THE GOVERNMET OF THE REPUBLIC OF THE UNION OF MYANMAR

MINISTRY OF EDUCATION

BIOLOGY

GRADE 10

BASIC EDUCATION CURRICULUM, SYLLABUS AND

TEXTBOOK COMMITTEE

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FOREWORD

Grade 11 Biology course consists of 12 chapters. The first five chapters deal with the basic aspects while chapter six to eleven deal with life processes. Chapter 12 includes environmental biology . All chapters are associated. The students who are thorough with the course given in Grade10 would not have any difficulty in taking up Grade 11 Biology. Therefore, thorough understanding of foundation course introduced in Grade 10 Biology is most important.

Regarding Grade 11, the basic aspects must be precisely taught associating them with the remaining chapters in the text. The first four chapters are concerned with Botany (study of plants). The terminologies with clarified meanings used in the first four chapters are further used in later chapters dealing with the life processes of plants. Chapter V is the only chapter that deals with the basic aspect of animal. Groups of mammals and general characteristics of mammals are given before going into the structural plan of the rabbit. Relevant diagrams in both plants and animals always support structural plans. General characteristics of mammals are the key factors to understand the structural plan of the rabbit and life processes of the animals in later chapters. Associate each character of mammals with the relevant structural plan of the rabbit, and life process of animal while teaching. Most of the terminologies used in Chapter V are further used in later chapters dealing with life processes of animals as in plants. Associated conceptual teaching is one of the most effective means to attract the interest of the receivers. Chapter dealing with environmental biology would be the easiest one, a student is thorough with the previous chapters. A subject when interested is liable to make self-learning possible. It would also achieve in making the students aware that Biology is not a difficult subject.

Deliverers must prepare each lesson carefully in order to draw the interests of the receivers. Suggested teaching methods to attract the attention of the students given in Grade 11 Teachers' Guide would be of aid while teaching. Deliverers are solely responsible since the concerned team who has prepared the text had taken great care to simplify the context in the text as far as possible.

CONTENTS

CHAPTER I

THE PLANT BODY

Most familiar plants belong to the group known as the flowering plants or the **angiosperms**. A definite organ that forms a fruit always encloses the seeds of angiosperms. They constitute, the most conspicuous part of the earth's vegetation and are the plants of greatest economic importance in man's life. Angiosperms, numbering about 250,000 known species, are the most highly developed of all plants. They are the most varied, useful, and abundant of all plant groups.

Parts of a plant

The **flowering plant** fundamentally consists of an underground root system and an aerial **shoot system**. The underground root system consists of the main root and the lateral roots. The aerial shoot system comprises the stems, branches, leaves, flowers and fruits. Roots, stems, and leaves are the vegetative organs and the flowers the reproductive organs.

Root

Roots of most plants are non-green in colour and usually grow beneath the surface of the soil. Roots are profusely branched bearing numerous root hairs, which are the actual absorbing organs of the root.

Stem

The stem is the aerial part of the plant. It produces branches and bears leaves, flowers, and fruits. The point on a stem from which a leaf develops is called the **node**. The region between two successive nodes is the **internode**. The upper angle between leaf and stem is the **axil** of the leaf. The buds found in the leaf axils are termed as **axillary** or **lateral buds**. These later grow into lateral branches. The buds found at the tip of the main stem as well as the branches are the **terminal buds**, meant for elongation of the plant. The apices of the stem and root including their branches are the growing points of the plant.

Leaf

The leaf is an expanded lateral outgrowth of the stem, arising at the node and possessing a bud in its axil. A typical leaf consists of three main parts, the expanded leaf blade or **lamina,** the slender stalk or **petiole** and the two lateral outgrowths at the base of the petiole, the **stipules**. The leaf is usually green due to the presence of the pigment, **chlorophyll.**

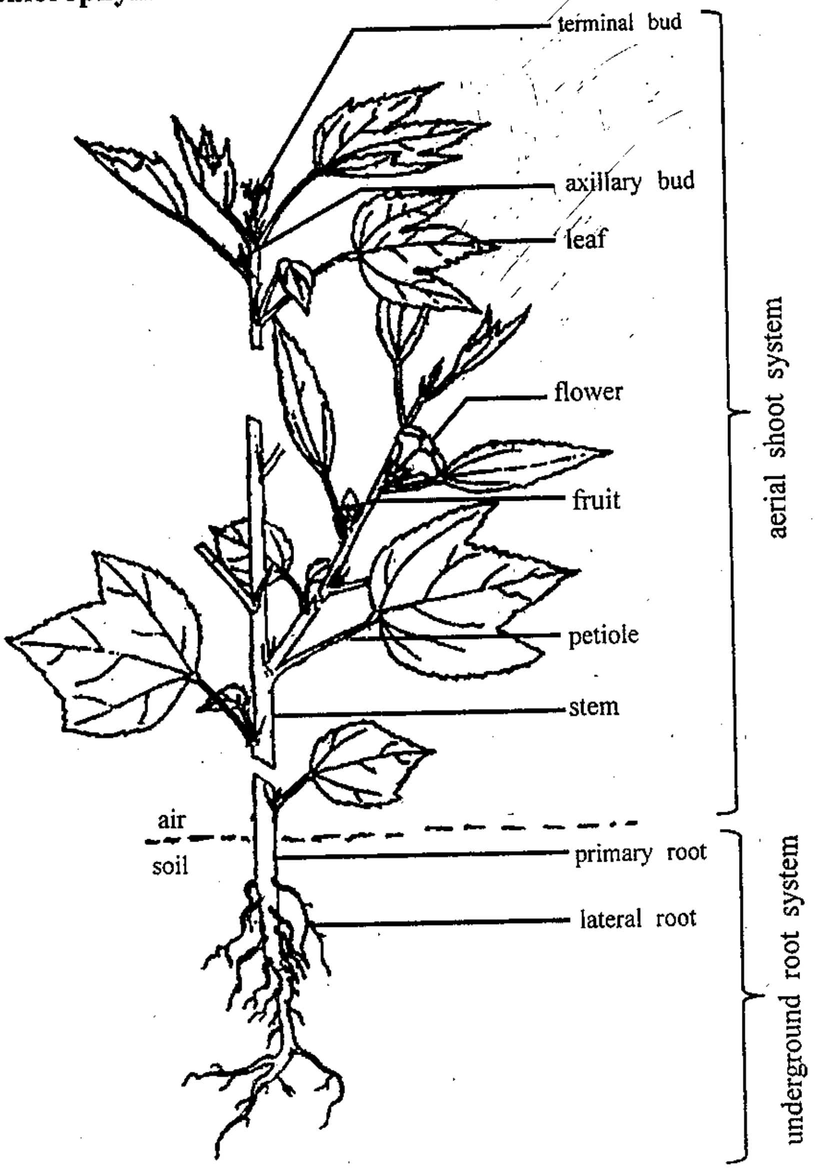


Fig. 1.1 Parts of a flowering plant (chin-baung)

Flower

The flower is a highly specialized branch modified for reproduction.

Fruit and seed

A fruit is a mature ovary of the flower, consisting of a fruit wall enclosing one to many seeds.

A seed is a fertilized and mature ovule, consisting of an embryo, one or two cotyledons (seed leaves), and seed coat.

Plants types based on nature of stems and growth habit

Three large groups of plants divided based on the nature of their stems and their growth habit is as follows.

Trees

A tree may be defined as a woody plant with one main trunk, *e.g.* mango (tha-yet), kokko, kyun, thit-to, padauk etc.

Shrubs

A shrub is a medium-sized plant, which has many branches arising from the ground level instead of one main trunk, *e.g. Hibiscus* (khaung-yan), croton (ywet-hla), rose (hnin-si).

Herbs

Plants which have soft stems are all termed as herbs, *e.g.* tomato (kha-yan-chin), most grasses, canna (bode-dan-tharanan).

Plants with weak stems

Climbers

These are plants which need support for them to grow upright, *e.g.* rattan (kyein).

Creepers

Plants with weak stems which trail on the ground, or creep about without growing upright are termed as creepers, *e.g.* grasses, strawberries.

F-1A

Diversity among angiosperms

Angiosperms show great diversity in size and in the lifespan of the shoot. Some angiosperms such as duckweeds (beza-pin) are minute discs floating on water. Others, like *Eucalyptus* and banyan trees, are a hundred meters or more in height. The lifespan of the angiosperm is also very variable. Small herbs as peas live for only a few weeks, while some *Eucalyptus* live for several hundred years old.

Plants distinguished according to the length of life

Annuals

An annual is a short-lived plant, which produces flowers and fruits within one growing season, *e.g.* peas and beans.

Biennials

Plants, which live for two growing seasons, are termed as biennials. They usually grow leafy shoots in the first season and produce flowers and fruits in the second, after which the plants perish, *e.g.* carrot (u-wah), cabbage (gawbi-htoke).

Perennials

Plants, which live for many years, are termed as perennials. The aerial shoots of these plants persist and grow from year to year, *e.g.* mango, padauk. In some cases, plants persist in the form of underground stems after all the leaves above ground have withered and dried, *e.g.* gladiolus (thit-sa-pan).

Habitats

Angiosperms are present in almost all places, in the sea, on top of high mountains, in deserts and in the snowfields of the arctic and the antarctic regions.

Plants distinguished according to habitats

Hydrophytes

Plants, which live in water or in very wet soil, are hydrophytes, *e.g.* water lilies (kya).

Xerophytes

Plants, which live in dry places where the water supply is scanty and irregular, are xerophytes, *e.g.* Cacti (kya-sha) and many *Acacia* species (hsu-phyu, hta-naung).

Mesophytes

Plants, which usually grow under conditions, intermediate between the two extremes of very dry and very wet situations are mesophytes, *e.g.* peas, beans and tomatoes.

Plants distinguished according to mode of nutrition

Autophytes

All green plants that can manufacture their own food are autophytes.

Parasites

Non-green plants lacking chlorophyll cannot manufacture their own food. They have to depend on other organisms for their nutrition and are called parasites, *e.g.* dodder (shwe-nwe).

Saprophytes

Those plants, which live upon dead organic matter, are saprophytes, e.g. fungi.

Epiphytes

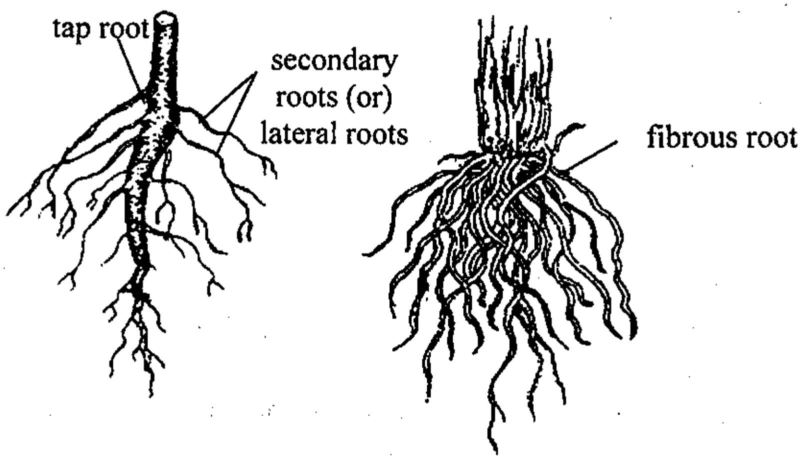
Some land plants grow attached to other plants but do not obtain any food from them. These are called epiphytes, *e.g.* orchids (thit-kwa).

Insectivorous or carnivorous plants

Insectivorous plants obtain their nourishment by feeding on insects, e.g. Sundew.

THE ROOT

The first root, which develops from the radicle, is the primary root. It gives rise to the main root of the plant and later becomes the **tap root**. Branches of the primary root are known as secondary roots or lateral roots. All these roots together form the tap root system.



Tap root **Fibrous roots**

Fig. 1.2 The roots

Roots that grow from any part of the plant body other than the radicle are the **adventitious** roots, as in sugarcane, bamboo, etc. Adventitious roots also develop on stem and leaf cuttings. In some monocotyledons, numerous slender roots of adventitious type which are equal in size and grow from the base of the stem. Such roots are **fibrous** roots, e.g. grasses.

Regions of the root

The root tip can be differentiated into four regions.

1. **Root cap:** A thimble-shaped root cap covers the tip of the root. It protects the delicate root tip from mechanical injury as it pushes its way through the soil. The underlying growing tissue renews the root cap, when worn out.

