CHAPTER XXI

TISSUES.

A tissue is a collection of similar cells adapted for a particular function. There are various tissues in the plant, performing different functions. Tissues are mainly divided into two groups :—

(*a*) **Meristematic tissues** and (*b*) **Permanent tissues.**

a. **Meristematic tissues**—

Meristematic tissue is composed of cells capable of further growth and division which are generally found at the growing point of root or stem. The growth of the meristem of the apical portion of the root or stem results in the increase in length of the structure. After some growth has taken place, the meristematic tissue assumes the permanent condition. The kinds of meristematic tissues are :—

(1) **Primordial meristem**—the apical cell found at the apex of the root or stem often gives rise to the meristematic tissue. This is the originator of the meristematic tissue. In phanerogams, a group of initial cells develop into the meristem.

(2) **Primary meristem**—the primordial meristem develops into the primary meristem consisting of **dermatogen, periblem** and **plerome** beginning from the outside. In the case of the growing point of the stem, the dermatogen develops into the epidermis, the periblem

into the cortex and the plerome into the central cylinder. Some of the cells of plerome are long and specialised and give rise to procambium strands which develop into the vascular bundles. In the case of the root, there is an additional layer called the region of root-cap or calyptrogen in addition to the three layers.

(3) **Secondary meristem**—sometimes the permanent tissues specially of the cortical part in stem become meristematic and in the root in the region of the pericycle; there is also the formation of the secondary meristem in the stelar region as a result of which wood and bast cells are cut off. This development of meristematic tissue in the permanent region is called secondary meristem.

b. **Permanent tissues**—

Permanent tissue has assumed a form which does not change and is incapable of further growth. The permanent tissues may be divided into :—

(1) **Cellular,** (2) **Vascular,** (3) **Laticiferous** and (4) **Glandular.**

Cellular—

The cellular tissue may be composed of parenchyma or prosenchyma. Parenchymatous cells are more or less isodiametric. These cells are composed of cellulose cell-walls and are thin-walled. They may be :—

(*a*) **Chlorenchyma,** or tissue having chlorophyll in their cells. These cells occur in the leaves. They are known as photo-synthetic cells capable of manufacturing organic food.

(*b*) **Aerenchyma,** this tissue occurs in water-plants, having large intercellular spaces. The air which is contained in the large spaces give buoyancy to the plant. It occurs in root, stem or leaves of water-plants.

(*c*) **Collenchyma,** these are parenchymatous cells but are thick-walled at the corners of cells, generally occuring in the cortex. These are found in herbaceous plants and give strength to them. Chloroplastids might occur in them.

(*d*) **Wood parenchyma,** occurs in the secondary wood of Dicots. They are lignified tissue and are thick-walled. Prosenchyma consists of long cells and are generally associated with the conduction of water.

Sclerenchyma are dead cells and consists of either parenchyma or prosenchyma. The walls are lignified. Hard bast and wood fibres are composed of sclerenchyma. They give strength to the plant.

(2) **Vascular—**

These consist of vessels *i.e.,* cells which have lost their partition-walls and have fused with one another. Fundamentally, there are two kinds of vascular tissue, one is **xylem or tracheal tissue or hadrome** and the other is the **Sieve tissue or Phloem or Leptome.** The xylem carries the water and dissolved food-matters from the soil to the leaf, the phloem translocates or transfers the prepared organic food from the leaf to different parts of the plant. Xylem consists of *tracheæ* or *tracheides* with parenchyma and sclerenchyma.

The *tracheæ* is a true vessel which is formed by the disorganisation of the partition-walls of several cells. Tracheid is a single elongated cell. The wall of *tracheæ* or *tracheides* may be pitted, annular, scalariform, reticulate etc.

Xylem has twofold function; (1) *Conduction* of water and (2) *Mechanical* support.

Phloem consists of sieve tubes and companion cells. The cells are thin-walled and are provided with sieves so that they are called sieve-tubes. The sieves are perforations which form callus in winter but dissolves in spring. They are rich in proteids, carbohydrates and other organic food. The sieve-tubes are the channels through which food is sent to different parts of the plant.

(3) Laticiferous tissue—

These cells give out a milky juice or watery juice called latex. The juice is regarded by some to be an excretory product while others regard it to be secretory product. Laticiferous tissue may be in the form of single cells called laticiferous cells as in the case of Akanda, Euphorbia. This is a much branched cell in the form of a coenocyte. Laticiferous vessel is formed by the absorption of the partition-walls of some cells and form a much branched structure.

Ex.—Plantain, Sunflower, Shealkanta (Argemone).

(4) Glandular tissue—

Glands may be distributed in various parts of the plant which secrete substances for different purposes. Glands may be multicellular solid glands, *e.g.*, nectaries of some flowers. Hollow glands are found in the oil glands of orange, lemon etc.

CHAPTER XXII

TISSUE SYSTEM.

A **tissue** means an aggregation of cells for a definite work but a system is a collection of tissues for the proper performance of certain functions. There are three main tissue systems :—

(1) The *tegumentary* or *Epidermal* tissue—system.

(2) The *conducting* or *Vascular* system.

(3) The *fundamental* or *ground* tissue system.

It is the primary meristem that gradually forms the different tissue—systems. Thus,

Dermatogen	Epidermis			Epidermal System
Periblem	Ground tissue of cortex	Hypodermis General cortex Endodermis		System of Ground tissue.
Plerome	Pith			System of Ground tissue.
Plerome	Stelar system	Conjunctive tissue	Pericycle Medullary rays	System of Ground tissue.
Plerome	Stelar system	Vascular Bundles		Vascular system.

The tegumentary system corresponds to the outer skin of animals. Usually the outer tissues of the plant form the tegumentary system consisting of epidermis and its associated structures. The epidermis is usually one layered but occasionally it is many layered as in the case of Velamen on the roots of epiphytic orchids and the leaves of Banyan, India-rubber show many layered epidermis.

Stomata—

The epidermis is not entire but has some openings called stomata. Each stoma is an opening guarded by two cells called guard cells having chloroplasts. When there is plenty of water, the guard cells curve and there is full opening of stoma but as a result of loss of water, the guard cells become flaccid and the pore closes. The opening and closing of the stomata are of great significance to the plant.

Formation of stoma—

The nucleus of one of the epidermal cells divides into two and a partition-wall is formed, thus forming two new cells. There is now a longitudinal splitting along the common wall, leaving a space, this aperture is the stoma and the two cells form the guard cells.

Function of stomata—

Stomata serve three functions of the plant.

(*a*) Respiration, CO_2 passes from the plant through stomata to the atmosphere.

(*b*) Transpiration, water-vapour escapes from the plant through stomata.

(*c*) CO_2 enters through stomata into the plant during photosynthesis. Therefore the chief organ for gaseous interchange of the plant is the stoma.

Stomata are found on the undersurface of leaves of land plants and on the upper surface of leaves of water-plants and on herbaceous stems. In plants where there is formation of bark, another structure is developed from stoma called lenticel.

The stoma is protected by the development of hairs or the epidermis develops sunken stomata as in the desert plants to prevent excessive loss of water. There is another type of peculiar stomata called hydathodes which secrete water from leaves and are found in Colocasia (Kachu), Lotus and Grass.

The hairs found on the epidermis of roots serve a very important function as they absorb water from the soil.

The epidermal system mainly protects the inner parts from external injury.

The conducting or Vascular system—

As the name signifies, it is responsible for the conduction of raw food material and transfer of prepared food from the leaves to different parts of the plant. This system essentially consists of xylem, cambium and phloem. Xylem conducts raw food and phloem transfers organic food of plants.

Xylem is also called Hadrome or Wood. Xylem consists of tracheal tissue with wood parenchyma and wood-fibres. The *xylem* of fern has only tracheids. Xylem consists of protoxylem and metaxylem. Protoxylem are smaller vessels and formed first and consists of spiral and annular vessels and are found towards the centre in stem and the larger vessels are known as metaxylem groups formed after protoxylem and consists of reticulate and pitted vessels. The cambium is a strip of meristematic tissue lying between xylem and phloem. Phloem is also known as leptome or Soft Bast. Phloem is generally associated, with companion cells in dicots.

The wall of phloem vessels are thin and made of cellulose. They transfer organic food of plants.

Vascular bundles—

There are several types of vascular bundles :—

(1) **Collateral,** when the xylem and phloem groups are arranged side by side. The phloem being external *e.g.*, Rose, Pea.

(2) **Bicollateral,** if there be two sets of Phloem vessels on the inner and outer sides of a bundle, it is called bicollateral *e.g.*, Gourd, Cucurbita in general.

(3) **Concentric,** if the xylem is surrounded by the phloem or the phloem by xylem, the bundle is called concentric. The former is hadro-centric *e.g.*, Fern and the latter is lepto-centric *e.g.*, Dracena.

(4) **Radial,** this is found in roots of Dicots and Monocots where the xylem and phloem groups are arranged separately in the form of radii of a circle. The protoxylem in roots is towards the circumferance.

If there be cambium in a collateral bundle, it is called open ; but if the cambium is absent in the bundle, it is called closed.

Ground tissue system consists of cortical tissue and conjunctive tissue. Cortical tissue consists of hypoderma, cortex and endodermis.

