABA also inhibits the division of cells (mitosis) in the vascular cambium, adjusting to cold conditions in the winter by suspending primary and secondary growth.
This hormone was first discovered in 1965. This hormone can be used in preventing the sprouting activities in seeds and buds. Other functions are as follows:

- Antitranspirant - Induces stomata closure, decreasing transpiration to prevent water loss.

- Inhibits fruit ripening
- Responsible for seed dormancy by inhibiting cell growth – inhibits seed germination
- Inhibits the synthesis of Kinetin nucleotide.
- Down regulates enzymes needed for photosynthesis.
- The hormone Abscisic acid (ABA) is a terpenoid whose synthesis occurs in leaves, stems, flowers and seeds.
- When the fruits mature in the plants then to prevent these to downfall the hormone Abscisic acid (ABA) is spread out.

Plant Nutrition

The plants can be autotrophs or heterotrophs. Autotrophs are self nourishing plants which manufacture their own food (organic substances) from inorganic substances. The photoautotroph plants use mineral nutrients, water and carbon dioxide and compose complex organic compounds in presence of sunlight.
Plants require essential nutrients for normal functioning and growth. A plant's sufficiency range is defined as the range of nutrient necessary to meet the plant's nutritional needs and maximize growth. The width of this range will depend upon individual plant species and the particular nutrient.

- Nutrient levels outside of a plant's sufficiency range will cause overall crop growth and health to decline due to either a deficiency or toxicity.
- Nutrient deficiency occurs when an essential nutrient is not available in sufficient quantity to meet the requirements of a growing plant.
- Toxicity occurs when a nutrient is in excess of plant needs and decreases plant growth or quality.

However, please note that Nutrient toxicity is less common than deficiency. There are 17 essential plant nutrients. Carbon and oxygen are absorbed from the air, while other nutrients including water are obtained from the soil. Plants must obtain the following mineral nutrients from the growing media. The major and minor plant nutrients are mentioned below:

Major Plant nutrients (Remember by CHOPKNS Café Mg)	Minor Plant Nutrients
Macro-Trace Elements	**Micro-elements**
Carbon	Iron
Hydrogen	Molybdenum
Oxygen	Boron
Phosphorus	Copper
Potassium	Manganese
Nitrogen	Zinc
Sulfur	Chloride
Calcium	
Magnesium	

Apart from the above, some elements such as Cobalt, Sodium, Selenium, Silicon, Gallium, Vanadium have been proved to be essential for some particular plant species. Nutrient uptake in the soil is achieved by cation exchange, where in root hairs pump hydrogen ions (H+) into the soil through proton pumps. These hydrogen ions displace cations attached to negatively charged soil particles so that the cations are available for uptake by the root.

Absorption of Water

The main source of soil water is rainfall. Water is held in soil in many ways such as gravitational water, capillary water, Hygroscopic water and combined water. Out of them **Gravitational water** is the water that moved downwards through the soil due to force of gravity. This water is beyond the reach of the roots of the plants and trees and NOT available for plants. The **Capillary water** is held by the thin capillaries or pore spaces formed by the soil particles. This is the main source of water for plants as it is what left after water has drained down due to gravity. Hygroscopic water is the water that is held tightly in the form of thin film around the colloidal particles of soil or organic matter. This water can not be easily removed by plants so this is also almost not available. Then we have the combined water which is in the form of chemical composition of the particles. It is also NOT available for plants.

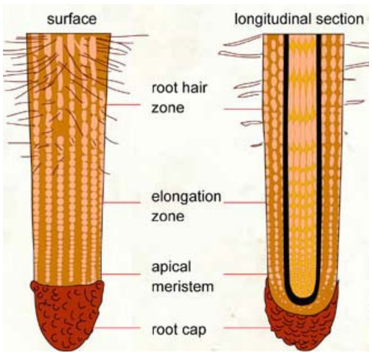
With the above small discussion, we come to the conclusion that it is the Capillary Water which is mostly available for plants. Here we need to know about three less used words.