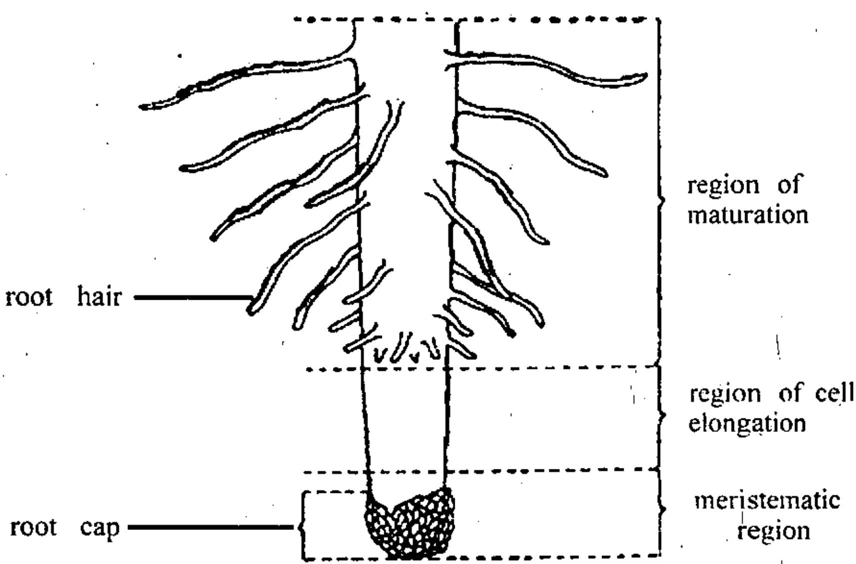


Fig. 1.3 Regions of the root tip

2. **Region of cell division or meristematic region:** This is the growing point of the root and lies just above the root cap. Cells are dividing rapidly in this region and hence it is termed as the meristematic region.
3. **Region of cell elongation:** This region lies above the region of cell division. The cells in this region undergo enlargement particularly in length.

4. **Region of maturation or differentiation:** The enlarged cell differentiated into various tissues of the primary root in this region. The upper portion of this region produces numerous fine and thread-like structures called root hairs. As the root grows, older hairs die off and replace by new ones. Root hairs intermingling with the soil particles keep the soil firm around the roots and thus reduce erosion by wind and rain.

Modified roots

The roots of some plants that perform various functions in addition to their normal ones are termed as modified roots.

Modified Tap Roots

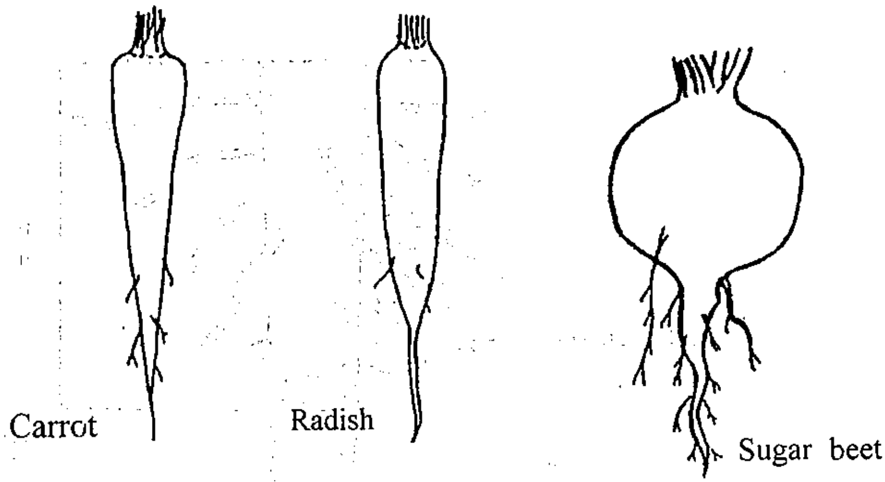


Fig. 1.4 Modified tap roots

The tap roots of biennials and perennial become thick and fleshy due to the storage of food. These roots assume various shapes as in carrot (U-wah), radish (mon-la-u), and sugar beet (u-ni).

Modified Adventitious Roots

Prop roots

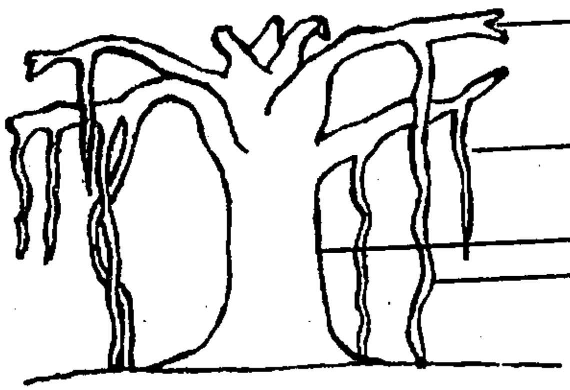


Fig. 1.5 Prop roots of banyan

The banyan tree produces numerous aerial roots, which grow downwards until they strike the soil. Before they reach the soil, they are termed as **drop roots**. Once they reach the soil, they become **prop roots** and these serve to support the spreading branches.

Climbing roots

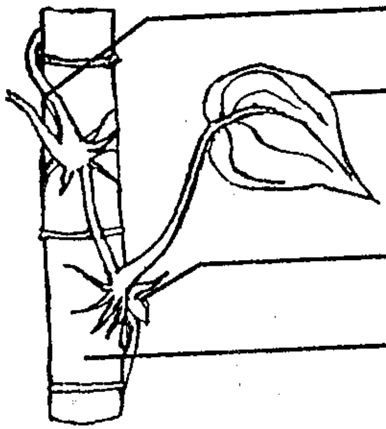


Fig. 1.6 Climb' ɪ roots of betel

Some plants having weak stems ,roduce adventitious roots from the nodes and often from the internodes. These gi·e support to the climbing stem. as in betel (kun).

Respiratory roots

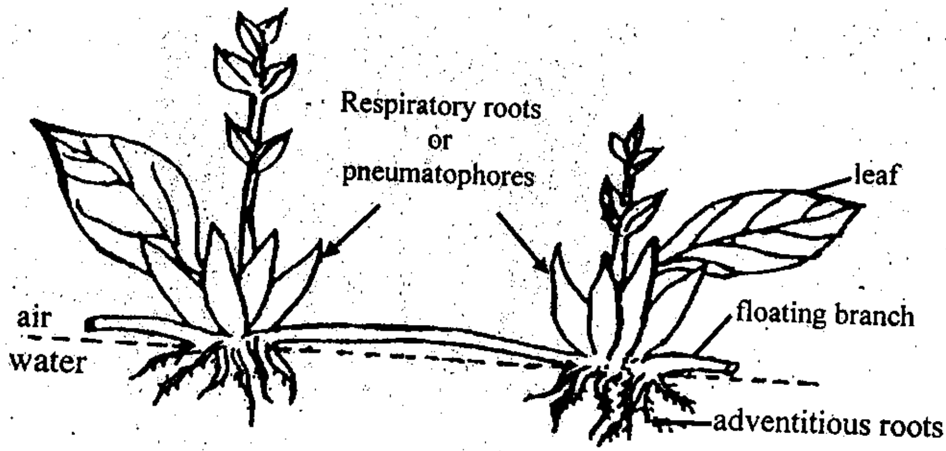


Fig. 1.7 Respiratory roots of *Jussiaea*

The aquatic plant, *Jussiaea*, (ye-ka-nyut) consists of two types of adventitious roots produced from the nodes of the floating branches. These are normal adventitious roots, which hang down in the water and respiratory roots or **pneumatophores**, which are buoyant or stay above the surface of the water. They are white, soft, and spongy and serve to store air and help in respiration.

Sucking roots or Haustoria

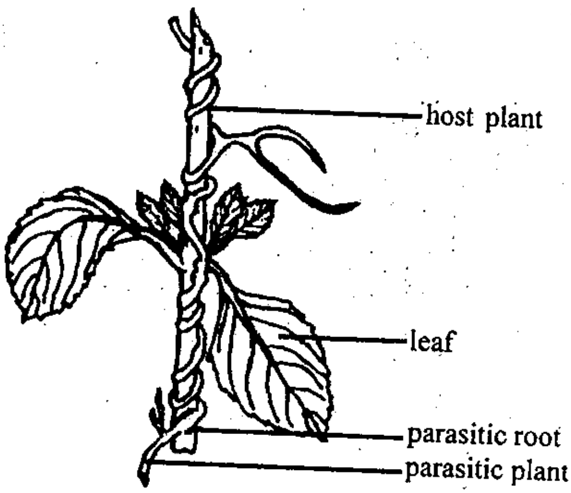


Fig. 1.8 Sucking roots of dodder

A parasitic plant produces certain special roots. These roots penetrate into the tissue of the host plant and absorb food and water from it as in dodder (shwe-nwe) and *Loranthus* (kyee-paung).

Function of the Root

Anchorage: anchor the plant firmly in the soil.
Absorption: absorb water and minerals from the soil.
Food storage: store a certain amount of food.

Economic importance:

Roots of many plants are used by man as food and as the source of several drugs. Many roots such as carrot and radish are eaten raw or cooked. Beet root also is the chief source of sugar in European countries. Many other plants are of medicinal importance.

THE STEM

The stem develops from the plumule of the embryo. It produces leaves and flowers. A young stem with its leaves is termed a shoot. All the stems, branches, and leaves of a plant constitute its shoot system.

Modified Stems

Stems are normally slender and upright, but sometimes they become modified.

Runner

A runner is the stem of a creeping plant. It grows horizontally along the surface of the ground, and has long internodes. When the nodes encounter the soil, they produce adventitious roots as in grass and strawberry.

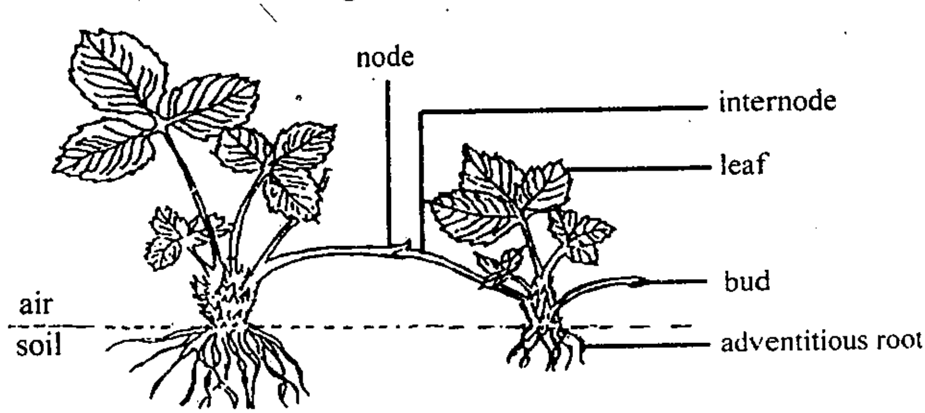


Fig. 1.9 Runner of strawberry

Twiner

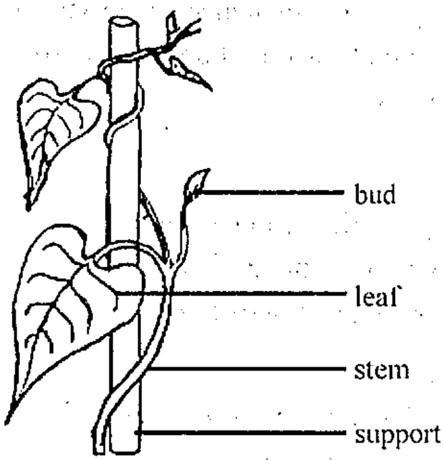


Fig. 1.10 ***Ipomoea*** **(ka-zun)**

Ipomoea with its weak stem twine around the support to climb higher and expose the leaves favourably to light.

Tendril climber

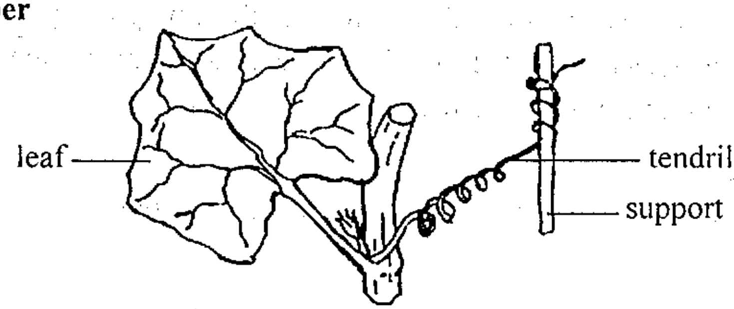


Fig. 1.11 Cucurbit (bu)

Spirally coiled structures (tendrils) of cucurbits twine around the support to keep it erect and expose the leaves favourably to light.

Rhizome

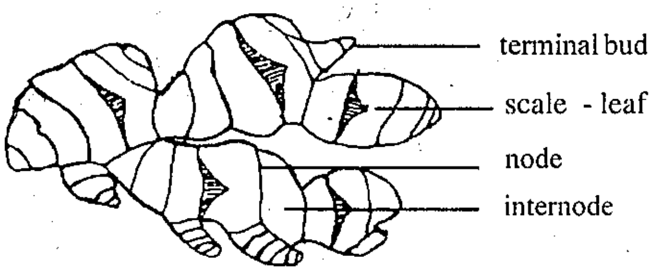


Fig. 1.12 Ginger (gyin)

A rhizome is a fleshy, horizontal stem, growing at or beneath the surface of the soil. It stores food and has distinct nodes with scale leaves enclosing the bud.