Hypoderma may be formed of collenchyma or sclerenchyma or of ordinary parenchyma. Collenchyma with chloroplasts can prepare food. Sclerenchymatous hypoderma is a strengthening tissue. Sclerenchymatous hypoderma is peculiar to Monocotyledons.

Cortex proper is parenchymatous and stores up food or conducts carbohydrates and assimilates food.

Endodermis—

It is the limit of the cortex on the inner side. It is also known as Starch-sheath because it stores up starch. The radial walls of endodermis are thick in roots. When the endodermis is old, all the cells of the layer become corky leaving a few thin-walled cells called Transfusion cells. The endodermis is also called the Casparian band.

Conjunctive tissue consists of pith, pericycle and medullary rays.

Pith occupies the centre of the stem and sometimes it may be hollow.

Pith consists of parenchymatous cells and performs the functions of :—

(*a*) Conduction of water, and (*b*) storage of water and food-material.

Medullary rays store up reserve food but mainly carry food in solution from the vascular bundle to the cortical region. They are composed of parenchymatous cells running from the pith to the pericycle between vascular bundles.

Pericycle—It occurs in single or many layers just outside the phloem. It may be composed of parenchymatous cells and perform the function of storage of food. Sometimes, it is many layered and formed of sclerenchyma when it is a mechanical support.

Stele—

The central portion of root or stem formed by pericycle, vascular bundles and pith go by the name of Stele.

CHAPTER XXIII

ANATOMY OF PLANTS.

Transverse and longitudinal sections of **Dicot stem.**

A transverse section of Dicot stem shows the following structure from the outside :—

(*a*) *Epidermis* consisting of a single layer of cells with multicellular hairs. The outer walls of the cells are cutinised.

(*b*) *Cortex* consisting of several layers of parenchymatous cells with intercellular spaces. (Sometimes collenchyma is found here).

(*c*) *Endodermis* is made of one layer of cells.

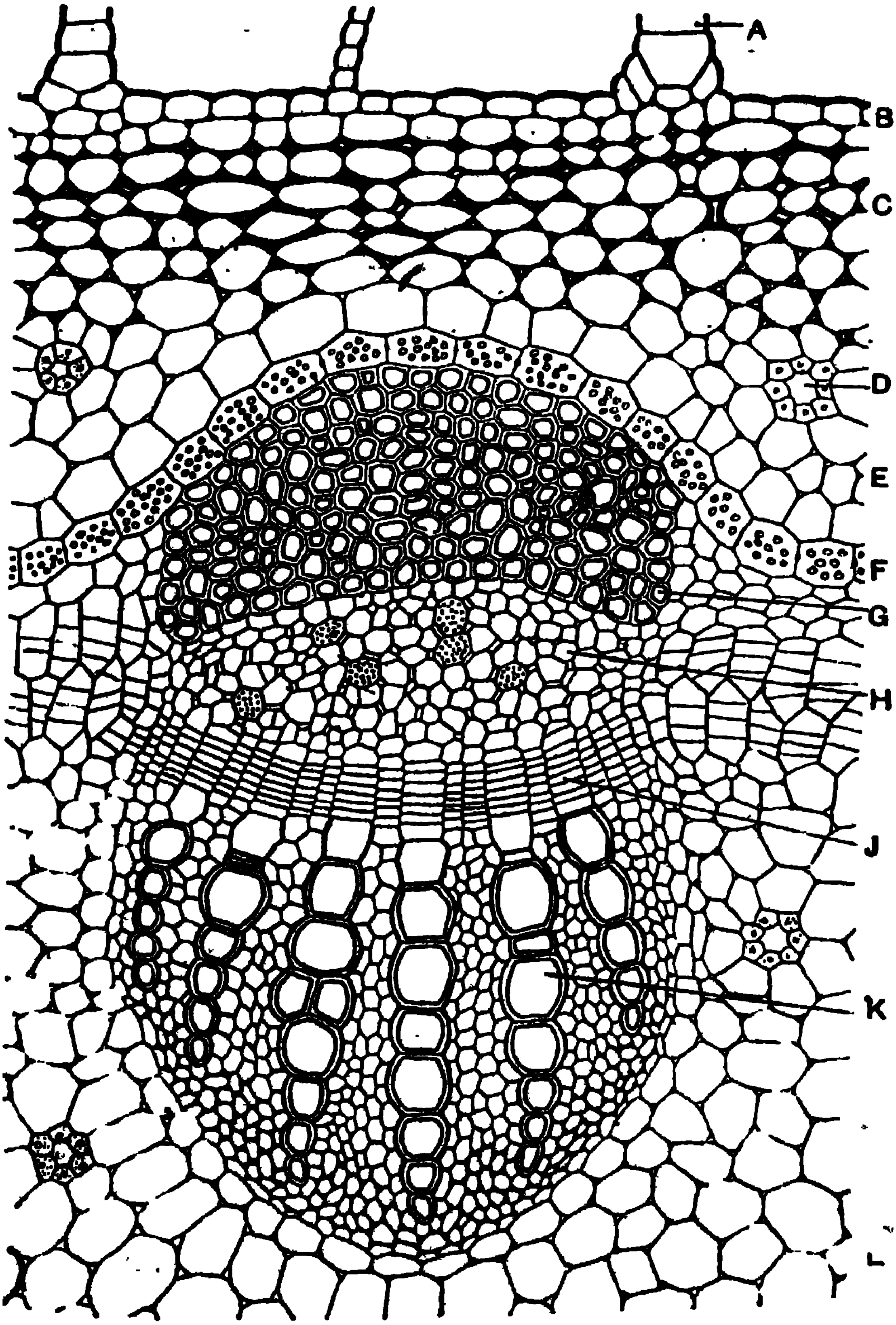
(*d*) *Pericycle* consisting of a few layers of cells (usually one layered).

(*e*) *Vascular bundles* are arranged in the form of a ring. Each vascular bundle conssts of xylen and phloem with cambium in the middle.

The xylem is made of metaxylem and protoxylem groups. The protoxylem is towards the centre or pith. The phloem is composed of metaphloem and protophloem. The protophloem is towards the outside. Between two vascular bundles, the medullary rays are situated running from the pericycle to the pith.

(*f*) *Pith* consists of parenchymatous cells with intercellular spaces and occurs in the centre.

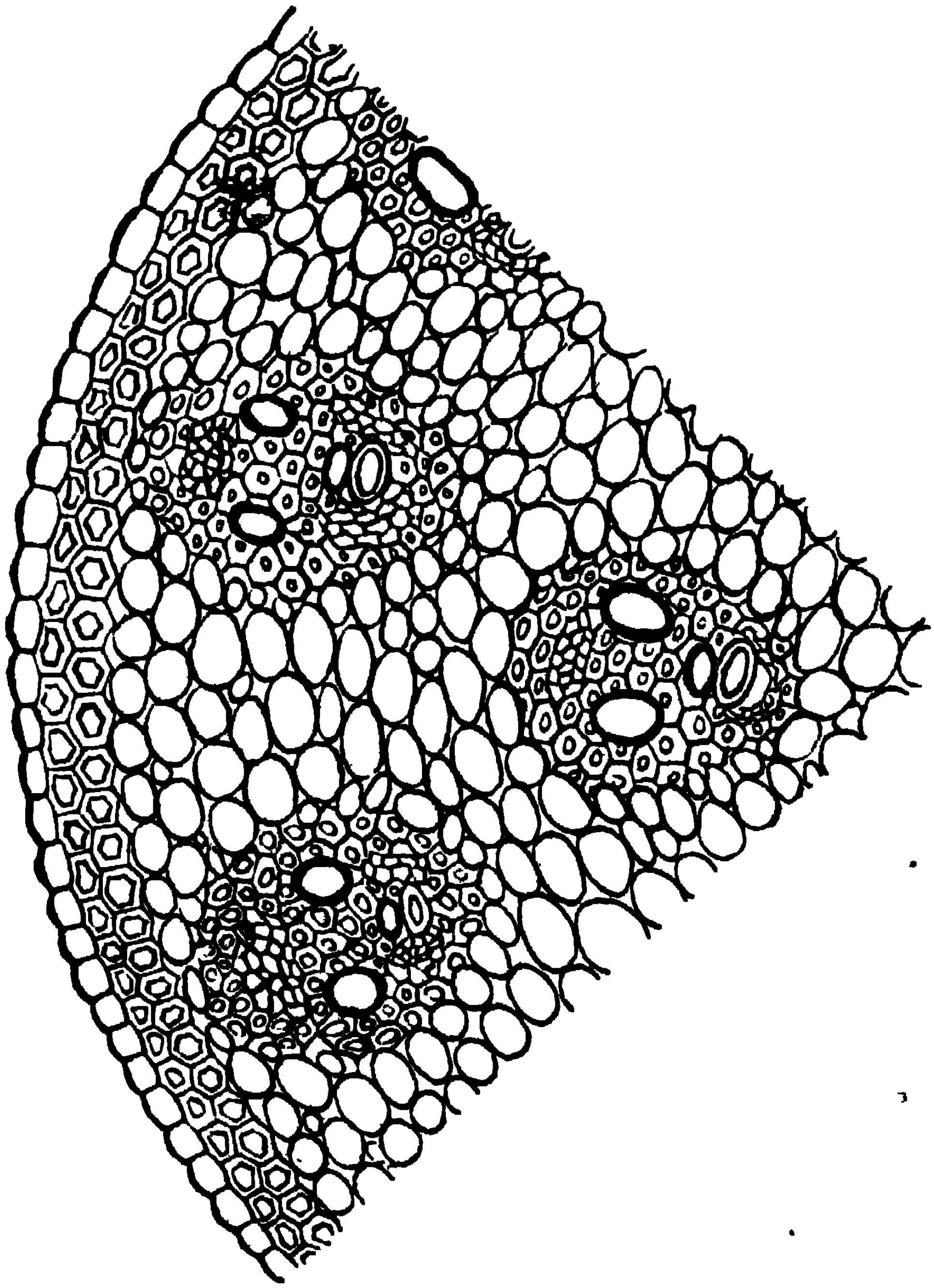
In the longitudinal section of stem, all the structures are found and the annular, spiral vessels of xylem and



A=hair, B=Epidermis, C=collenchyma,
D=resin duct, E=Cortex, F=Endodermis,
G=Hard bast (pericycle), H=Phloem, J=Cambium,
K=Xylem, L=Pith.

the companion cells of phloem become distinct and prominent.