- Total Amount of Water Present in soil is **Holard**
- The amount of Holard, which can be absorbed by Plants is **Chresard**
- The amount of Holard, which is Not absorbed by plants is Echard

This means that ***Holard = Chersard + Echard***

Further, the amount of capillary water available in soild depends upon texture and structure of the soil. This means that Sandy soil and clay soil are NOT suitable for growth of plants. The best soil is the Loam soil which is cocktail of sand, silt and clay.

The maximum absorption of water takes place at the tip of the roots of small plants and tips of branches of roots in larger plants.



The growing root tip contains four regions viz. a root cap, meristematic region (apical meristem), region of cell elongation, region of cell differentiation and maturation. Out of them the region of cell differentiation possesses root hairs. These root hairs are slender unicellular outgrowths of the epidermal cells. Most of the water absorption takes place in this region.

The large number of root hairs increases the absorption area. Please note that in some plants leaves also absorb water. Example is *Sequoia*. Orchids can absorb moisture from atmosphere by their modified roots.

The absorption can be passive or active. In the **passive absorption**, there is no role of root cells. The rapid evaporation of water from the leaves during the transpiration creates a tension in water of the xylem of roots, through the xylem of stem and water is lifted upwardly. Water is absorbed by the root hairs due to **diffusion pressure gradient** produced by transpiration.

In the active absorption, there is NO role of transpiration and the job is performed by the cells of roots by development of forces. It may be osmotic or Non-osmotic. Here we should note that the osmotic pressure of the roots is higher than the osmotic pressure of the soil water, due to which, the water enters into the cell plasma via cell membrane. This will increase the osmotic pressure of these cells in comparison to the cortical cells, thus water is drawn into these cells. By osmotic diffusion water enters into the cells.

However, please note that **it is always NOT necessary that there should be low osmotic pressure of soil** to get the water absorbed. The root cells are able to absorb the water even if there is high osmotic pressure in the soil water, but for this, the metabolic energy of respiration is used.

Plant Adaptations

The study of relationships between the individual plants and their environment is called **Autecology.** While the study of relations between the plant communities and environment is called **Synecology**. Accordingly, there are several groups of plants, which despite of belonging to different taxonomic groups, actually belong to broad groups based upon their environment and adaptations. For example, the water plants are called **Hydrophytes**. The plants that can live only on those lands which are neither dry nor moist are called **mesophytes**. The plants which live in deserts and very dry condition are **Xerophytes**.

This is just a simple classification. Some more words are there to define specialized habitats and they are as follows:

- Plants that live on acid soils are Oxylophytes
- Plants that live on saline soils are Halophytes.
- Plants that live on sand are called Psammophytes.
- Plants that grow on rocks are called Lithophytes.
- Plants that grow in cold soils are called Psychrophytes.
- Plants that grow in wastelands are called Chersophytes.
- Plants that grow on marshy area are called Helophytes.
- Plants that grow in full sunlight are Heliophytes
- Plants that grow well in dark / low light conditions are Sciophytes.

On the basis of the temperature conditions, the vegetation in general can be as follows :

- Megatherms: It refers to the high temperature through the year. Examples are Tropical rain forests.
- Mesotherms: It refers to the alternation of high and low temperatures. Examples are tropical deciduous forest.
- Microtherms: It refers to low temperature. Example is coniferous forests
- Hekistotherms: These refer to very low temperature. Example is alpine vegetation.

Here are some brief improatnt points about Hydrophytes and Xerophytes.

Hydrophytes

- ✓ Since there is lot of water available to Hydrophytes, they have less developed Roots. This is one important features. In some plants such as *Wolffia* and *Salvinia*, there are no roots at all.
- ✓ In some aquatic plants such as *Jussiaea*, floating roots develop which work in respiration.
- ✓ In some plnats such as Trapa, the roots become green and Photosynthetic.
- ✓ The stem of aquatic plants is usually weak and spongy. In some plants the stem is freely floating on water. These plants prefer vegetative propagation and sometimes become problematic for our lives. The cortex of the roots has a large number of air cavities which work in exchange of gases and provide buoyancy.