Tuber

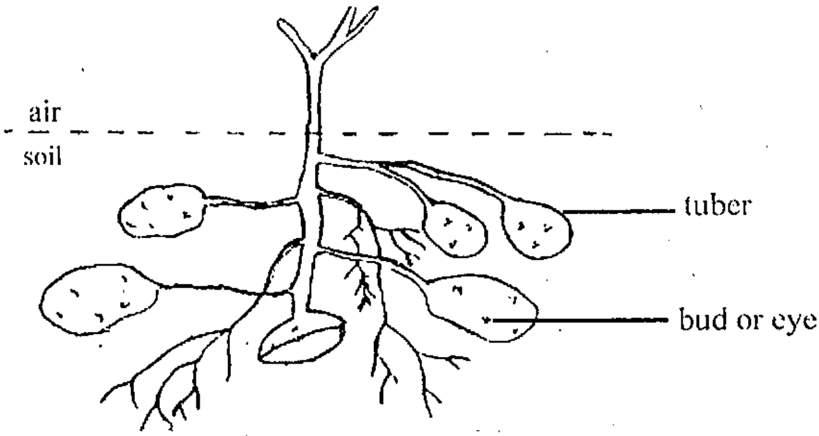


Fig. 1.13 Potato

A tuber is the swollen tip of a special underground branch e.g. potato. It stores food and grows either obliquely or more or less horizontally. A number of buds or eyes are present on the surface of the tuber.

Phylloclade

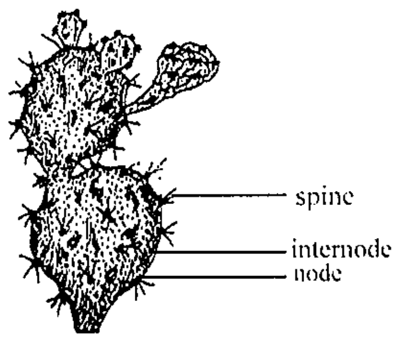


Fig. 1.14 Cactus

Certain stems are flattened, green and become leaf-like in appearance. Such stems perform both the functions of leaves and stems as in cactus.

Functions of the Stem

Support : It includes two parts:

(a) the main trunk that supports the whole plant and

(b) the branches that bear leaves, flowers, fruits and emergences.

Conduction: To conduct water from the root to all the aerial parts and to conduct food manufactured by the leaves to the other parts of the plant.

Economic importance

A large number of useful and medicinal products derived from stems. Bamboo is one of the most important materials, variously used in this country.

Timber obtained from woody trunks of trees may be used in many different ways. The best timbers are derived from teak, pyin-ka-doe, in and kanyin.

The stems of jute produce important fibres.

The extracts from the stems of sugarcane (kyan) produce sugar. Milky juice from rubber trees produces rubber.

THE LEAF

There are various types of leaf forms for functions other than food manufacture. They are the cotyledons or seed leaves of the seeds, scale leaves of various kinds, bracts, and floral leaves of the reproductive shoots.

Parts of a leaf

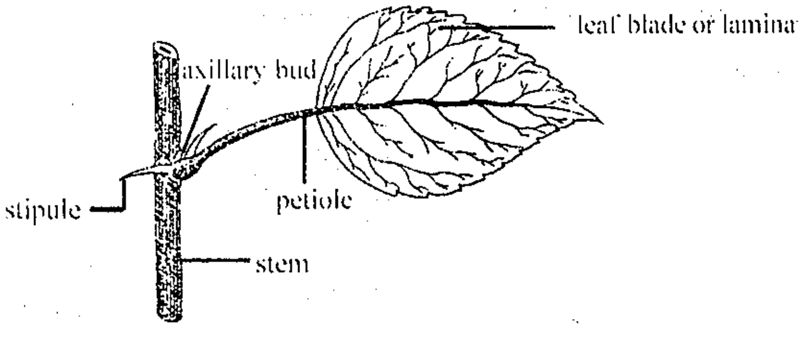


Fig. 1.15 Leaf of *Hibiscus*

A leaf of *Hibisucs* is one of the representatives of a typical leaf consisting of three main parts.

Leaf blade or lamina

This is the expanded portion of the leaf. It is green and usually thin and flat. It has a network of veins on it

Petiole

It is the stalk of the leaf, and connects the lamina with the stem. It is usually cylindrical, sometimes flattened.

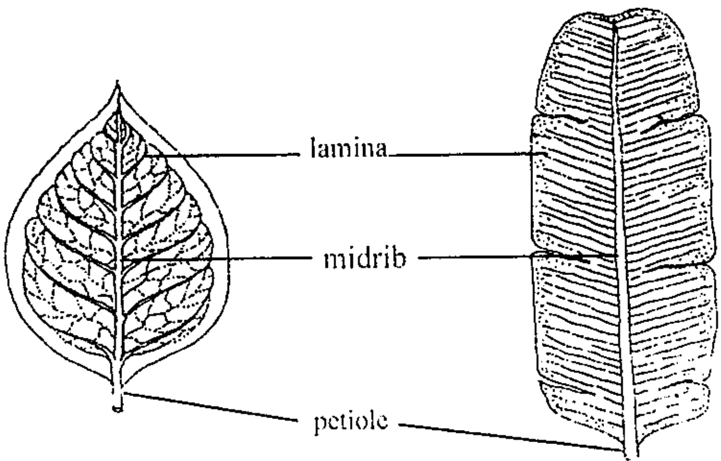
Stipules

They are the lateral outgrowths, one on each side of the petiole base. The normal functions of the stipules are to protect the leaf when young and to protect the bud in its axil. Stipules may vary greatly in shape and size.

Venation

Venation is the arrangement of the veins on a leaf surface. There are two main types of venation.

Unicostate or pinnate venation



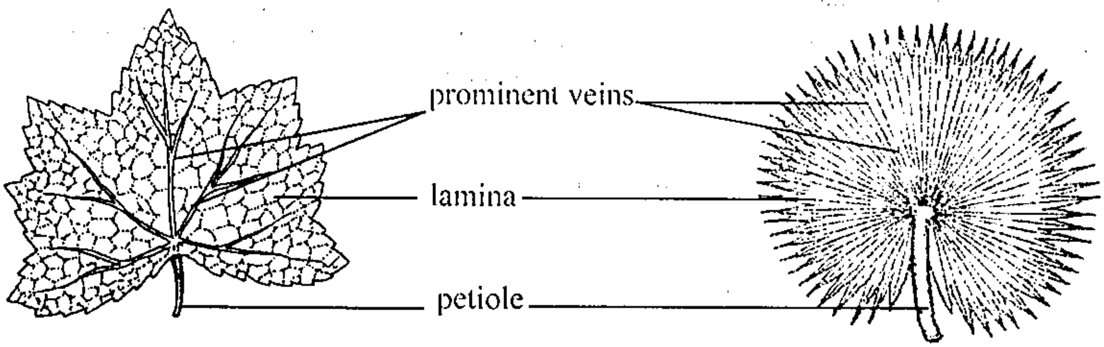
pinnately net-veined leaf of jasmine

pinnately parallel-veined leaf of banana

Fig. 1.16 Pinnate venation

In this type of venation, all other veins originate from a single distinct midrib The midrib is the continuation of the petiole into the lamina. Leaves of dicots such as mango, ponna-yeik, jasmine (sa-be) etc. have unicostate and reticulate (netted) venation. Those of monocots such as canna, banana have unicostate and parallel venation.

Multicostate or palmate venation



Palmately net-veined leaf of *Urena*

Palmately parallel-veined leaf of palm

Fig. 1.17 Palmate venation

In this type of venation, there are three or more equally prominent veins, which extend from the lamina base as in the leaves of *Urena* (kat-say-ne) and palm (htan).

Modified leaves

Some leaves have specialized functions in addition to their chief one of photosynthesis.

False trunk or supporting leaf sheaths

In banana and other similar plants, the leaf bases transform into leaf sheaths. They are greatly elongated, expanded and overlap one another to produce a false trunk which is similar to the ordinary one.

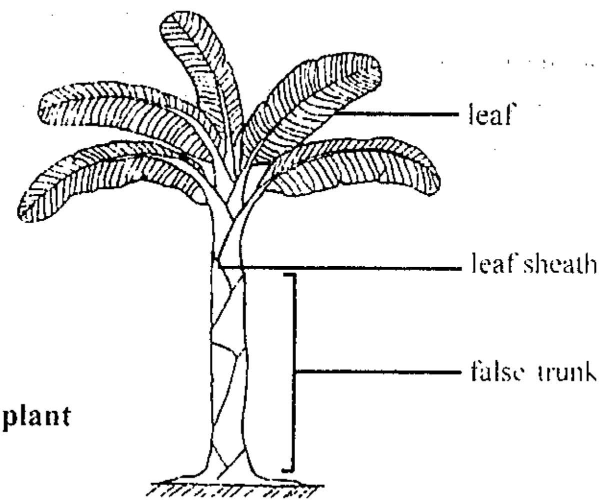


Fig. 1.18 A banana plant

Buoyancy by leaf floats

In water hyacinth (beda) etc. the petioles are swollen and spongy, consisting of numerous air spaces. The presence of these air spaces makes the plants lighter and enables them to float on water.

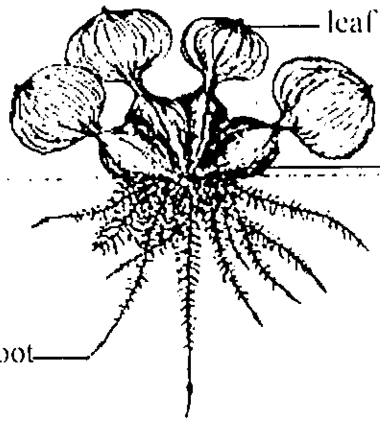


Fig. 1.19 Leaf of water hyacinth

Insectivorous or carnivorous plants

Some plants obtain part of their nitrogenous food by catching insects in various ways, by means of modified leaves and afterwards absorbing the soft parts of the insects, e.g. sundew (nay-hnin-pauk), pitcher plant (ye-ta-gaung), venus-fly-trap and bladder-wort.

(a) Pitcher plant

In the genus *Nepenthes*, some of the leaves are modified into pitchers, which are borne on long tendrillar, leaf-like petioles. These petioles are flattened and laminar in structure, while the leaf blade becomes modified into pitchers with lids.

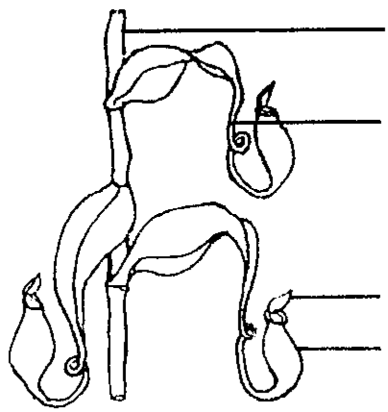


Fig. 1.20 Pitcher of *Nepenthes*

(b) Sundew

Glandular hairs thickly cover the upper surface of the leaf in the genus *Drosera*, commonly called Sundew.

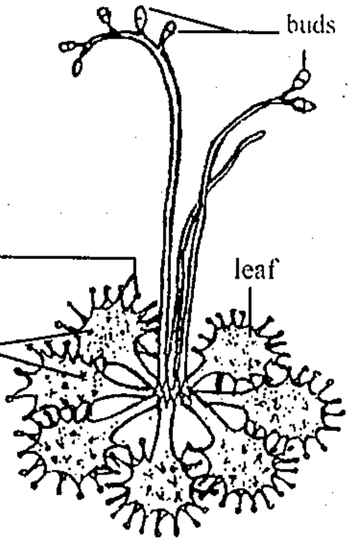


Fig. 1.21 Insectivorous leaf of *Drosera*

(c) Venus flytrap

The leaf blade of *Dionaea* consists of two halves, each of which has three bristle-like sensitive hairs on the upper surface and long strong spines on the margins of the leaves.

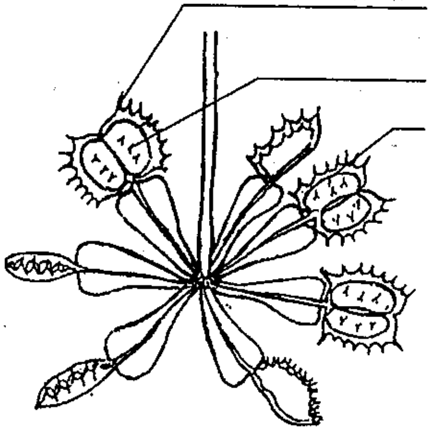


Fig. 1.22 Insectivorous leaf of *Dionaea*

(d) **Bladder-wort**

In *Utricularia*, a floating aquatic plant, common in ponds, and flooded paddy fields, consists of greatly segmented leaves. This plant is commonly known as bladder-wort as some of the segments are modified into bladders.