Transverse section of **Monocot stem.** The parts are :—



T. S. of Monocot Stem.

1. *Epidermis* is one layer thick with cutinised outer walls.

2. *Hypodermal Sclerenchyma* consisting of a few layers of sclerenchymatous cells.

3. *Ground tissue* consisting of parenchymatous cells with intercellular spaces.

4. *Vascular bundles* are scattered throughout the ground tissue.

5. *Each vascular bundle* consists of *xylem and phloem.* The xylem vessels are in the form of " V " and the phloem is towards the open limb of " V." The bundle is surrounded by sclerenchyma sheath. There is no distinct pith or medullary rays. There is no cambium so the bundles are closed. Ordinarily, cambium is absent in Monocots but in certain Monocots *e.g.*, Dracena, Yucca there are cambium, so secondary growth is possible in them.

Transverse section of **Dicot root.**

1. *Epidermis* or Epiblema or piliferous layer. There is one layer of cells with non-cutinised walls with a number of unicellular hairs called root-hairs.

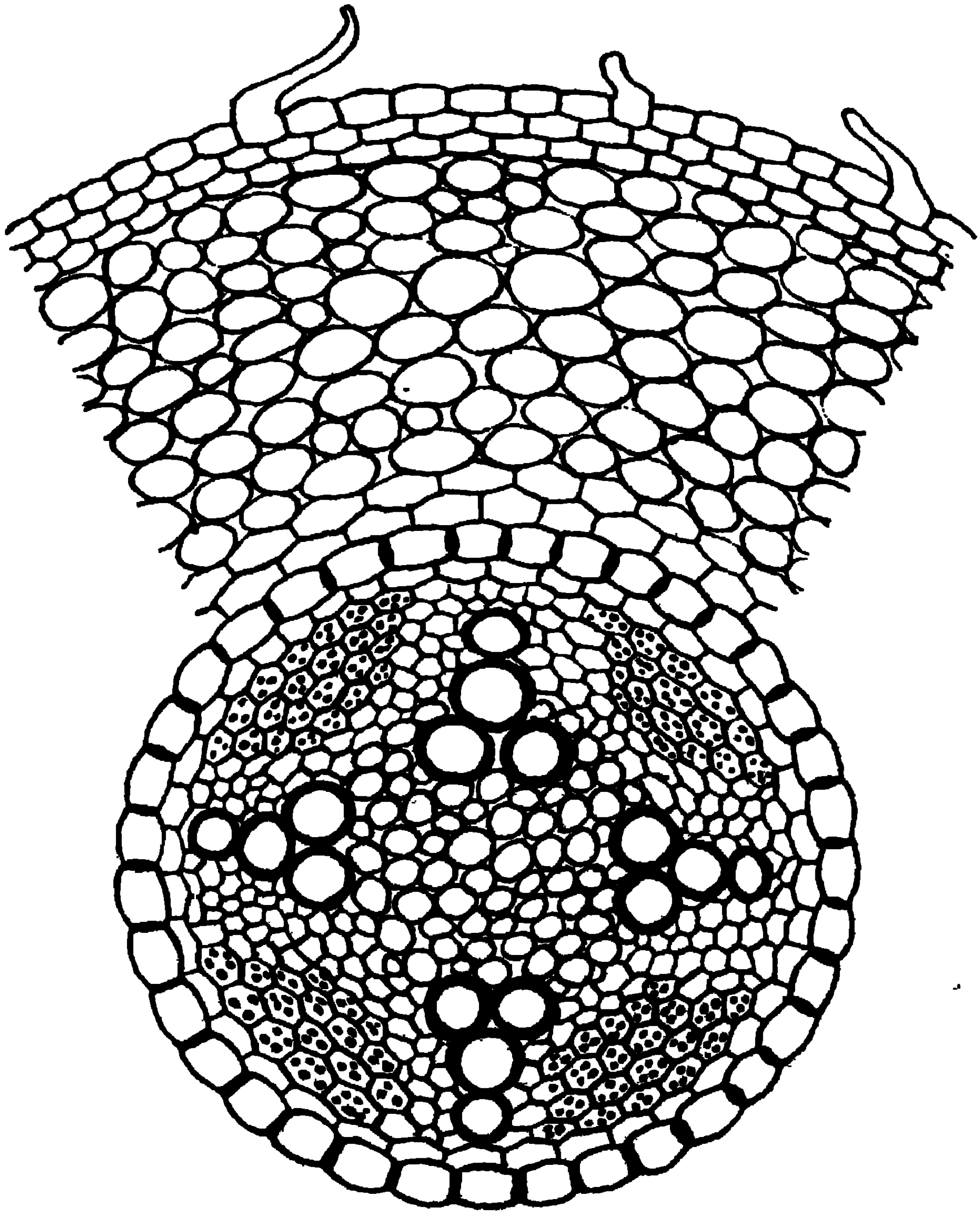
2. *Cortex* has many layers of parenchymatous cells with intercellular spaces, often it is divided into exodermis, cortex proper and endodermis. The exodermis is the layer just below the epidermis. The cortex consists of thin parenchymatous cells.

3. *Endodermis* consists of one layer of cells with thick radial walls.

4. *Vascular bundles* are in separate groups of xylem and phloem bundles arranged alternately. The bundles are radially arranged. The protoxylem is towards the circumferance. The number of bundles is either 2, 4 or 6.

6. There is a distinct *pith*.

T. S. of Dicot root.



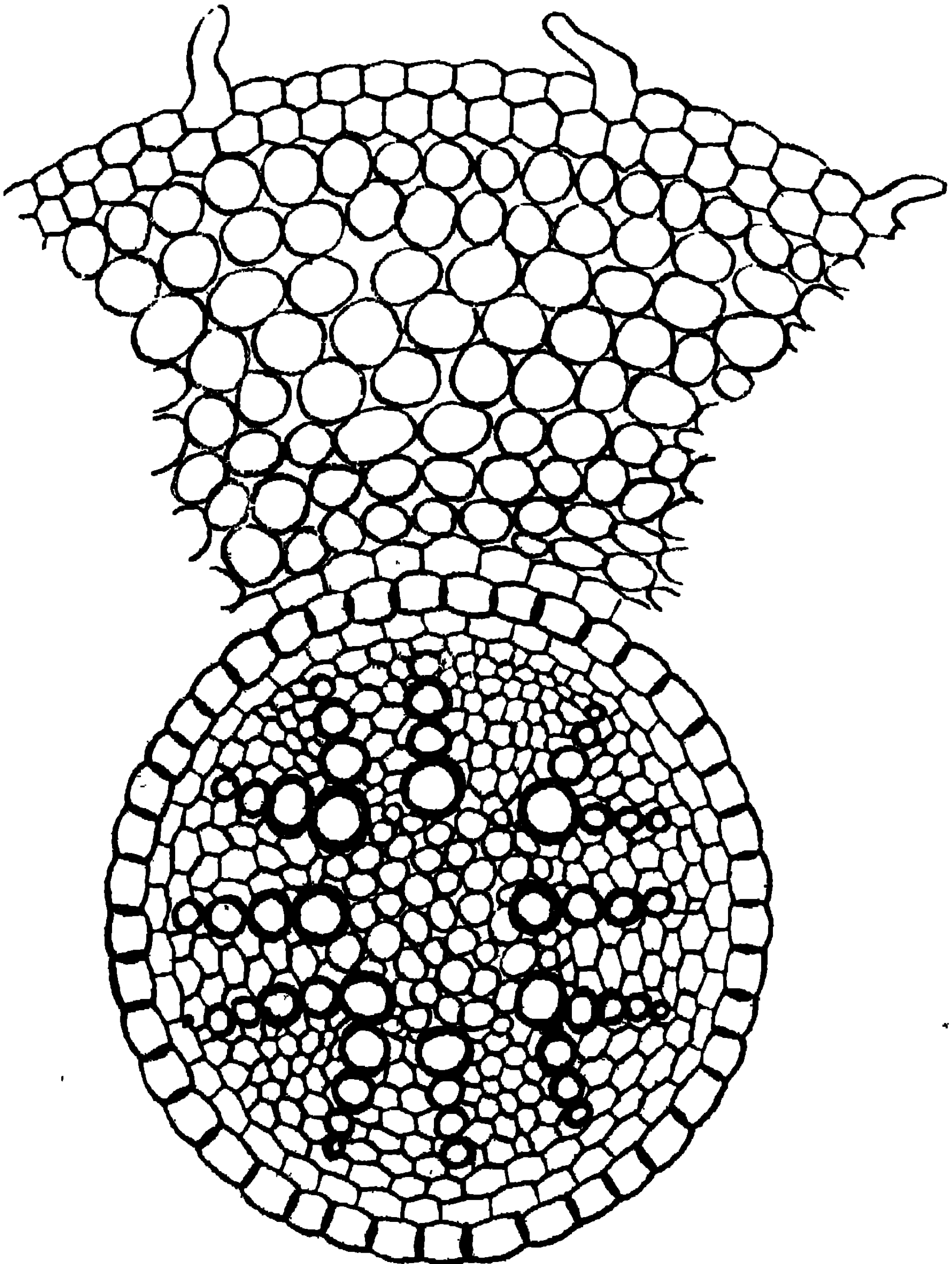
Transverse section of **Monocot root.**

1. *Epidermis* or *Epiblema* from the outside.
2. *Cortex.*
3. *Endodermis.*
4. *Pericycle.*

5. The *number* of bundles *is numerous* and the arrangement is radial *i.e.*, Xylem and phloem groups are arranged alternately in different radii.