- ✓ If the plants are submerged in water, the leaves are thin. If the plant is floating, the leaves are very broad and upper surface is covered with wax. This wax makes them hate water and keep it away from accumulating on the surface.
- ✓ The submerged aquatic plants usually have no flowers. The flowers of floating plants and other plants are nice but they seldom produced seeds.
- ✓ The protective covering on both the roots and stem is thin, poorly developed and sometimes absent.

Xerophytes

These plants have to survive in scarcity of water and very high temperatures. So, they are adapted to such conditions. Some xerophytes appear that they have died in arid conditions but as soon as moisture becomes available to them, they flourish with increased biomass and production rate. All xerophytes are adapted to the cycle of periodical droughts. If they grow in sand and pebbles, they are called **psammophytes**, if they grow on rocks, they are called **Lithophytes** and if they grow in cold deserts, they are called **Psychrophytes**. Apart from that there are plants that grow on very high saline soils and develop special organ such as specialized roots called Pneumatophores. They are called **Halophytes**.

The plants which avoid the drought condition by storing water in Fleshy organs are called succulents example is Aloe vera.

- ✓ The most important thing about the roots of the Xerophytes is that they are huge and vividly branched so that they don't leave a fraction of water available till the last inch of depth , they can reach.
- ✓ Obviously the roots will be well developed in Xerophytes. They root caps and root hairs are excellent in their respective jobs.
- ✓ In some plants like *Opuntia* the roots become fleshy and green and look as if they are stems or even leaves.
- ✓ The stems of most of the Xerophytes is covered with hairs or wax.
- ✓ Leaves are turned into spikes and are very thorny like in Cactus and Opuntia.
- ✓ In some cases leaves become fleshy like in Aloe vera.
- ✓ In some plants like ammophilia, the leaves become rolled so that less transpiration takes place.
- ✓ In some plants leaves are small (microphyllous) to stop the loss of water.
- ✓ In Australian Acacia, the compound leave soon fall off. The petiole or any other part of the rachis soon becomes leaflike and starts doing the jobs of a leaf. This is known as **Phyllode**.

Halophytes:

The Xerophytes which grow in saline soil with heavy concentration of salts such as NaCl, MgCl2 etc. are called Halophytes. Please note that most of the Halophytes are succulents. They produce negatively geotropic roots called Pneumatophores which are **primarily meant for Gas exchange**. Many halophytes show viviparous germination of seeds which means that seeds germinate while still on parent plant.
The halophytes may grow in either salt swamps or in littoral swamps. In Littoral swamps, they produce characteristic vegetation, which is called Mangroves. Mangroves found in tropical and subtropical regions.

Selected Questions and 2-markers in Botany

Red Tides

Red tides are the result of a massive multiplication of tiny, single celled algae called Karenia brevis, usually found in warm salt water, but which can exist in lower temperatures. It is a natural phenomenon, apparently unrelated to manmade pollution. In high concentrations, K. brevis may create a brownish red sheen on the surface of the water; in other instances, it may look yellow green, or may not be visible at all.

Flame of Forest

The Royal Poiniciana or Flamboyant tree, Delonix Regia (family Fabaceae), is the most colourful tree. Its vivid orange/ red flowers and bright green foliage make it an exceptionally striking sight. It is sometimes known as the 'Peacock Tree' or 'Flame of the Forest'. The tree is native to Madagascar, found in the West Malagasy forest.

Ribbon plant

The scientific name of the ribbon plant is *Dracena sanderiana* and it belongs to family Agavaceae. It is a tropical perennial requiring partial shade for growth. It has toxic properties that harm pets such as cats and dogs. It is also called the lucky bamboo when grown in water though it does not belong to poaceae (grass) family. One of the genera of ribbon plants is called "the tapeworm plant" due to flat stems while another is the spider plant due to elongated cascading leaves.