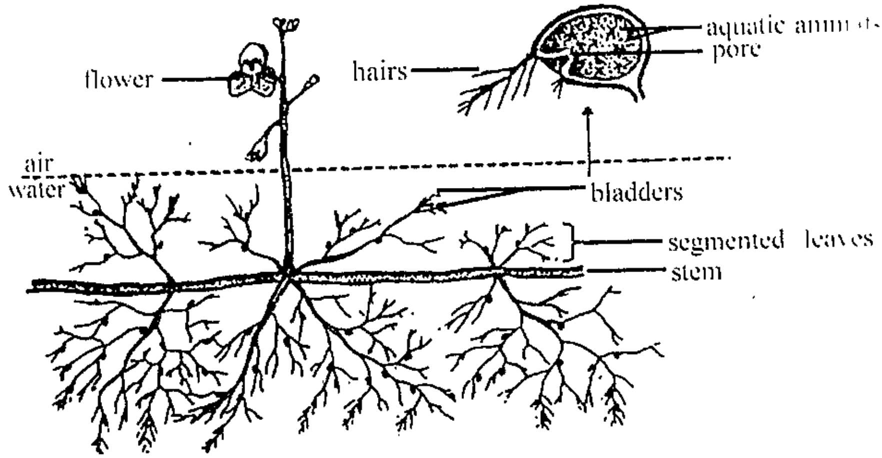


Fig. 1.23 Insectivorous leaf of bladder-wort

Bryophyllum

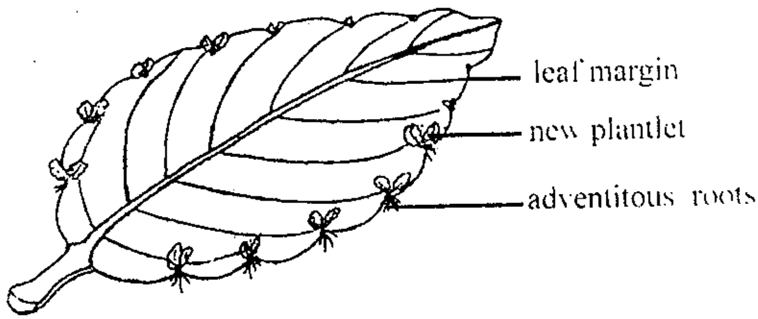


Fig. 1.24 *Bryophyllum*

The leaf of *Brophyllum* with crenated margins when sown in moist soil produces adventitious roots from each crenated area from which develops a new shoot

Water storage leaves

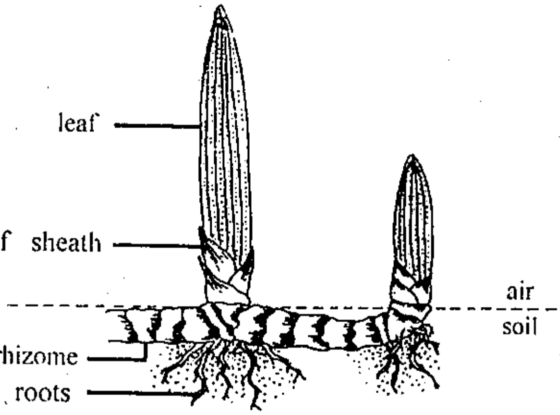


Fig. 1.25 Water storage leaves of *Sansevieria*

Some plants, which grow in dry regions, have thickened leaves. These leaves are able to store water, e.g. *Sansevieria* (sin-swe-gamon).

Food storage leaves

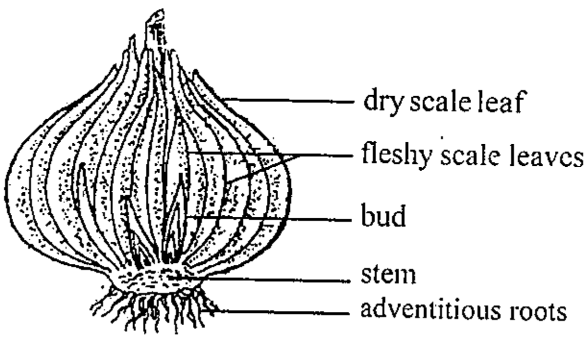


Fig. 1.26 L.S. of onion bulb

The leaves of onion bulb arise from the upper part of the condensed underground stem. The outer scale leaves are dry and they prevent loss of water from the bulb. The inner ones are fleshy as they store food and water while adventitious roots emerge from the base of the stem.

Function of the Leaves

Food manufacture: manufacture food from carbon dioxide and water with the help of chlorophyll using radiant energy of the sun (photosynthesis)

Exchange of gases: exchange gases such as carbon dioxide and oxygen through openings of the leaves called stomata

Respiration: convert the potential energy stored in food to kinetic energy for various physiological processes

Transpiration: loss of water from the surface of the plant

Economic importance

The leaves of many plants provide vegetables. Some common examples are cabbage, chin-baung, kin-mon-ywet, etc. Economically and medicinally important products also derived from the leaves of many other species.

SUMMARY

Flowering plants (angiosperms) are most familiar and constitute the most conspicuous part of earth's vegetation. They are the plants of greatest economic importance in man's life. Angiosperms are most varied, useful, and abundant of all plant groups. Two main parts: aerial shoot system and underground root system constitute the entire plant. The aerial shoot system consists of stem, branches, leaves, flowers, and fruits. The underground root system may be tap root system or fibrous root system. Tap root develops from the radicle and adventitious roots develop from any part of the plant other than radicle. Fibrous root is a type of adventitious roots that grow from the base of the stem. All the constituents of a plant perform their respective functions.

The four regions of the root are root cap, region of cell division or meristematic region, region of cell elongation, and region of maturation or differentiation. These regions lie above one another. Root cap protects the root tip; cell division and enlargement take place respectively in region of cell division and region of cell elongation. The cells become permanent cells in region of maturation. This region produces root hairs.

Roots, stems, and leaves perform various functions in addition to their normal functions. Modified roots include two types: modified tap roots and modified adventitious roots. Types of modifications are given with plant examples distributed in Myanmar.

CHAPTER II
THE FLOWER, POLLINATION AND FERTILIZATION

The flower

A flower is the reproductive structure of a plant, regarded as a leafy shoot highly specialized for reproduction. Flowers differ greatly in size, shape, colour and arrangement of their parts, yet most of them have a common structural plan.

Parts of a flower

The flower is borne on a short or long axis. The axis is made up of two regions namely, the pedicel which is the stalk of the flower and the receptacle which is the expanded end of the pedicel. In many flowers, there are four sets of floral leaves, which are borne in whorls or circles on the receptacle.

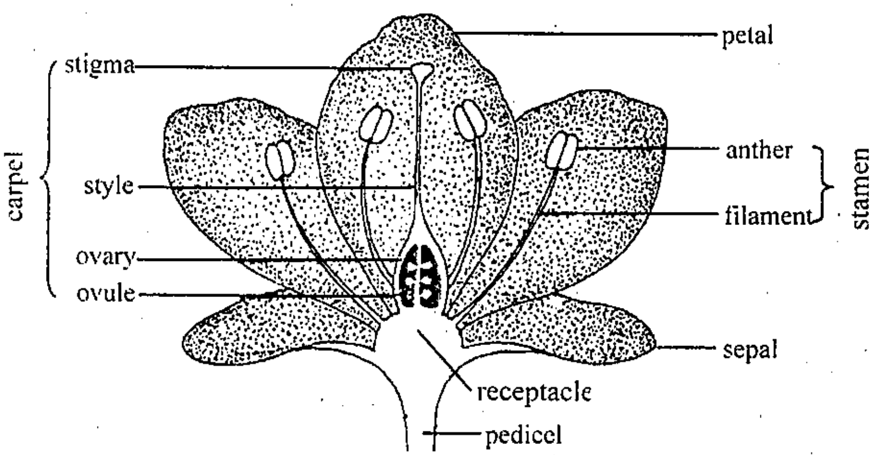


Fig. 2.1 L.S. of a flower showing floral parts on the receptacle

Calyx

The calyx is the outermost whorl of the flower and consists of **sepals**, which are usually green and small. Sometimes they may be large and brightly coloured.

Functions

(i)	Protection	(ii)	Assimilation
(iii)	Attraction	(iv)	Special function

Corolla

The corolla is the second whorl of the flower, and consists of brightly coloured petals. This is the most conspicuous part of the flower. The flower colours result from the presence of pigments called **anthocyanin** and **carotenoids**. The fragrance of flowers is due to the presence of essential oils in the petals.

Functions

(i) Protection (ii) Attraction

Since the calyx and corolla are not necessary for reproduction, both these whorls are termed as the **non-essential whorls.**

Androecium

The **androecium** is the third whorl of floral leaves. It consists of the male reproductive organs of the flower, the **stamens.** Each stamen consists of a **filament** and an **anther.** The thread-like stalk of the stamen is the filament. At the tip of the filament is an anther having two sacs inside which are numerous **pollen grains**. A connective joins the two anther sacs. The pollen grain bears the male reproductive cells or **gametes**.

Gynoecium

The gynoecium is the fourth whorl and lies in the **center** of the flower. It is the female reproductive organ. It consists of **carpels.** Each carpel consists of three parts: **ovary, style** and **stigma**. The basal swollen part of the carpel is the ovary, which produces immature seeds or ovules containing the female gametes. The slender extension from the top of the ovary is the style. The expanded or divided end of the style is the stigma on which pollen from another flower will fall on pollination

Function

The function of both the androecium and gynoecium is reproduction. Hence these two whorls form the **essential whorls** of the flower.

Position of Floral Leaves on the Receptacle

The relative position of the floral whorls with respect to the ovary is of three kinds, **hypogyny, perigyny and epigyny.**

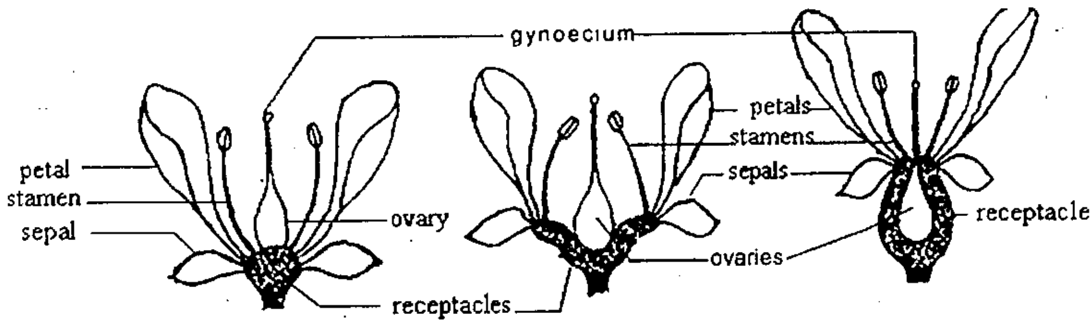


Fig. 2.2 Position of floral leaves on the receptacle

Hypogyny

The receptacle is more or less convex. The gynoecium is developed at the apex of the receptacle. The stamens, petals, and sepals are inserted on the side of the receptacle below the gynoecium. Such a flower is said to be **hypogynous.** The ovary in this case is superior and the rest of the floral members inferior, *e.g.* mustard (mon-nyin), eggplant (kha-yan).

Perigyny

The receptacle forms a shallow or deep cup-like structure. The gynoecium is found in the centre of the cup and the stamens, petals and sepals on the rim or margin. The receptacle wall remains distinct from the ovary. Such a flower is said to be **perigynous** and the ovary half-inferior, *e.g.* rose, peach.

Epigyny

The receptacle grows further upward, completely enclosing the ovary and fusing with it. The stamens, petals, and sepals are inserted on top of the ovary. Such a flower is said to be **epigynous.** The ovary is inferior and the rest of the floral members superior, *e.g.* sunflower, guava, cucumber.

Inflorescence

Flowers occurring in a cluster on the same main stalk are termed as inflorescence.

Inflorescences may be classified into (a) **indefinite** or **racemose** and (b) **definite** or **cymose**.

(a) **Racemose Inflorescence**

The main axis of the inflorescence continues growth and produces flowers laterally. The lower or peripheral flowers are always older or open earlier than the upper or inner ones.