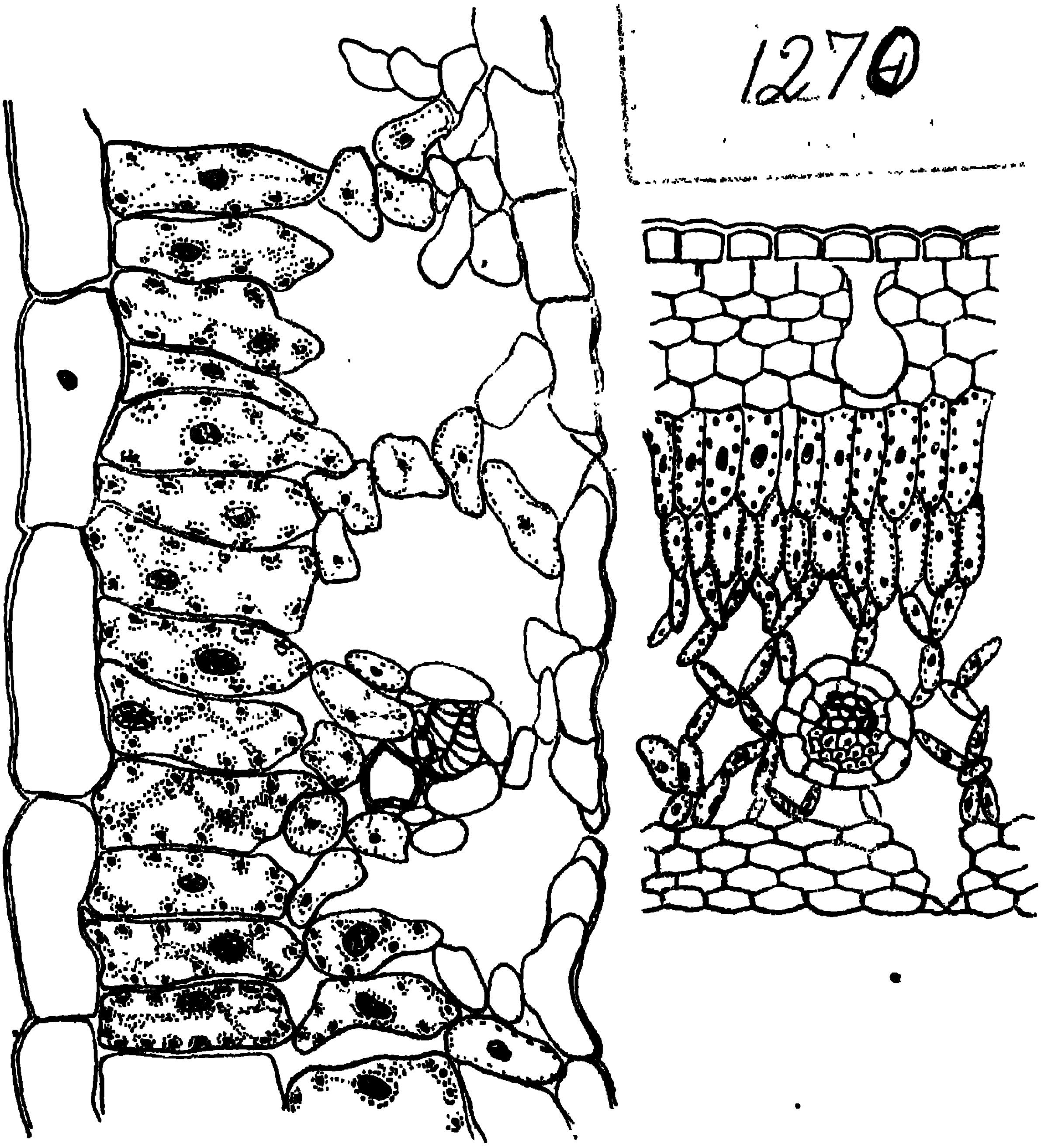
6. There is a *large pith*.

T. S. of Monocot root.



Transverse section of **Dorsiventral leaf.**

This type of leaf shows in section upper and lower epidermis and in India-rubber leaf, the epidermis is three-layered. There are cystoliths in the epidermis. The lower epidermis shows some stomata. The epidermis has cuticle on the outer surface. Between the upper and



T. S. of Dorsiventral leaves

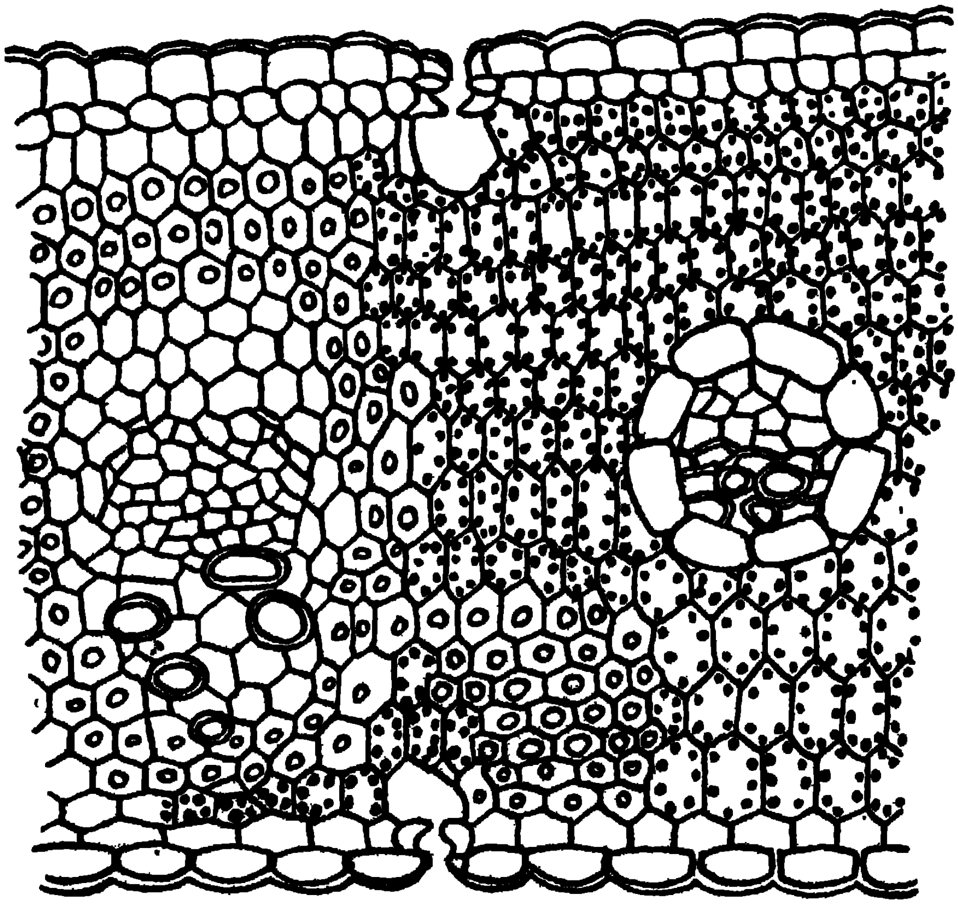
lower epidermis is the *mesophyll.* Mesophyll consists of *palisade* and *spongy parenchyma.* Palisade parenchyma has long cells with numerous chloroplastids in them.

The palisade parenchyma has no intercellular space. The spongy parenchyma on the other hand has plenty of intercellular spaces and are more or less oval or round in form. If the section passes through a midrib, it shows the same type of stele as the stem. Generally, the xylem is towards the upper epidermis and phloem towards the lower in the case of smaller veins.

Transverse section of **Isobilateral leaf.**

In the case of Datepalm, there is *Isobilateral* type of structure *i.e.* there is upper epidermis and lower

T. S. of Isobilateral leaf.



epidermis but stomata are present in both. Below the epidermis, there is found a layer of colourless cells. There is no *distinction of palisade and spongy parenchyma.*

There are large and small veins. The small have xylem and phloem surrounded by a Sheath of parenchyma whereas the larger veins are covered by sheaths of Sclerenchyma.