Hydroponics

Hydroponics is cultivation of plants in water. Since many aggregates or media support plant growth, the definition has been broadened to read the cultivation of plants without soil. Growers use hydroponics techniques due to lack of water supply or fertile farmland. Home gardeners have used it to grow fresh vegetables year round and to grow plants in smaller spaces. Greenhouses and nurseries grow their plants in a soil-less, peator bark-based growing mix.

Frankenstein foods

Frankenstein foods are produced from genetically modified organisms (GMO) which have had their genome altered through genetic engineering techniques. The general principle of producing a GMO is to insert DNA taken from another organism and modified in the laboratory into an organism's genome to produce both new and useful traits or phenotypes. These foods have been available since the 1990s, with the principal ones derived from plants being soyabean, maize, canola and cotton seed oil.

Guttation

Guttation is the loss of water in the form of water droplets from hydathodes (small pores) on the leaf margin of a small herbacious plant. Water has the ability to rise up to 2 feet on its own through the xylem of the plant. During the evening or early morning, when the rate of absorption by roots exceeds the rate of transpiration (evaporation) by leaves, a lot of water gets accumulated in the plant body which can damage the cells. Plants have hydathodes at the end of the veins, through which this excess water is lost in the form of droplets. It takes place mostly in small plants like banana, rose, etc.

No-till Farming

No-till farming is a cultivation technique of planting crops in previously unprepared soil or piece of land by opening a narrow slot, trench or band only of sufficient width and depth to obtain proper seed coverage. It requires no other preparation as required in conventional farming. Widely accepted in England and Europe, this soil conservation technique is also known as conservation tillage or zero tillage.

Palynology

Palynology is the branch of science dealing with study of decayresistant remains of certain plants and animals. It can be classified as an interdisciplinary science and is a branch of earth science (geology or geological science) and biological science, particularly plant science (botany). The term Palynology was introduced by Hyde and Williams in 1944, on the basis of the Greek words paluno meaning to sprinkle and pale meaning dust.

Gravel Culture

Gravel culture is a kind of hydroponic culture (a method where plants are grown without soil for experimental and hobby purposes). Here, pea-sized gravel supports and distributes the root system. This coarse gravel allows a nutrient solution to flow down a slope or to seep from a surface drip and filter down through the roots. When the nutrients flow back into the container, they can be recirculated; otherwise, they are replenished weekly. This cycle maximises both nutrient delivery and aeration to the roots.

Allethrins

Allethrins are compounds used in household insecticides like mosquito coils because they have low toxicity for humans. They are sourced from chrysanthemum flowers, found in Asia and eastern Europe. These plants are cultivated for ornamental, culinary or insecticide-preparation purposes. The flowers are pulverized and the allethrin compounds found in the seed cells are extracted and sold to insecticide makers.

Sciophytes

Sciophytes are shade-loving trees or plants. These plants have larger photosynthetic units than sun plants or heliophytes. Sciophytes are also known as photophobous plants and they reach their saturation level in only 20% sunlight. Shade-plants essentially follow strategies of optimum use of available energy and conservation of energy. Adaptation to achieve these strategic goals include thinner leaves with a relatively higher chlorophyll content per unit leaf volume; lens-shaped epidermal cells that focus incoming light into and within the mesophyll; a redcell layer that reflects outgoing light back into the mesophyll, and greater allocation of available energy to defence-mechanisms against herbivory.

Xeriscaping

The word is derived from the Greek word *xeros*, meaning dry. It refers to landscaping which doesn't require additional water. It uses plants which are suited to the local climate, and practitioners ensure that water doesn't evaporate or run off. Xeriscaping is also called zeroscaping, drought-tolerant landscaping, smartscaping and waterconserving landscapes.