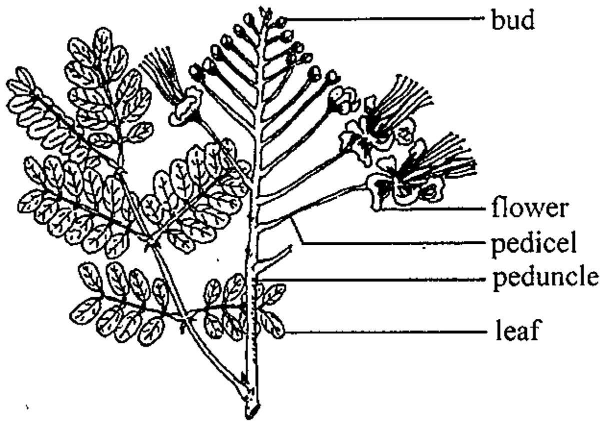


Fig . 2.3 Racemose Inflorescence (sein-pan-ga-lay)

(b) **Cymose Inflorescence**

The main axis or the lateral ones terminate in flowers. The terminal flower is always older and opens earlier than the lateral ones.

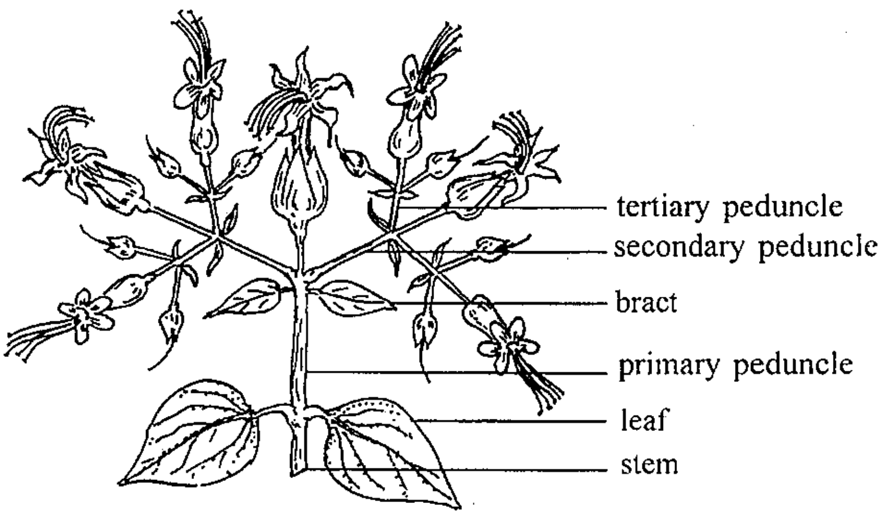


Fig 2.4 Cymose Inflorescence (teik-pan)

Unusual type of racemose type, the head, or capitulum is found in sunflower family. The sunflower is not a single flower but a collection of a large number of tiny flowers on a flattened receptacle. The florets borne on the periphery are the ray florets. Those in the centre are the disc florets.

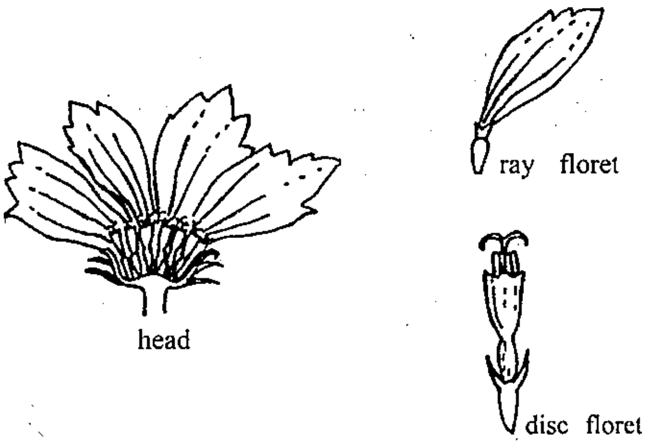


Fig. 2.5 Head or capitulum

Pollination

Pollination is the transference of pollen grains from the anther to the stigma. There are two types of pollination namely, **self-pollination** and **cross-pollination.** If the pollen from the anther of a flower falls onto the stigma of the same flower, it is self-pollination. On the other hand, when the pollen from the anther falls onto the stigma of another flower either of the same plant or another plant of the same species, it is termed as cross-pollination.

Self-pollination

Self-pollination can only occur in **bisexual** flowers (i.e. flowers having both androecium and gynoecium). The adaptations for self-pollination are as follows:

Homogamy

In homogamy both the anther and the stigma of a bisexual flower mature at the same time. Self-pollination is thus easily achieved and it may take place even before the flower opens, e.g. paddy, tobacco, wheat, and some legumes.

Cleistogamy

There are some bisexual flowers, which never open. They are termed as cleistogamous or closed flowers. Therefore, self-pollination is the only rule e.g. *Commelina* (myet-cho) and *Impatiens* (dan-pan).

Cross-pollination

Cross-pollination occurs in **unisexual** as well as self-sterile bisexual flowers. Since plants cannot move about like animals, the help of external agents is necessary for transferring the pollen from one flower or one plant to another. The main agents are **insects, wind, water, and animals**. There are four types of cross-pollination depending on the kinds of agent.

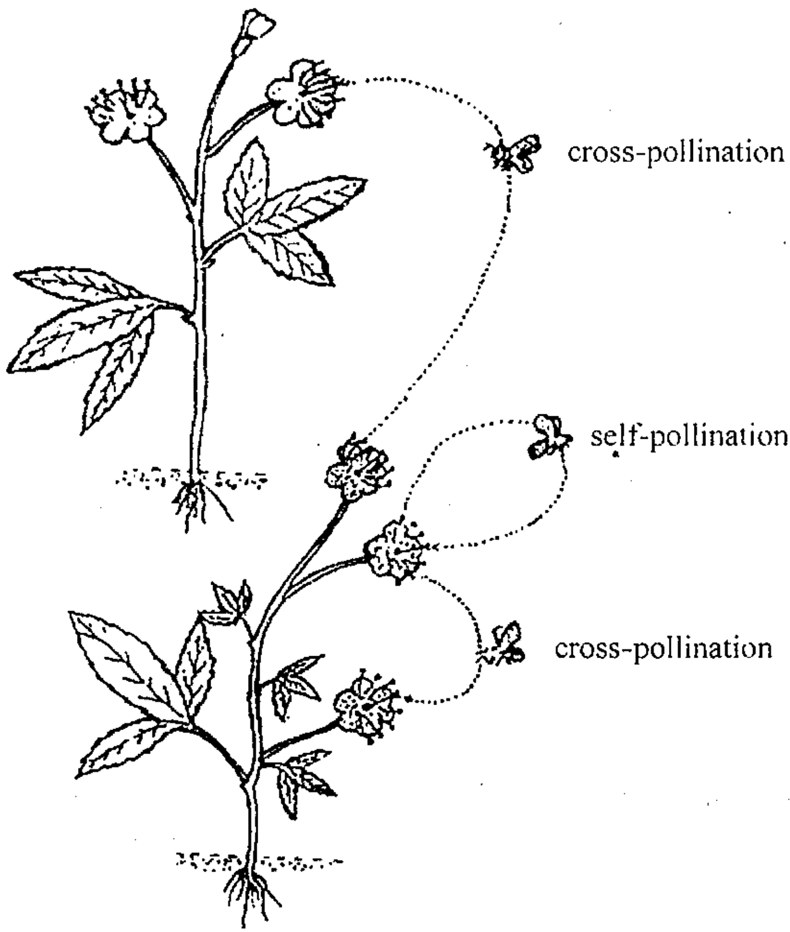


Fig. 2.6 Self-pollination and cross-pollination

Entomophily

Cross-pollination brought about by insects is termed as **entomophily**. Insects such as bees, butterflies, and moths are important external agents. The insects visit one flower after another gathering pollen and nectar.

The pollen grains of entomophilous flowers are either sticky or provided with spinous outgrowths, so that they may stick easily to the body of the insect and be carried along with it.

The colour, nectar, and scent of the flowers can attract insects for pollination. e.g. sunflower.

Anemophily

Cross-pollination brought about wind is termed as **anemophily**. The pollen grains of anemophilous flowers are small, smooth, light and easily carried by wind. Large numbers of pollen grains are produced. The flowers are generally small, scentless with green or dull-coloured petals, e.g. maize.

Hydrophily

Cross-pollination in aquatic plants brought about by water is termed as **hydrophily**, e.g. *Vallisneria* (nga-shint-myet).

Zoophily

Cross-pollination brought about by animals such as birds, squirrels, bats, and snails is termed as **zoophily**, e.g. *Bombax* (let - pan) and *Colocasia* (pein).

FERTILIZATION

Fertilization is the fusion of the male and female gametes.

Female gamete

Fertilization takes place inside the ovary inside which is the female gamete. One or many ovules are found attached to the inner wall of the ovary by means of funicles.

The body of the ovule is termed as the **nucellus** and one or two layers of integuments cover it. A pore, left uncovered, at the tip of the ovule, is the **micropyle.** Embedded in the nucellus is a large oval-shaped embryo sac, containing eight nuclei. Three of these are situated at the micropylar end. The biggest is called the **egg cell** or the **female gamete.** The other two are the **synergids**. At the opposite end are three nuclei, known as the **antipodal cells**. At the centre of the embryo sac are two **polar nuclei**.

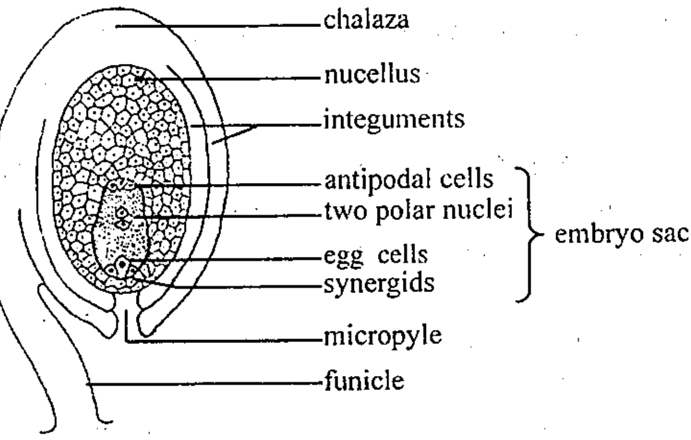


Fig. 2.7 L.S. of ovule

Male gamete

The formation of male gamete takes place inside the pollen, a more or less rounded structure. It is uninucleate and possesses a two-layered wall. The inner wall or the **intine** is soft and thin. The outer wall or the **exine** is tough and often provided with spinous outgrowths. Some weak spots called **germ pores** may be present in the exine.

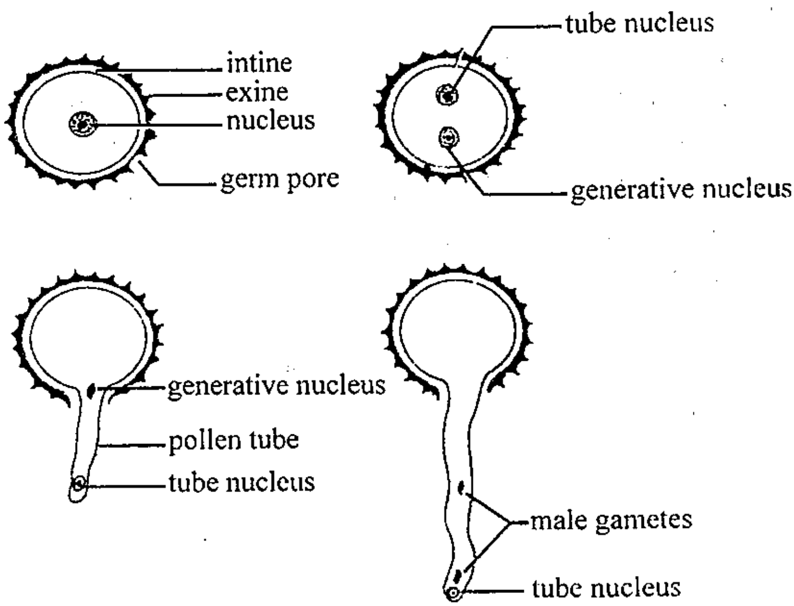


Fig. 2.8 Germinating pollen grain

At the time of pollination, the stigma is viscous with a sticky substance containing sugar and other compounds. This substance stimulates the pollen grains to germinate.

Just before pollination, the nucleus of the pollen divides into two, the **tube nucleus,** and the **generative nucleus.** On pollination, the pollen begins to germinate and the intine protrudes through the germ pore of the exine and elongates to form a pollen tube. The tube nucleus, carried along with the generative nucleus at the tip of the pollen tube controls the growth of the pollen tube.

The pollen tube penetrates the stigma and grows down the style until it finally reaches the ovule. By that time, the generative nucleus has already divided into two **male gametes.**

Fertilization

The pollen tube enters the ovule through the micropyle, and passes through the nucellus to approach the embryo sac. Then the tip of the pollen tube dissolves and the two male gametes are set free into the embryo sac. The tube nucleus disintegrates eventually.

One of the two male gametes fuses with the female gamete or egg cell, resulting in the fertilized egg or **oospore**. This process is termed as "fertilization". The two polar nuclei fuse to form the **definitive** or **secondary nucleus.** This in turn fuses with the second male gamete to form the **primary endosperm nucleus.**

The fusion of three nuclei, i.e. the two polar nuclei and the male gamete is therefore termed "triple fusion ". One male gamete fuses with the egg cell and the other with the two polar nuclei, and that is why this process of fertilization and triple fusion are together known as "double fertilization".