Secondary growth and formation of Bark.

The stems and roots of Dicots generally have secondary growth. The intrastelar secondary growth results from the activity of interfascicular and fascicular cambium in stem and extrastelar secondary growth of stem is due to the attainment of meristematic condition by some cells of cortex. As a result, cork is produced and all dead tissue outside the cork-cambium form the bark of plants.

CHAPTER XXIV

CRYPTOGAMS AND SPERMATOPHYTA.

The **cryptogams** are not the plants with which we are familiar *i.e.* they are neither like the pea, rose, mango nor like the maize, grass, palms etc. They are peculiar in that they do not produce the seeds but produce unicellular reproductive structures called **spores.** Some are very minute and can not be seen with the naked eye and require the use of the microscope. All disease producing bacteria as also beneficial bacteria like the lactic acid bacillus of sour milk belong to the group of cryptogams. Various examples of cryptogams are found around us namely the toadstool popularly called " Bangerchata " or the white incrustation found on damp articles in the rainy season or thread-like structures found floating in the tanks or the multi-coloured ribbons found floating near the sea-shores of Puri or South India. The cryptogams are divided into three main groups.

- Cryptogams
  - Thallophyta
    - Algae
    - Fungi
  - Bryophyta
    - Moss
  - Pteridophyta
    - Fern

The first group is Thallophyta because the plant-body is an undifferentiated mass called Thallus. In thalloid structure, there is neither root nor stem nor leaf. They may be composed of one cell or many cells. The thallophyta again is divided further into **Algae** and **Fungi,** on account of some fundamental difference.

Algae are generally capable of manufacturing their own food and they contain some colouring matter either green, red, yellow or brown. But **Fungi** are devoid of the colouring matter, in other words they cannot prepare their food but have to depend upon food prepared by other plant or animal.

Fungi live either as **parasite** or as **saprophyte.** When they live on living matter, they are called parasites but when they live on dead organic matter, they are known as saprophytes. Examples of Algae are Spirogyra, Diatoms etc. and examples of Fungi are Bacteria, mucor, yeast etc.

The second group is the **Bryophyta.** Here the differentiation of stem and leaf is found but no true roots. The plant-body is a step above the thallophyta, although in some bryophytes namely Marchantia, the plant-body is still a thallus. The plant-body although showing difference of stem and leaf represents the gametophyte—phase. Here the sporophyte is not independent and lives as a parasite or as semiparasite upon the gametophyte. There is no separate existence of gametophyte and sporophyte, one is dependent upon the other. Example—Moss.

The third group is the **Pteridophyta.** The group is very important from the point of view of evolution. Here there is differentiation of root, stem and leaf and they seem to approach the Phanerogams, the group highest in development in the plant kingdom. The commonest example is the Fern. The plant itself is the sporophyte and the gametophyte is less prominent but independent. There is a reversion of the dominance of the gametophyte that is found in the Bryophytes. In the higher plants like rose and pea, the plant-body is the sporophyte and the gametophyte really becomes inconspicuous.

Spermatophyta—

Spermatophyta are characterised by :—

(1) The **formation of a pollen-tube;** (2) the **production of seeds.**

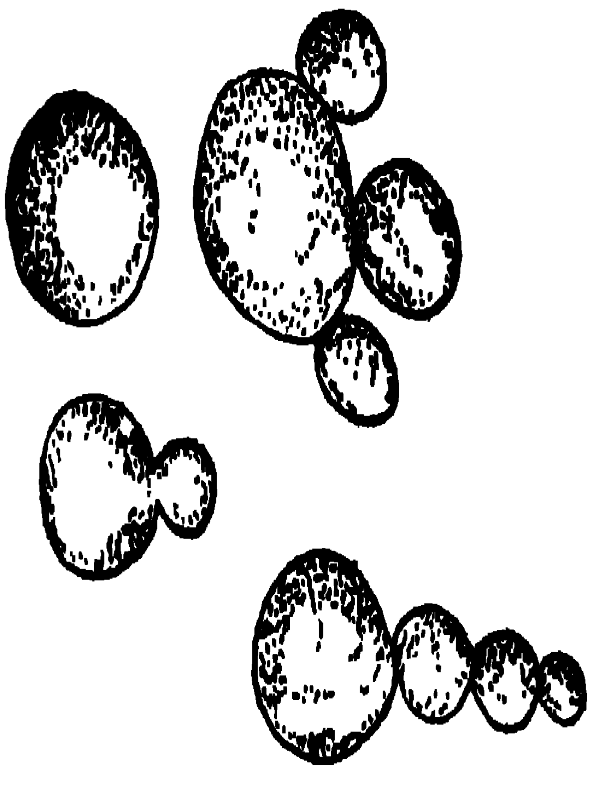
The cryptogams are spore-producing plants. Spermatophyta are sub-divided as follows :—

Spermatophyta

- Angiosperms
  - Dicotyledons e.g. Pea.
  - Monocotyledons e.g. Maize.
- Gymnosperms e.g. Pine.

The first group is the **angiosperms,** they are close-seeded plants *i.e.,* their seeds are found in a case called ovary whereas the **gymnosperms** are called open-seeded plants *i.e.,* their seeds are not found in a case but are open. The ordinary plants like pea, rose etc. are all angiosperms but the gymnosperms are generally prominent in the hills but at one time in the history of the earth, there was greater dominance of the gymnosperms and were found as plentifully as the angiosperms of to-day.

The angiosperms are divided into **Dicotyledons** *i.e.*, plants which have two cotyledons in their seeds and **Monocotyledons** which have one cotyledon in their seeds. The example of the former is pea and of the latter maize.



Yeast—a fungus in a state of budding.

CHAPTER XXV

LIFE-HISTORY OF YEAST.

The plant belongs to the group of Fungi. It consists of a single cell sometimes remaining joined with one another forming a chain and often it separates and lives independently as a single cell. It is able to set up alcoholic *fermentation* in Saccharine solution. (Two species are generally found namely Saccharomyces cerevisiae and S. ellipsoideus. The last species is used for the preparation of wine from grape-juice) The plants generally float in air and specially near vine-yards and thrive well in sugary solution and can be found in toddy. The plant consists of a single cell, with cell-wall composed of fungus cellulose. There is a nucleus, vacuole and a number of oil globules.

Nutrition—

The nutrition is obtained from sugar-solution by direct absorption. The active agent extracted out of Yeast plants is zymase. The solution of sugar breaks down into carbon-dioxide (CO_2) and alcohol. The froth that is seen on the upper part of a vessel containing fermented liquid is due to CO_2 and the alcohol remains behind in the vessel.

The equation of the chemical reaction is:—

$$C_6H_{12}O_6 = 2CO_2 + 2C_2H_6O$$

Sugar Carbon dioxide alcohol.

The yeast-cell thrive well in the presence of oxygen but the transformation of sugar-solution is very meagre in comparison with the condition when oxygen is absent *i.e.*, more alcohol is produced in the absence of oxygen.

Yeast is able to *ferment sugar-solution*. Such a process where fermentation takes place by a living organism is spoken of as organised ferment. But an active agent has been extracted from yeast which is able to ferment. It is known as *Zymase*.

The significance of fermentation is peculiar in that it is a process of respiration. Ordinarily, respiration can take place only in the presence of oxygen, such a process is called aerobic respiration but there are plants like yeast which can decompose their complex food substances to liberate oxygen even in its absence with the help of ferments, such peculiar oxidative processes are called anaerobic respiration.

Reproduction—

Budding or **Pullulation** or **Gemmation.**

When there is plenty of sugar-solution, the yeast plant grows and divides by gemmation. At first, the nucleus divides and a projection appears on the cell which forms another yeast plant. A series of plants may be attached one upon another forming a chain.

Spore-formution—

Previously, it was thought that with the approach of unfavourable period, the yeast plant produced spores to tide over the period *i.e.*, when there was any want of the sugar-solution. The single cell produced four-nuclei, each of which collected some cytoplasm and formed spores. Generally, the number of spores was four. The structure containing the spores was called *Ascus.* The view was that the spores were formed parthenogenetically. Recently, Winge has shown that the spores are formed in yeast as a result of Conjugation. As regards the combination, he has shown various haploid cells conjugating to form the zygote. One thing which is to be noted is that the conjugating cells must be completely or almost full grown; young buds never conjugate. The spores come out of the ascus with the approach of favourable period and the wall of each spore bursts to form a new individual. The yeast goes on budding until the period for conjugation comes up.