Creepers and climbers

Both creepers and climbers are weak-stemmed plants and, hence, cannot grow erect without support. The difference is that creepers spread horizontally along the soil. At the nodal regions — where leaves grow — they produce fibre-like roots arising from the base of the stem, which get fixed and grow further. Such stems in creepers are called prostrate stems. Climbers take the support of an object for climbing. Some climbers twine around supporting plants in a spiral manner; some of them produce hooks to climb, and some others produce special roots serving as holdfasts.

Switchgrass

Switchgrass, (*Panicum Virgatum* L)., is the perennial tall grass found in North America and Mexico. Its height varies from 5 ft to 12 ft, and the diameter of its stem at ground level is about 20 inches. It can grow in poor-quality soil, with low requirement of fertilizers, and can tolerate hostile conditions, including floods and drought. The grass has main roots that penetrate into the soil, and temporary fine roots, which enable it to conserve the soil in which it grows, and make it nutritionally rich. Hence, switch grass has been grown traditionally for soil conservation and to serve as fodder. Since the 1990s, interest in this plant has increased because it generates a lot of biomass, which can be used for producing fibre, ethanol, electricity, and other chemicals.

Apomixis and Amphimixis

Apomixis is asexual reproduction without fertilization — developing or producing without sexual union. This is a botanical term (also known as apogomy) used with respect to many plants. Apomixis can occur in two ways: when the embryo arises from unfertilized egg produced without meiosis, called agamugenesis; a nucellar embryo is formed from surrounding nucellus tissues. The seeds produced are generally identical to the main plant. Examples of apomixis are hawthorns, shadbush, white beams, black berries, dandelions, etc. Recently, it has been discovered that Sahara cypress seeds are got from pollen with no genetic help from the female parent. This differs from amphimixis which is reproduction through the sexual process involving egg fertilization through sperm.

Micro-propagation

Micro-propagation is the technique of multiple production of plants in-vitro. It is used for plants that do not produce seeds or respond to normal vegetable reproduction. Micropropagation's main advantage is to produce disease-free plants in multiple numbers and cloning of plants.

Hay Fever

Allergic rhinitis, also known as **pollenosis** or hay fever, is an allergic inflammation of the nasal airways. It occurs when an allergen, such as pollen, dust or animal dander (particles of shed skin and hair) is inhaled by an individual with a sensitized immune system. During certain seasons, many plants, grasses release their pollens into the air in large quantities. A person is said to have hay fever when he/she is sensitive to these pollens and other substances present in the air. It is called hay fever because the symptoms of the disease appear during spring and fall in England. In such individuals, the allergen triggers the production of the antibody immunoglobulin E (IgE), which binds to mast cells and basophils containing histamine.

Thigmotropism

Thigmotropism is the growth of a plant around a support. Tropism is a phenomena by which a plant, usually climber like money plant and ivy, responds to a stimulus. Stems of the pea plant, for instance, are weak and have coil-like structures called tendrils. When tendrils approach a support (stick), a phytohormone called auxin is released in the side of the tendril away from the support. Auxin, a growth hormone, elongates the cells of that portion and makes it strong. The other portion, devoid of auxin, becomes weak and coils around the support.

California Rosewoods

Redwoods are among the world's tallest living trees. They are 60 to 85 metres in height and 2.5 to 4 metres in diameter. A redwood in northern California is the tallest-known tree in the world — it is about 110 metres high. It is called a redwood because of the red colour of its wood. The redwood grows along the west coast of the United States, from central California to southern Oregon. The redwood is also called as **Coast of California redwood**. It belongs to taxodium family, Taxodiaceae. It is classified as *Sequoia sempervirens.*

As of now, the world's largest tree, that is, the one with the greatest mass, is the 'General Sherman', a giant sequoia located in Sequoia National Park, California, US. It is 84 meters tall and has a girth of 31.3 meters.

Florigen

Like all other flowering plants, jasmine also produces a flowerinducing hormone in its leaves when exposed to bright sunlight. This hormone is called florigen (flower-generating hormone) and it migrates from the leaves to flowering shoots during the day. It accumulates in the flowering shoots of the jasmine plant and induces flowering during the night.