During the process of fertilization, the synergids direct the male gamete towards the egg cell and the polar nuclei. They then disintegrate. The antipodal cells disappear before fertilization.

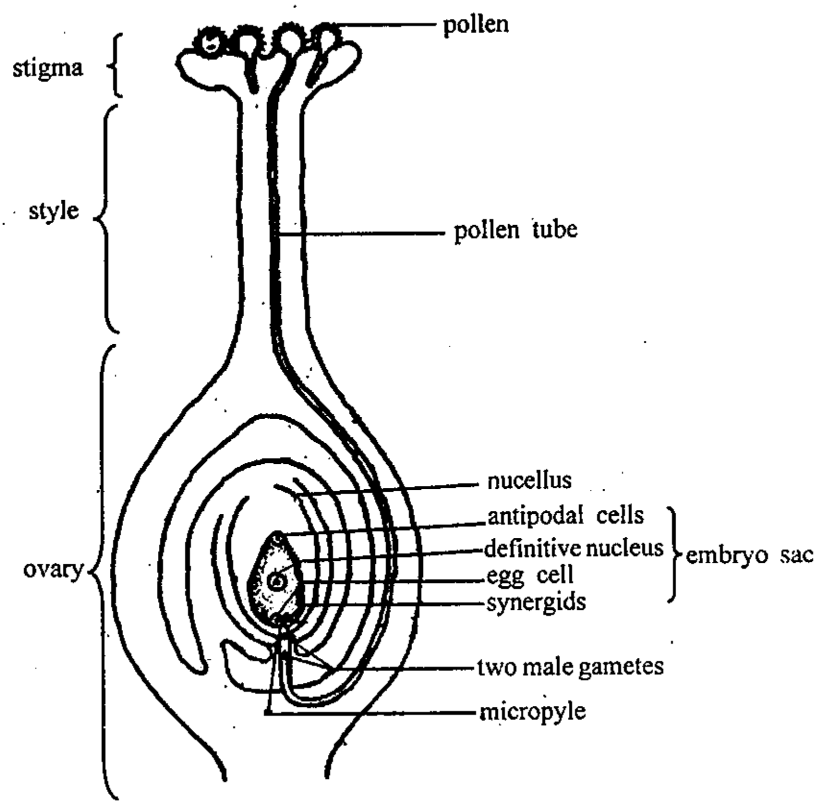


Fig. 2.9 L.S. of the ovule showing the process of fertilization

Changes after fertilization

After fertilization, the stigma, style, stamens, and petals wither and fall off. The sepals may fall off in some plants, in others they may persist until the formation of the fruits. The ovules develop into seeds and the ovary as a whole changes to form a fruit. The embryo sac enlarges and the fertilized egg grows and gives rise to an embryo. At the same time, the primary endosperm nucleus divides repeatedly to form the **endosperm**, which stores food material for the growing embryo. The integuments become the seed coats.

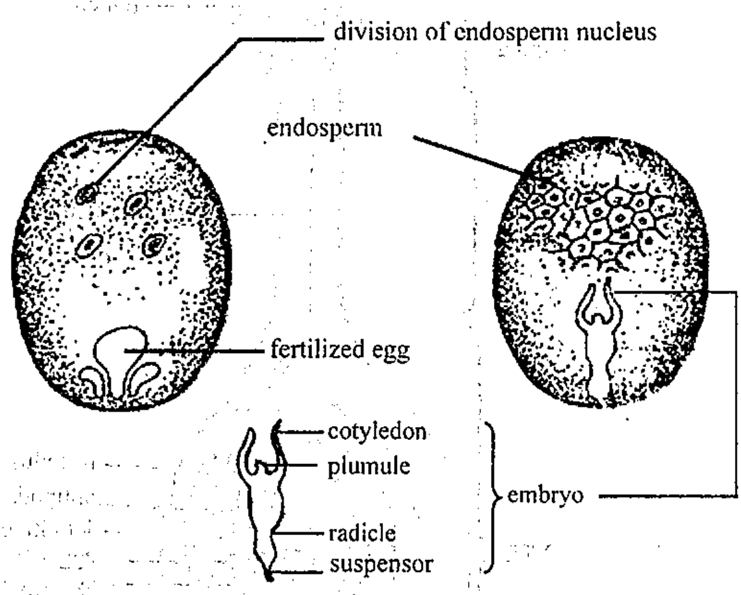


Fig.2.10 Development of embryo and endosperm

In some cultivated plants like banana, papaya, orange, grape, apple, and pineapple, the ovary may develop into a fruit without fertilization. Fruit formation in the absence of a male gamete is termed as "**parthenocarpy**". Parthenocarpic fruits are mostly seedless. Horticulturists produce parthenocarpic fruit by using various methods of induction.

SUMMARY

Flower is a leafy shoot highly specialized for reproduction. Most flowers have common structural plan consisting of four whorls (floral leaves): calyx (sepals), corolla (petals), androecium (stamens), and gynoecium (carpels). Of the four whorls, the first two are non-essential whorls (do not take part in reproduction) while the remaining two are essential whorls (take part in reproduction). Each whorl performs respective functions.

Position of floral leaves on the receptacle categorizes the flower into three types: hypogyny (receptacle convex, ovary superior), perigyny (receptacle shallow or deep cup-like structure, ovary half-inferior), and epigyny (ovary enclosed by the receptacle, ovary inferior). Inflorescence is a cluster of flowers on the main stalk. Two types of inflorescence are racemose and cymose. Sunflower, a collection of tiny flowers consists of ray (peripheral) and disc (central) florets are an unusual type of racemose inflorescence.

The process of pollination that transfers pollen grains from the anther to the stigma is of two types: self-pollination and cross-pollination. Self-pollination does not require external agents to undergo the process while external agents like insects (entomophily), wind (anemophily), water (hydrophily), and animals (zoophily) are required for cross-pollination. Self-pollination occurs only in bisexual flowers. Cross-pollination occurs in unisexual and self-sterile bisexual flowers.

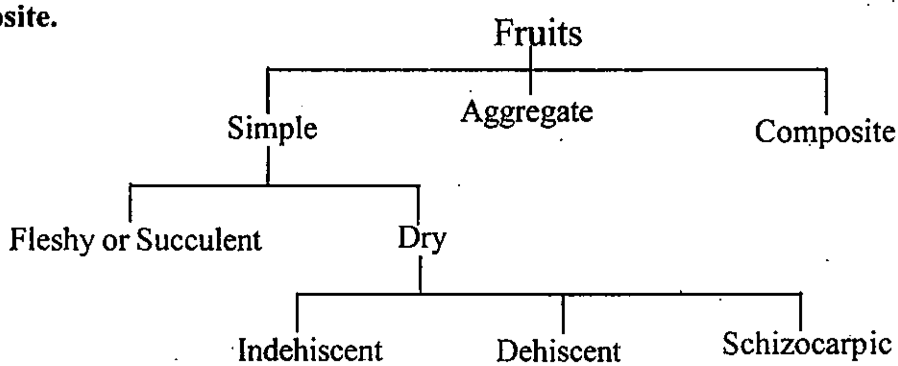
Fertilization occurs after pollination. The concepts given in this chapter will aid to understand the process of reproduction in plants given in Chapter X.

CHAPTER III
THE FRUIT AND ITS DISPERSAL OF SEEDS

A fruit is a fertilized and mature ovary, consisting of a fruit-wall enclosing one to many seeds.

Classification of fruits

Fruits are generally classified into three groups, **simple, aggregate,** and **composite.**



Fruits develop from the ovaries of flowers. The ovary wall grows to become either a fleshy and juicy or a dry and hard pericarp.

(a) **Fleshy fruits** — provide food for animals and man. They are usually attractive and brightly coloured. There are two types of fleshy fruits:

(i) Fruits with large seed, e.g. mango, the seed is thrown away after the fleshy part is eaten.

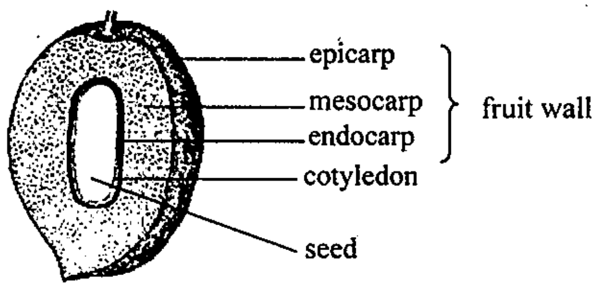


Fig. 3.1 L. S. of mango

(ii) Fruits with many small seeds, e.g. tomato, guava, the indigestible seeds pass out with the faeces.

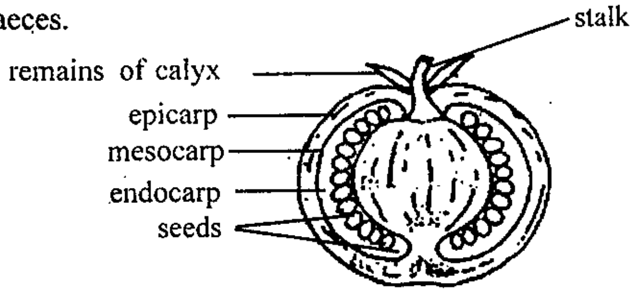


Fig. 3.2 L.S. of tomato

(b) **Dry fruits** - hard and dry pericarp of dry fruits either split open when ripe or do not release their seeds by splitting.

(i) **Dehiscent fruits** – fruits whose pericarp splits open with such force, when mature, that the seeds are scattered over a wide area. A good example is the pod belonging to the bean family, e.g. Flame of the forest (Pauk), *Clitorea* (Aung-me-nyo) etc.

(ii) **Indehiscent fruits** - fruits whose pericarp cannot split open when ripe. The seeds are scattered by various methods. The Angsana fruit (Padauk), for example has a flattened wing-like pericarp, which can be easily blown by the wind. The *Clematis* fruit (Khwa-phyu) has furry style.

(iii) **Schizocarpic fruits** - When the dry fruit breaks up into one-seeded parts or mericarps at maturity, it is called schizocarpic e.g. *Urena* (kat-say-ne)

Fig. 3.3 Schizocarpic fruit

Aggregate fruits

An aggregate fruit is composed of more than one fruitlet derived from the free carpels of a single flower. Therefore a cluster of fruitlets is attached to a common receptacle or stalk, e.g. *Polyalthia* (thinbaw-te).

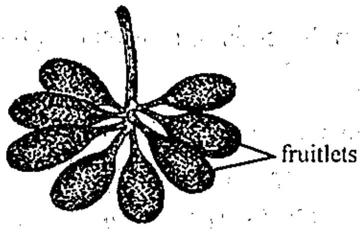


Fig. 3.4 Aggregate fruit

Composite fruits

If all the individual flowers of an inflorescence, together form a single collective fruit, it is said to be composite, e.g. jackfruit.

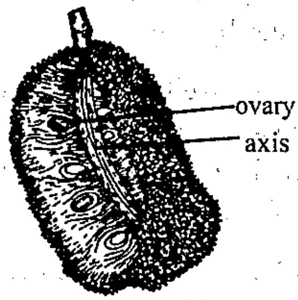


Fig. 3.5 Composite fruit

Dispersal

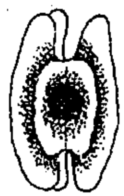
Dispersal of seeds is desirable for the following reasons:

(a) avoids overcrowding and competition for light and nutrients;

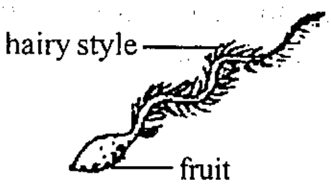
(b) helps to colonize new and favourable habitats.