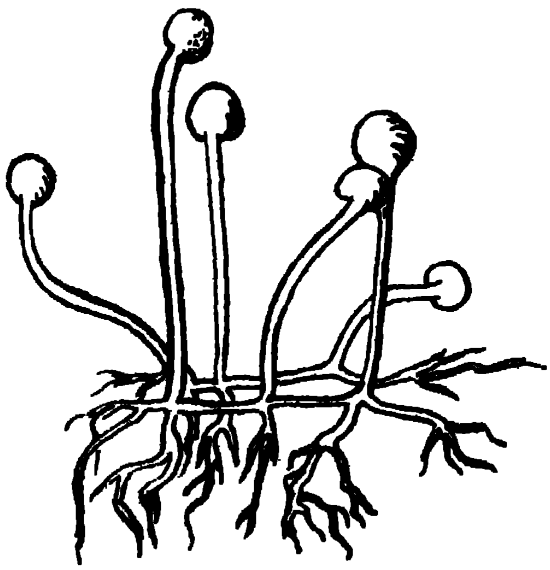
Mucor —

It belongs to the group of *Fungi* and are known as moulds. It is a saprophyte *i.e.,* lives upon dead organic matter. It is generally found as white patches on the surface of decaying organic matter namely on wet bread, dung and even on damp shoes but the colour ultimately changes to black. The plant consists of net-work of fine structures called collectively **mycelium** and the individual threads are known as **hyphae.** There is no partition-wall separating the cells but a number of nuclei are found. Such a structure is called coenocyte. The commonest forms are *Mucor mucedo* and *Mucor stolonifer.*

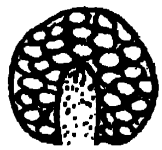
Asexual method of reproduction—

The individual threads or branches of the mycelium become erect and bear spherical sacs which are known as **Gonidangia** containing within them spores called

Gonidia. The gonidangium is also called Sporangium. The stalk of the *gonidangium* is called gonidiophore. The gonidiophore has a projection inside the sac which is called columella. This columella helps in the dispersal of the spores. When the *gonidangium* is mature, it bursts liberating the spores. Each spore or gonidium



Mucor,



Sporangium.

Zygospore.

when free, puts out a germ-tube and forms a new mycelium. Recently it has been shown that the columella is a vacuolar structure and is formed by the union of vacuoles.

Sexual reproduction—

Sexual reproduction takes place as a result of *conjugation* of two similar gametes. Sexual organs are formed by the mycelium. The tip of the hypha is cut off by a partition and the protoplasmic contents form the gamete. The separated part containing the gamete is called the gametangium. The gamete has many nuclei so it is called coenogamete. By a similar process another gamete is formed, the two gametes fuse up forming a structure called zygospore. The zygospore has a thick warty wall consisting of two layers, the outer one is called exosporium and a delicate inner endosporium. After sometime which is a period of rest, the zygospore germinates and the exosporium is ruptured but from the endosporium another tube-like structure is formed which is called the promycelium. The promycelium bears a sac called the sporangium containing a number of spores. Each of the spores can produce a mycelium. Sexual reproduction in Mucor is remarkable in that it can take place only between two different **strains** of this plant. The two strains show no morphological difference, but there must be some physiological difference. They are referred to as the + and — strains. The only physiological difference so far recognised is that the + strain grows more vigorously. Two hyphæ from a + strain cannot fuse to form zygospores neither can two hyphæ from a — strain. Sexual reproduction takes place between a hypha of a + strain and a hypha of a — strain. Thus sexual reproduction is rare, since a + and — strain are not often found near enough to each other.

Sometimes the gametes instead of fusing with each other, can grow out into a *promycelium*. Such gametes which behave like zygospores are called azygospores.

Torula condition of Mucor—

The mycelium of mucor occasionally when placed in sugar solution divides into thin-walled cells called *oidium cells*. These cells are capable of budding and fermenting sugar solution like the yeast. This condition of Mucor is known as its **Torula condition.**

Spirogyra

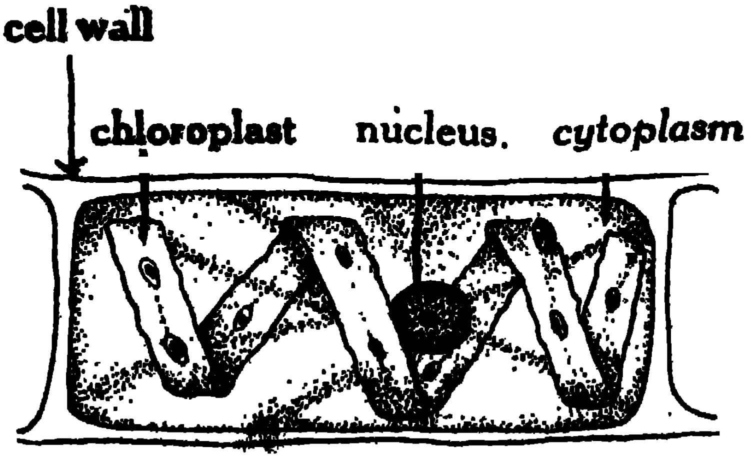
The plant belongs to the group of Algae. It floats as a mass of tangled threads in freshwater ponds and streams. The plants consist of a number of cells joined end to end sometimes having a mucilaginous covering. There is no distinction of base and apex of the plant as a number of equal cylindrical cells are joined to form a filament. Each cell of the filament has a distinct nucleus, the most characteristic *chloroplast* is in the form of a *ribbon* and the protoplasm generally recedes towards the wall and is known as primordial utricle. The band-shaped chloroplast may be 1 to 8 in number and each ribbon has a number of round bodies called pyrenoids. Pyrenoids are protein grains surrounded by starch grains. The filament can grow in length by the division and growth of the cells. Growth in length of the filaments takes place by the elongation of each individual cell and by the production of new cells by mitosis. This division usually takes place at night. Any cell is capable of division. This is known as **intercalary** growth as opposed to **apical** growth which takes place only at an apex.

Reproduction —

The cells of the filament can break up but at least one cell is required to form another new filament. This is called *Vegetative* method of reproduction.

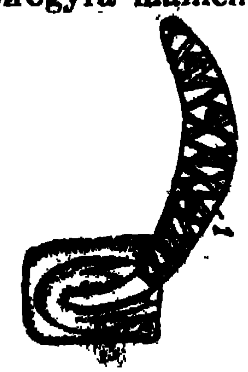
Sexual reproduction takes place when two filaments come to lie side by side. The walls of opposite cells project and gradually increase in size and ultimately fuse up to form a tube-like structure called conjugation—tube.

Here the cells form the gametangia and the protoplasmic contents excluding the chloroplasts form the gametes. Such a union between two gametes of the same kind is called *conjugation*. As a result of conjugation, the contents of one cell *i.e.,* one gamete travels towards the other gamete and fuses with it to form the zygospore. The zygospore passes through a period of rest after it has formed a hard wall. After the resting period, the outer coat of the zygospore ruptures and the inner contents grow out into a new filament.



A cell from spirogyra filament.

Spirogyra filament.



Zygospore germinates to form new filament.

When two different filaments lie side by side and conjugate, it is called **Scalariform** conjugation. Sometimes however, cells of the same filament may conjugate, in which case it is known as **lateral** conjugation. There is a slight physiological differentiation of sex; but the structural difference is not sufficient to warrant it being referred to as heterogamy or true fertilisation.

In some species, the gametes conjugate in the conjugation canal.

Sometimes the gametes without fusion can behave like zygospore. Such gametes are called azygospores and may be compared to a process of *parthenogenesis*.

Moss —

The moss plant belongs to the group of **Bryophyta** which is a step higher than the Thallophyta.

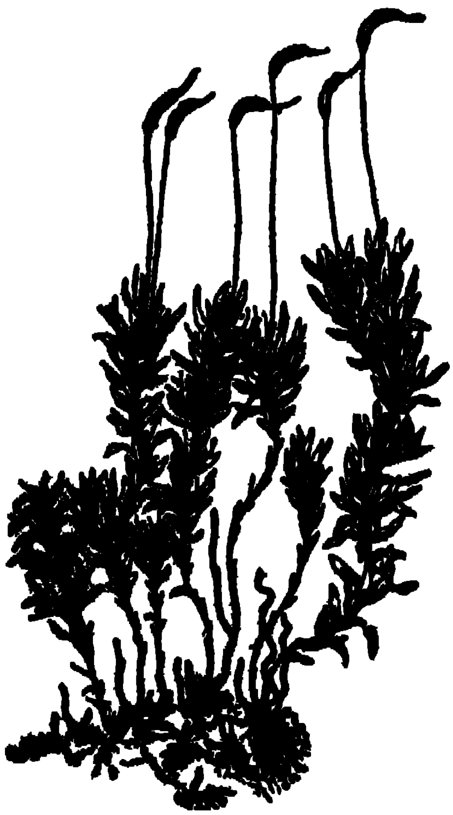
Mosses are abundant in the rainy season and generally grow as green velvety patches upon earth, rocks, tree-trunks, old walls and on the steps of ponds and streams.

General Characters —

The plants are very small scarcely attaining an inch in length. Leaves are thin, small and green in colour with a distinct midrib. The stem occasionally branches. There is no true root but a number of root-like structures are found at the base which perform the function of roots and are known as rhizoids which are multicellular.

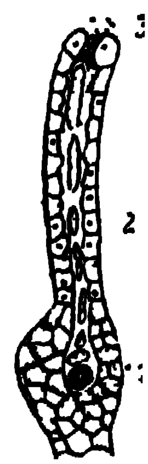
Life-History —

The life-history of the plant shows two distinct phases. Firstly, the ordinary green plant which ultimately bears the sexual organs is the gametophytic stage and secondly as a result of some sexual process another structure rises from the apex of the moss plant which bears the spores contained in a Sac-like structure. This represents the sporophyte-stage of the plant. Spores are produced within the sac and when mature, they come out and produce the moss plant but growing at first on a structure called **protonema.** Therefore a regular *alternation of sporophyte and gametophyte* is found in



1 = Leaf.

Moss with capsule
1 = Moss plant.
2 = Seta,
3 = Capsule.
4 = Stem.



1 = Ovum,
2 = Canal.
3 = Archegonium

the mocsplant, which is described as alternation of generations. The gametophyte is also called the *gamobium* or sexual stage and the sporophyte is called the *agamobium* or asexual stage.

Anatomy of Stem —

A transverse section of the stem shows that it consists of an outer layer of epidermis followed by cortex of many—layered cells and a central strand of thin-walled cells called the conducting strand.

Anatomy of the Leaf —

The leaf consists of a number of cells containing chloroplasts *i.e.,* they are capable of manufacturing their food.

Reproduction —

(A) **Vegetative reproduction.**

(1) By buds,—leaf-buds may arise from any part of the plant, detach themselves and develop into new individuals.

(2) The protonemal filaments may be developed from some cells of the sporogonium.

(3) Some branches may separate to form new individuals.

(B) **Sexual reproduction.**

The sexual organs are generally borne at the apex of the stem among a tuft of small leaves. There are male and female organs called **antheridia** and **archegonia** respectively. The organs may be borne by the same plant when it is called *monoecious* or the organs may be found in separate plants when it is called dioecious *i.e.* moss plants are either monoecious or dioecious. Each antheridium is a club-like body borne on multicellular stalk. It has a wall consisting of a single layer of cells and a number of mother-cells for the male elements. Each mother-cell produces one antherozoid which is biciliate *i.e.* bears two cilia. Each archegonium is a flask-shaped body containing a female cell within it called the oosphere. There is a neck of the archegonium which forms a canal at the time of union of male and female cells. The canal has a mucilaginous secretion rich in cane-sugar which seems to attract the antherozoids but only one is allowed to fuse with the oosphere. This process of fusion is called fertilisation. As a result of fertilisation, the oosphere is converted into oospore and it receives a stimulus of growth and forms another structure which is called the sporogonium of moss.

The sporogonium has a stalk called seta and an upper ovoidal head called the capsule. The capsule has a special tissue within it which is called the archesporium or the spore-producing tissue which becomes evident on a longitudinal section of the capsule. The central tissue of the capsule is called columella. It has a cap-like upper portion called operculum connected with columella by annulus. There is a tooth-like portion near the annulus called peristome which helps to disperse the spores by absorption of water.

When the capsule is ripe, the upper portion of the sporogonium which might carry the remnants of the neck-portion of the original archegonium is thrown off and the spores come out. Each spore can germinate and produce a filamentous structure called protonema. The moss plant arises as a bud on this protonema.

The Life-Cycle of a Moss.—The life-cycle may be summarised in a few brief statements :—

1. Germination of the spore results in a branched filamentous, alga-like growth called the protonema.
2. The formation of special protonema branches, and the setting of an apical cell at the end of each branch.
3. The growth of each of these branches or "buds" into a stem bearing rhizoids at the lower end and simple spirally arranged leaves above.

4. The formation at the tip of some of the leafy shoots of groups of antheridia and paraphyses.

5. The formation at the tips of other shoots of groups of archegonia and paraphyses.

6. The opening of antheridia and archegonia during a period when the plants are wet and the escape of the sperms.

7. Swimming of some of the sperms to the archegonia whither they are probably directed by certain substances which diffuse outward from the open archegonia.

8. Fertilization, followed by the formation of a cell-wall about the zygote. The zygote nucleus and all the nuclei of the sporophyte generation have $2n$ chromosomes.

9. The development of the zygote by growth and cell divisions into an embryo sporophyte which is enclosed by the enlarged archegonium venter (calyptra) until just before the maturity of the sporophyte when the calyptra is torn away from its attachment to the leafy shoot.

10. The development of the embryo into the mature sporophyte consisting of (*a*) the foot which penetrates the tip of the stem of the gametophore and serves as an organ of attachment and absorption, (*b*) the seta or stalk and (*c*) the capsule, a complex structure within which the spore mother cells are produced but which is mostly made up of sterile tissue.

11. The two successive divisions of each spore mother cell to form a tetrad of spores. The first division of the spore mother cells is a reduction division and marks the end of the diploid or sporophyte phase and the beginning of the haploid or gametophyte phase in which all the nuclei have n chromosomes.

12. The drying out of the capsule, the loss of the operculum or capsule cover, and the escape, assisted by the hydroscopic movements of the peristome teeth, of the spores.

According to true cytological data, the spore starts the gametophytic stage (n chromosomes) upto the formation of zygote (oospore) ($2n$ chromosomes) which is the starting point of the sporophytic stage.

Graphic representation of the life-history of Moss.

Vegetative repro.
|
Moss plant
(Gametophyte) (n)

Antheridium (n) — Archegonium (n)
Antherozoid (n) — Oosphere (n)

Oospore ($2n$)
|
Sporogonium or Capsule ($2n$)
(Sporophyte)
|
Spore (n)
|
Protonema (n)
|
Mossplant (n).

Fern—

The ferns belong to the group of **Pteridophyta.** Ferns are generally known as Filices or Filicales.

Habitat: Generally it grows on damp places and is more or less shade-loving. The plants are rhizomatous herbs, but in tropical countries large tree-ferns like palms are found. The temperate climate is suitable for its growth because the hills of Darjeeling, Simla and Kashmir are famous for their luxuriant growth of ferns. In cities, the ferns adorn the gardens and palaces of the rich. People take a fancy for some ferns as for example, the maiden-hair fern is invariably associated with the handiwork of florists. The narrow water-ways of Bengal are provided with a good variety of ferns specially the shady lands through which the water courses its way.

The plant is a small herb with an underground rhizome. The leaves are generally compound and of the pinnate type although the palmate type is also found. In some ferns, the leaves are simple. Sometimes ferns are found as epiphytes *i.e.*, growing upon another plant and live upon air. The plant is covered all over by hair-like structures called ramenta. The leaves are green in colour and provided with distinct midrib and veins. The ordinary leaves are called fronds or **trophophylls** whereas spore producing leaves are **sporophylls.** The ptyxis of the leaf is circinate *i.e.*, rolled up in the young condition like a dog's tail. Roots are found in ferns but are adventitious. It takes about two years for the maturation of a leaf but usually a number of leaves open every year. The leaves bear some globular bodies on the undersurface which are either on the veins, or on the margins or on surface. These bodies are known as sori. Each **sorus** consists of a number of sac-like structures called sporangia. Each **sporangium** is stalked and rises from a tissue of the leaf called placenta. The sporangia are protected and covered by a structure called **indusium.** The sporangium has a wall called **annulus** with a weak spot called **stomium.** The spores are found within the sporangium, the number is about 64. When the sporangium is mature the spores come out through the stomium. The spore is a minute one-celled reproductive unit having its wall differentiated into two parts called exosporium (outer) and endosporium (inner). Each spore can germinate and ultimately by celldivisions forms a heart-shaped structure called the **prothallus.** This prothallium is a thin, green, multicellular body bearing a number of rhizoids on the undersurface. These rhizoids draw nourishment from the soil. The rhizoids are unicellular. The prothallus has a notch at the upper part and this prothallus represents a definite stage in the life-history of fern. The prothallus on the underside bears two kinds of *sexual organs*, the *antheridia* and the *archegonia*. The antheridia are found at the base together with the rhizoids whereas the archegonia occur near the notch. This is the **gametophyte** stage of fern. Each archegonium is shaped like a flask and consists of a basal portion called the venter completely placed in the tissue of the prothallus and a neck. The venter has a single female gamete called oosphere or ovum and above it a ventral canal cell and the neck consists of four-rows of cells. Just above the ventral canal cell is a single neck canal cell. The neck is at first closed but at maturity opens and due to the disorganisation of the canal cells a mucilaginous secretion comes out which is rich in *malic acid* to attract the male elements or antherozoids.

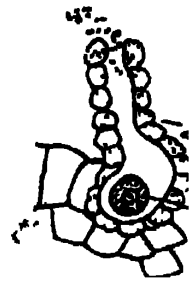
The male organ or antheridium is a capsular body. The capsule contains a number of the mother-cells of the antherozoids. One antherozoid develops in each cell. Ultimately the antherozoids are set free and they move towards the neck of the archegonium. The antherozoid has got swimming capacity owing to the presence of a number of cilia on it's body. Therefore the antherozoids are multiciliate. One of the antherozoids attracted by the secretion of malic acid fuses with the oosphere, nucleus with nucleus, cytoplasm with cytoplasm and forms the oospore. This process is called fertilisation. The process of fertilisation generally takes place between

Fern.

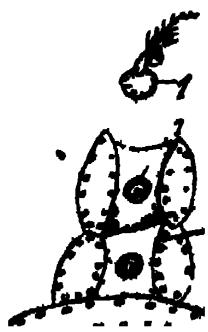
antherozoid produced by one prothallus with the oosphere produced by another prothallus *i.e.*, cross fertilisation takes place although the prothallus of fern is hermaphrodite, the sexual organs of the same prothallus do not mature at the same time and thus it favours cross-fertilisation.