Dispersal is carried out by the following methods:

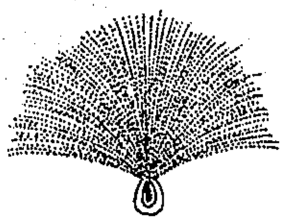
1. **By wind** – e.g. *Pterocarpus*, *Clematis* (khwa-phyu), seeds of Ye-pyut-pin or African tulip, drum-stick seed, *Dipterocarpus* (Ka-nyin), Poppy, *Calotropis*, cotton, orchid



Drum-stick seed



Clematis



Calotropis

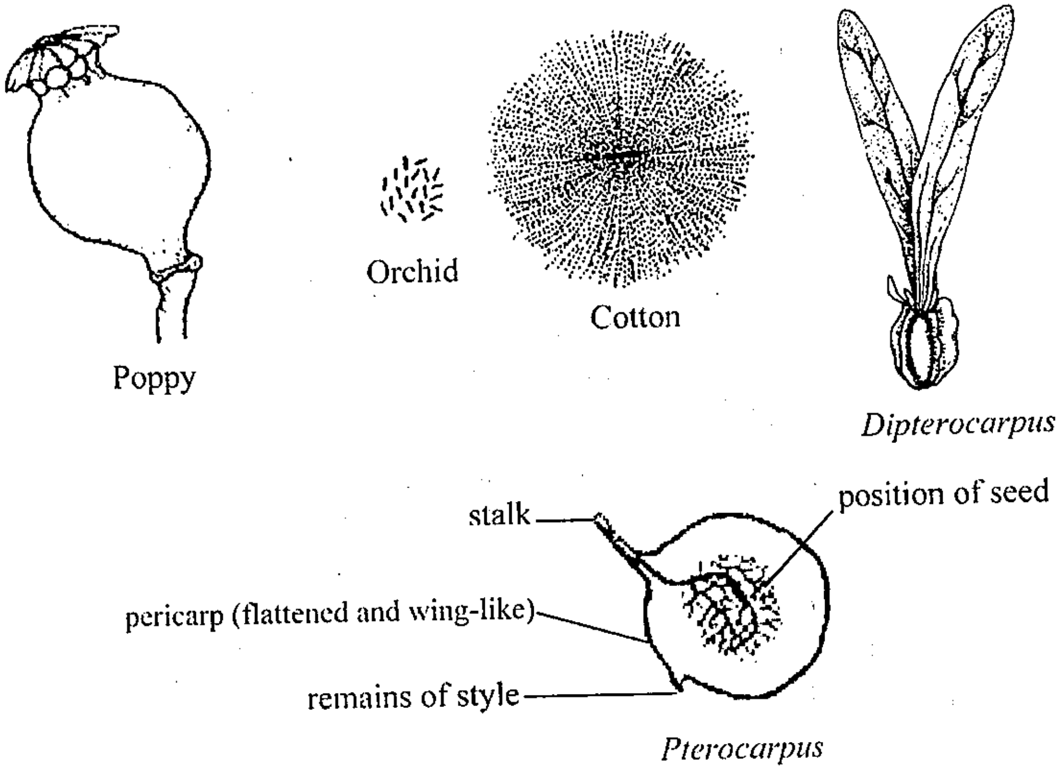
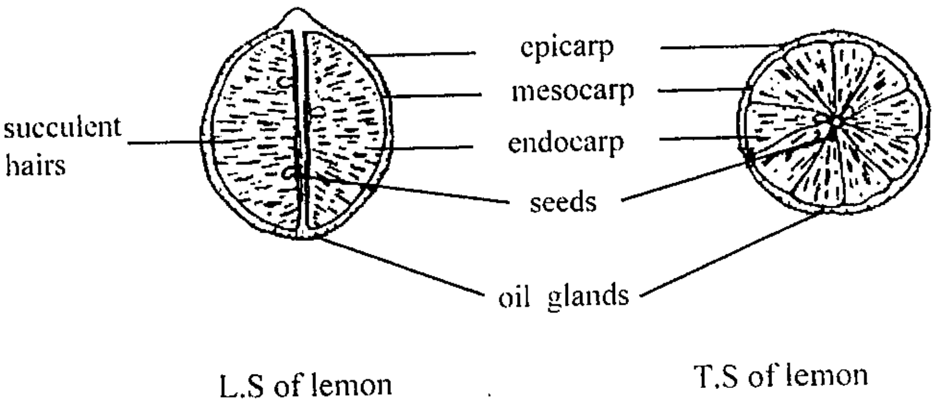
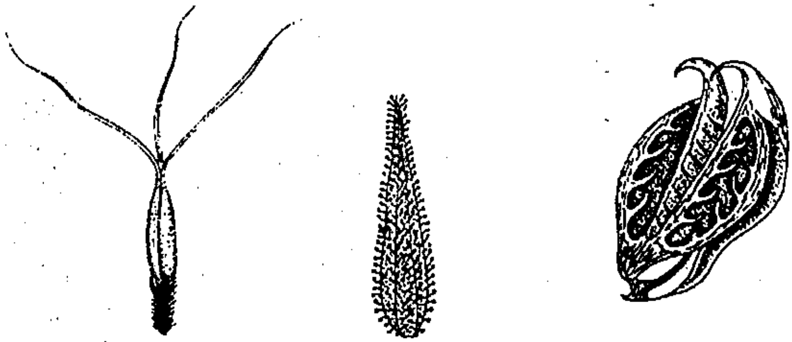


Fig. 3.6 Fruits and seeds dispersed by wind

2. **By animals** such as birds, bats, etc. – e.g. mangoes, lemons, tomatoes, love grass (Naukpo-myet), *Plumbago* (kand-kyoke), *Martynia* (say-galon).

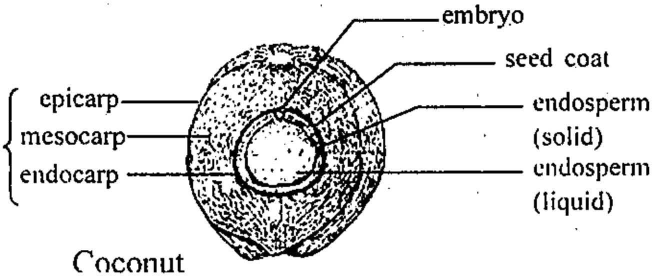




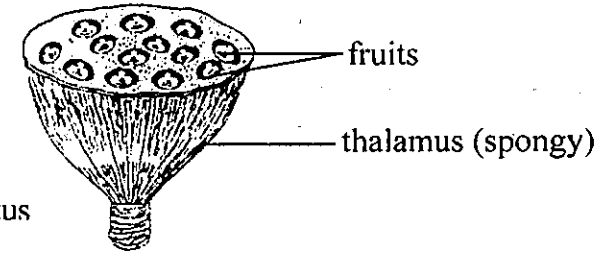
Love grass *Plumbago* *Martynia*

Fig 3.7 Fruits dispersed by animals

3. **By water** - e.g. coconuts, lotus (padonma-kya).



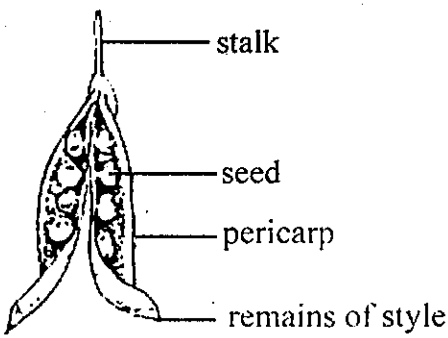
Coconut



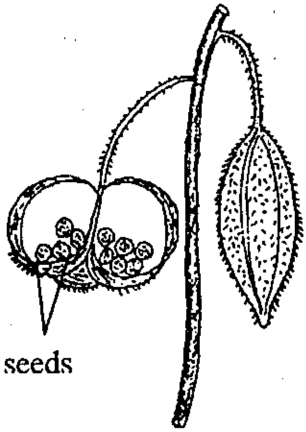
Lotus

Fig 3.8 Fruits dispersed by water

4. **By explosive mechanism** - e.g. *Clitorea* (Aung-me-nyo), balsam (Dan-pan).



Clitorea



Balsam

Fig 3.9 Fruits dispersed by explosive mechanism

Economic importance

Not all fruits are edible, as some are indigestible and others even poisonous. Many edible fruits are of high nutritive values as they contain large amounts of proteins, fats, carbohydrates, vitamins and minerals. Many commercial products like dyes, oils, waxes and drugs, etc. are obtained from fruits.

SUMMARY

The nature of the fruit-wall (pericarp) distinguishes the fruits into two types: fleshy fruits with fleshy and juicy pericarp and dry fruits with dry and hard pericarp. Fleshy fruits are further categorized into fruits with large seeds and the other with many small seeds. Dry seeds on the other hand are categorized into dehiscent fruits (pericarp splits open with force when ripe) and indehiscent fruits (pericarp cannot split open when ripe). Dispersal of seeds is essential for the survival of the plants as it avoids overcrowding and competition for light and nutrients. In addition, it helps to colonize new and favourable habitats for the plants. The external agents that aid in the dispersal of fruits and seeds are wind, animals, water, and explosive mechanisms. Dispersal of seeds maintains healthy environments. All examples given in this chapter are fruits of the plants distributed in Myanmar.

CHAPTER IV

THE SEED AND ITS GERMINATION

A seed is a fertilized and mature ovule, consisting of an embryo, one or two cotyledons (seed leaves), and seed coat.

Depending on the number of cotyledons, a seed may be classified either as **dicotyledonous** (e.g. bean) or **monocotyledonous** (e.g. maize).

All monocotyledonous seeds are endospermic i.e. the food for the growing embryo is stored in a separate tissue known as the endosperm. In the case of dicotyledons some seeds are endospermic while others are non-endospermic i.e. the food for the growing embryo is stored in the cotyledons and not in the endosperm.

Structure of a Bean Seed

The External Structure

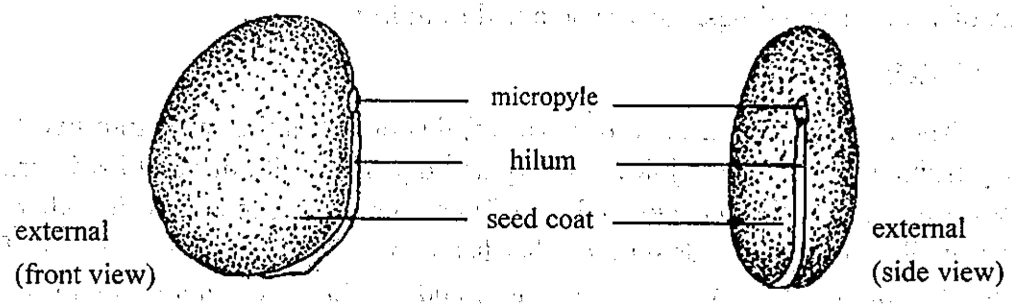


Fig. 4.1 External structure of a bean seed

A single layer, the seed coat that is formed by the fusion of the **testa** (the outer seed coat) and the **tegmen** (the inner seed coat) covers the whole seed. The function of the seed coat is to reduce evaporation from the seed and to protect it against diseases and mechanical injuries. Near the middle of the convex edge of the seed, there is a large oval scar called the **hilum**. It is the scar of the seed stalk (**funicle**). Food and water from the fruit-wall are supplied to the young seed through it. A small pore at one end of the hilum is the **micropyle**, through which the pollen tube enters the ovule and from which the embryo will grow out of the seed.

The Internal Structure

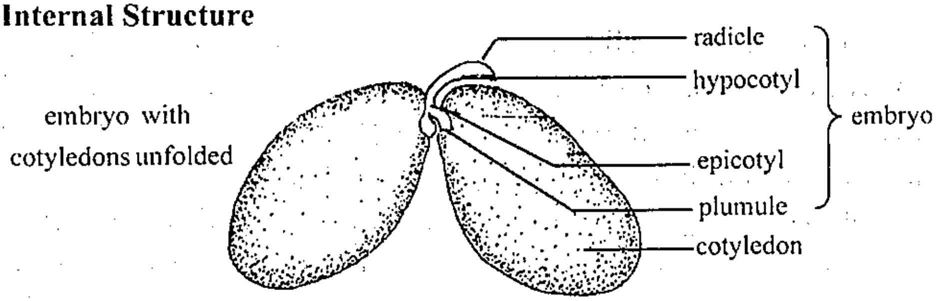


Fig. 4.2 Internal structure of a bean seed

Two large kidney-shaped cotyledons, closely attached to each other are seen on removing the seed coat. They are thick because food is stored in them. The cotyledons also serve as the very first pair of leaves of the seedling. On parting them, a curved embryo is seen attached at the micropylar end. The slender acute end of the embryo is the **radicle**, which will grow into the future root. The small feathery structure at the opposite end is the **plumule** or potential shoot. A cylindrical axis connects the radicle and the plumule. The **hypocotyl** lies below the point of attachment to the cotyledons and above the attachment is the **epicotyl**. The embryo eventually develops and grows into a seedling and finally into an adult plant.

Structure of a Maize Grain

The External Structure

The maize grain is not a seed, but a single-seeded fruit called a **caryopsis.** Its fruit-wall fuses with the seed coat into a single layer. The grain is monocotyledonous and endospermic. There is a small protuberance near the top of the grain. A very slight, whitish patch on one side of the grain marks the embryo. The micropyle lies at the base of the grain.