1 = Leaf,
2 = Root,
3 = Circinate,
4 = Rhizome,
5 = Leaf

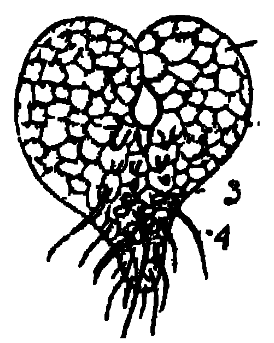
1 = Spore,
2 = Stomium,
3 = Annulus,
4 = Stalk



1 = Ovum,
2 = Archegonium



1 = Antherozoid
2 = Mother cell



1 = Prothallus
4 = Rhizoid.

The oospore continually divides and segments forming the primary root, first leaf or cotyledon, stem and a massive foot. The foot absorbs nutrition for the developing embryo until it becomes independent and absorbs moisture from the soil. The primary root is replaced by a number of adventitious roots. The prothallus in the meantime dries up and the plant becomes an independent organism to all intents and purposes.

Graphic representation of the Life-history of *Fern*.

Vegetative repro.

Fern
(Sporophyte) ($2n$)

Sporangium ($2n$)

Embryo
Oospore ($2n$)

Spore (n)

Antherozoid (n)

Oosphere (n)

Antheridium (n)

Archegonium (n)

(Gametophyte) (n)
Prothallus

Alternation of generations—

The life-history of ferns shows two distinct stages or Phases. The plant itself is the sporophyte and before another sporophyte is formed, there occurs the gametophyte in the form of prothallus. The prothallus is quite independent and manufactures its own food. Therefore the sporophyte is followed by the gametophyte and then another sporophyte. Such a phenomenon is called alternation of generations. The gametophyte is the sexual phase and sporophyte is the asexual phase of the plant.

Apospory and Apogamy—

The fern-plant often adopts the process of vegetative reproduction by producing another fern-plant from the surface of the leaf which is known as bulbil or from rhizome or from a part of the leaf.

In some cases, the fern-plant arises without the spore stage or the sexual process is eliminated. The former is called apospory and in such cases the prothallus may directly develop from the sporangium or from any portion of the frond. In apogamy, the ordinary cells of the prothallus can give rise to the fern-plant.

Anatomy of rhizome—

A transverse section of the rhizome shows a number of vascular bundles arranged in the ground tissue. There is hypodermal sclerenchyma and on the outside is the epidermis. Each vascular bundle consists of xylem in the centre surrounded by phlœm. The phlœm has on the outside, a circle of pericycle and a layer of endodermis. There are some smaller bundles which pass on to the leaves.

The section of petiole is similar to rhizome but the stele is like a horse-shoe.

Pea—

The pea plant belongs to the group of Dicotyledons under angiosperms. The plants are delicate herbs. The stem is soft. The leaves are compound and of the pinnate type and each leaf has a number of leaflets.

The ultimate leaflets are modified into tendrils. At the base of the compound leaf there are leaf-like structures which are the foliaceous stipules. The root is of the dicotyledonous type *i.e.,* a primary root branches and produces a branch system of roots. The roots have a peculiar property of fixing nitrogen of the atmosphere with the help of nitrogen-fixing bacteria which are found in the form of swellings or tubercles on the roots.

Flowers are in racemes. Each flower has four whorls. The first and outermost whorl is the calyx forming a tube by the union of the sepals. The calyx is gamosepalous. The number of teeth is five. The next whorl is the corolla, consisting of 5 petals, and is of the *papilionaceous* type. The corolla is polypetalous. Of the five petals, the posterior one is the largest and is known as the Vexillum or standard. There are two petals on the two sides called Alae or Wings. On the anterior side, two petals are united to form a boat-shaped structure called keel or carina.

The third whorl is the andraecium consisting of ten stamens, of which nine are united and one is free. The stamens are di-adelphous. The fourth whorl is the gynoecium or pistil. The gynoecium is monocarpellary *i.e.,* consists of one carpel. The ovary is superior. The fruit is a *legume.* The seeds are *exalbuminous.*

Maize—

The **maize** plant belongs to the group of Monocotyledons under angiosperms.

The plants are stout herbs with solid stem. The nodes and internodes are solid. The leaves are simple, with sheathing leaf-bases. The roots are fibrous or adventitious.

The inflorescence is in the form of spikelets. Male flowers and female flowers are found on separate spikelets on the same plant *i.e.,* monoecious. Male flowers occur on the top and female flowers lower down on the stem. Male flowers are two in each *spikelet,* of which one is sessile and the other flower is pedicelled. Each flower has four glumes, of which the first and second glumes are empty. The third and fourth glumes are hyaline, paleate and enclosed by the first one. The perianth is represented by two fleshy lodicules. Stamens are three in number. Anthers are versatile.

Female spikelets are one-flowered and are arranged on a fleshy rachis. The ordinary "Bhutta" represents so many flowers arranged on the axis of an inflorescence. There are four glumes of which the first two are broad, the third one is empty and the fourth is two-fid. Perianth is not represented, and even the lodicules are absent. The ovary is superior with long thread-like two-fid styles. Fruit is a *caryopsis.* Seeds are *albuminous* and the axis of the embryo is situated at one side of the seed.

CHAPTER XXVI

INTRODUCTION TO THE GENERAL CLASSIFICATION OF ANIMALS.

There are various types of animals on the face of the Earth, too numerous to be counted upon, so they are grouped into convenient divisions called **Phyla.** The whole kingdom is sometimes divided into **Protozoa** or **unicellular** animals and **Metazoa** or **multicellular** animals. The **Protozoa** consist of a single cell which performs all its functions through this cell; example Amœba, Monocystis, Malarial parasite etc. The **Phylum Protozoa** again is divided into a number of **classes** called **Rhizopoda** *e.g.*, Amœba; class **Flagellata** *e.g.*, Euglena, class **Ciliata** *e.g.*, Paramœcium and class **Sporozoa** *e.g.*, Monocystis.

The other group Metazoa is a vast group and includes all multicellular animals. The Metazoa is again sub-divided into **Porifera, Coelenterata** and **Coelomata.** The Porifera includes sponges with two body layers Ectoderm and Endoderm and hence they are termed Diploblastica. The Coelenterata is also two layered and includes the Hydra and the Obelia. The body-cavity of the Cœlenterata is known as the Cœlenteron.

The Cœlomata includes all animals from the **Annelids** like Leech and Earthworm to the highest group like the **Mammals.** It is better to adopt the following classification in order to have a bird's eye view of the

The Chordata and the Invertebrata are divided into the following phyla :–

Phylum Chordata

- **Acrania** (without skull)
  - **Subphylum Cephalochorda** *e.g.* Amphioxus.
  - **Subphylum Hemichorda** *e.g.* Balanoglossus.
  - **Subphylum Urochorda** *e.g.*, Tunicates.
- **Subphylum Vertebrata or Craniata** (with skull).
  - Without true jaws, Cyclostomata *e.g.*, Lamprey.
  - With true jaws.
    - Class 1. Pisces.
      - Sub-class Elasmobranchii *e.g.*, Sharks
      - Teleostei *e.g.*, Bony Fishes, Bhetki, Rohu etc.
    - Class 2. Amphibia *e. g.*, Frogs, Toads, etc.
    - Class 3. Reptilia *e.g.*, Snakes, Lizards, Crocodiles, etc
    - Class 4. Aves *e.g.*, Birds.
    - Class 5. Mammalia *e.g.*, Guineapig Cat, Dog, Tiger, Man.

Invertebrata

- Phylum Protozoa *e.g.*, Amœba Monocystis.
- Phylum Porifera *e.g.*, Sponges.
- Phylum Cœlenterata *e.g.*, Hydra.
- Phylum Platyhelminthes *e.g.*, Liver Fluke.
- Phylum Nemathelminthes *e.g.*, Round worms.
- Phylum Echinodermata e.g., Star-fish
- Phylum Arthropoda *e.g.*, Prawn.
- Phylum Mollusca e.g., Fresh-water mussel, Snails and Slugs.

whole animal kingdom. The animals are broadly divided into **Vertebrata** and **Invertebrata**. Animals without a vertebral column or a notochord come under the group **Invertebrata** or **Non-chordata**, while those possessing a **vertebral column** or **Notochord** are designated **Vertebrata** or **Chordata**. Both these groups are again divided into several phyla.

The chordata and the Invertebrata are divided into the following phyla :—

The Chordata are similarly divided into several sub-phyla and classes. The following scheme will enable the student to grasp the subject more easily than the usual long description found in the textbooks.

The chordata have some lower groups like Balanoglossus where the Notochord is confined to the neck region. In Tunicates the Notochord is confined to the larval condition. In the Amphioxus the Notochord persists from one end of the body to the other. In the Vertebrata or Craniata there is a bony case for the Brain called the Cranium whereas it is absent in the Acrania. The higher chordates show the development of jaws as organs of mastication.

The mammals are again sub-divided but it will suffice for the Intermediate course students to remember that it is a class of the Vertebrata and are specialised with the nursing of their young with breast milk in the early stage of life.

The **invertebrata** are characterised by :—(1) Absence of vertebral column, (2) Nervous system with ventral cord generally, (3) Heart when present is very rudimentary. (4) **Body-cavity** either cœlenteron, haemocoele or coelome.

The **vertebrata** have (1) Dorsal nervous system, (2) Ventral heart, (3) **Vertebral** column, (4) Respiratory organs like gills or lungs.