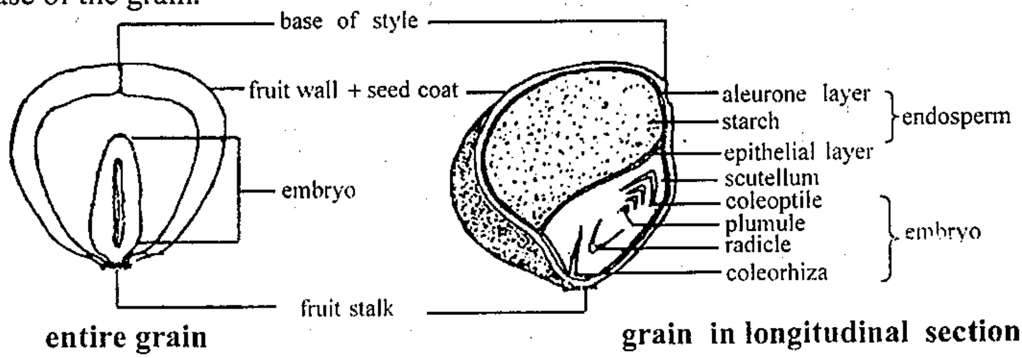


Fig. 4.3 Structure of a maize grain

The Internal Structure

The fusion of the fruit-wall and the seed coat forms the outermost layer of the maize grain. The endosperm constitutes the upper one-third to three-quarters of the grain. The endosperm has a thin outer **aleurone layer** and an inner part containing starch grains. The aleurone layer consists of proteins and fats.

A shield-shaped single cotyledon is termed as the **scutellum**. The **epithelial** layer separates scutellum from the endosperm. The embryo is embedded in the scutellum. A sheath called the **coleoptile** covers the plumule and the radicle by the sheath **coleorhiza**.

Germination

Germination is the series of changes occurring in an embryo and resulting in a seedling.

Method of Germination

Most seeds germinate by either of two methods, **epigeal** and **hypogeal**.

Example: Germination of a bean seed

In the first stage, a bean seed sown in moist soil, absorbs water, swells up and becomes soft. Moreover, the seed coat usually bursts at the micropylar end.

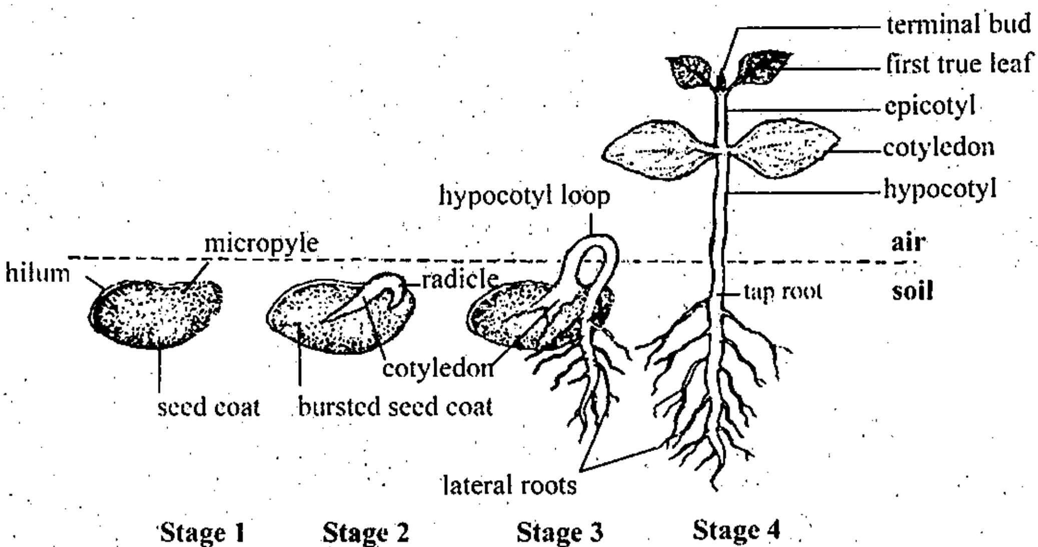


Fig. 4.4 Germination of a bean seed

The second stage may begin after two or three days. The embryo starts growing and the radicle pushes through the micropyle. Whatever the direction of the micropyle may be, the radicle turns and grows downwards to enter the soil. After the radicle anchors the seed in the soil, it begins its function of absorbing water and dissolved salts.

In the third stage, the hypocotyl elongates markedly. Rapid elongation of the hypocotyl results in a loop above the ground since it is attached to the cotyledons and plumule at one end and to the radicle at the other. By this time, the radicle has become firmly established as a tap root with the development of many lateral roots. Those portions of the cotyledons and hypocotyl, which become exposed to sunlight, turn green due to the formation of chlorophyll.

During the fourth stage, the hypocotyl loop straightens up, pulls the plumule and the cotyledons from the seed coat in the soil and raises them above the ground. The cotyledons then spread out, turn green and become the first pair of leaves. Although they can photosynthesize, they are not thin like true leaves, because of the stored food. When the true green leaves emerge, the cotyledons shrivel up and fall off.

The cotyledons are raised above the ground, and hence this type is called epigeal germination (epi = above, geal = earth).

Example: Germination of a maize grain

Maize grain is monocotyledonous and endospermic and the germination is the hypogeal type.

In the first stage, if the grain is sown in moist soil absorbs water, swells up and becomes soft. The radicle elongates and pushes out the coleorhiza through the micropyle. The coleorhiza can just be seen as a very small white protuberance near the base of the grain.

In the second stage, the radicle grows through the coleorhiza and anchors the germinating grain to the soil. It then develops into the primary root.

In the third stage, the coleoptile elongates and emerges above the ground. A cluster of adventitious roots appears from the base of the radicle, and serves for anchorage and absorption.

In the fourth stage, the plumule emerges through the coleoptile. It serves as a terminal bud, which grows to form the shoot system. By this time, the primary root stops functioning and perishes eventually. The root system is then completely replaced by adventitious roots. The cotyledon and endosperm remain buried in the soil, and decompose or fall off eventually.

The cotyledon remains buried in the soil and hence this type is termed as hypogeal germination. (hypo = below, geal = earth)

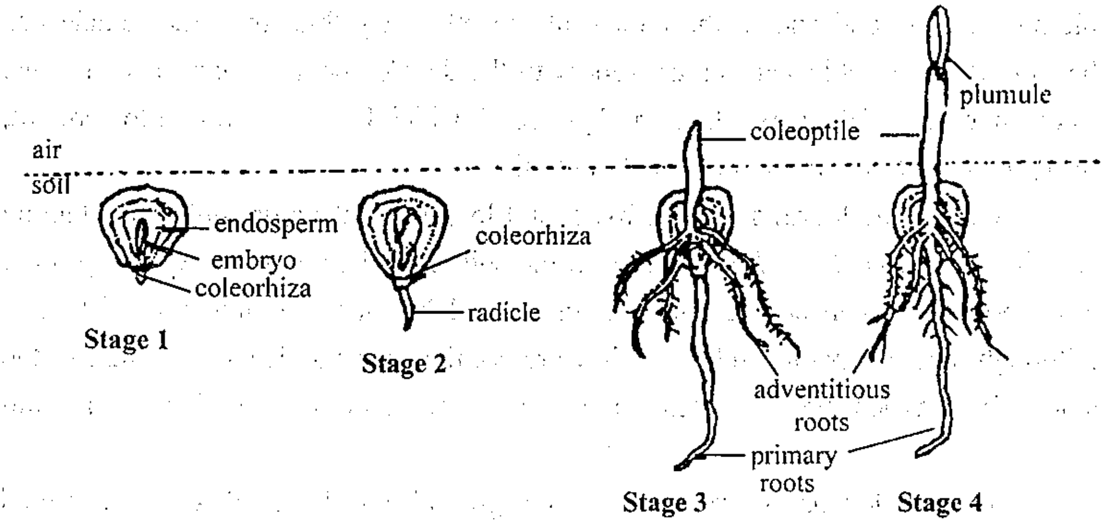


Fig. 4.5 Germination of a maize grain

Economic importance

The grass family is the most important among seed-producing plants. It includes such staple foods as rice, wheat, corn, barley, oats etc. The bean family stands second being represented by many well-known varieties of peas and beans.

Fats and oils obtained from a large variety of seeds form sources of the most valuable commercial products. Groundnut, sesame, cotton, castor, oil palm and sunflower seeds are sources of oil. Drugs produced by many seeds such as nuxvomica (kha-baung), nutmeg (zar-daik-pho) etc. are useful for medicine. Seeds may also be the source of commercial fibres, *e.g.* cotton and kapok (thinbaw- letpan).

Indeed, seeds, more than any other plant organs, play an important role in our every-day lives.

SUMMARY

The number of seed leaves (cotyledons) present in a seed categorizes the seed types. The seed with one cotyledon is termed as monocotyledonous seed and that with two cotyledons is termed as dicotyledonous seed. Depending on the presence of endosperm (a separate tissue apart from cotyledon), the seed is further categorized as endospermic (with endosperm) and non-endospermic (without endosperm) seeds. Seeds with endosperm store the food for the growing embryo in the endosperm while the seeds without endosperm store the food for the growing embryo in the cotyledon. All monocotyledonous seeds are endospermic. Some dicotyledonous seeds are endospermic some are non-endospermic.

The bean seed given is a dicotyledonous seed without endosperm. The maize grain, a single-seeded fruit (caryopsis) is monocotyledonous with endosperm. Two types of germination are epigeal (the cotyledons rose above ground at the end of germination) and hypogeal (the cotyledon remain buried in the soil at the end of germination). Bean seed germinates by epigeal method and maize grain germinates by hypogeal method. Four stages occur in the process of germination in both cases. Water is essential in the process of germination.

CHAPTER V
A TYPICAL MAMMAL

Mammals are the highest group of animals, belonging to the class Mammalia of the phylum Chordata. They include (1) the egg-laying forms, (2) the marsupials, which have pouches and (3) the placental mammals. Of these, the placental mammals are the majority. The general characters common to mammals are as follows:

1. Body is usually covered with hair. The skin has many glands (sebaceous, sweat, scent, and mammary).
2. Skull is with two occipital condyles, and the neck vertebrae are usually seven.
3. Teeth are in sockets on both jaws and are modified in relation to food habits.
4. Generally with four limbs, each having five or fewer digits, with horny claws, nails or hoofs.
5. Heart is four-chambered with two atria and two distinct ventricles. Only the left aortic arch persists.
6. Respiration is only by lungs. A complete muscular diaphragm separates the lungs and the heart from the abdominal cavity.
7. Brain is highly developed with both cerebrum and cerebellum enlarged. Twelve pairs of cranial nerves are present.
8. Body temperature is regulated (homoiothermal).
9. A urinary bladder is present and the excretion (urine) is fluid.
10. Male has a copulatory organ and fertilization is internal. Eggs are usually minute and retained in the uterus for development. Embryonic membranes are present usually with placenta for nourishment and respiration of the embryo. Young are nourished by milk after birth secreted from mammary glands of the female.

The Rabbit *(Lepus cuniculus)*

Rabbits live in groups in burrows. The life span, under normal condition is seven to eight years. It is very prolific, frequently breeding four times a year.

External Features

The body of the rabbit is covered with soft hair or fur. The head bears a terminal mouth bounded by soft lips. The upper lip is divided by **a cleft** running back to the nostrils, and exposing the **chisel-shaped incisors**. The eyes are large and provided with upper and lower eyelids and a nictitating membrane. Long stiff hairs (**vibrissae**) occur above and below the eyes, and on the snout. External ears (**pinnae**) are long and conspicuous. The neck is distinct and the trunk is divisible into thorax and abdomen. The fore legs are smaller than the hind, which are elongated and adapted for leaping. The fore legs have five digits and the hind only four, all provided with claws. On the ventral surface of the abdomen in the female are four or five pairs of mammary glands, externally evident through teats. The anus is below the short tail. Anterior to the anus is the urogenital opening. Perineal glands (**scent glands**) open on the depressed area of the skin between the anus and the urogenital opening.

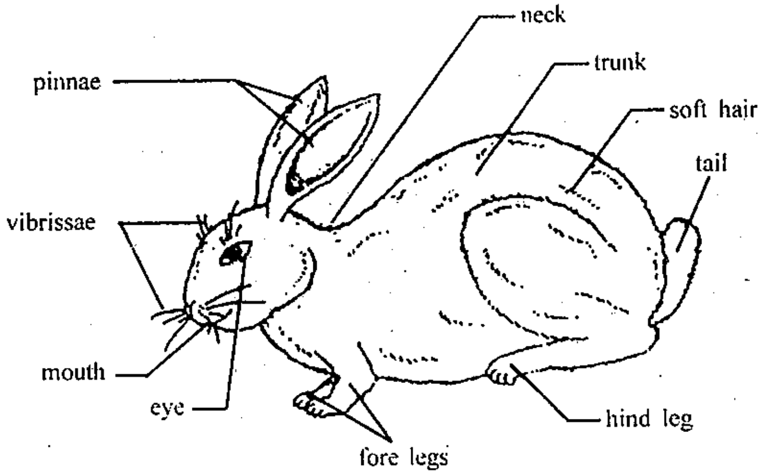


Fig. 5.1 External features of a rabbit

Body Cavity

The diaphragm, a muscular transverse partition across the body, internally separates the thorax and abdomen. The **coelom** is divided into four compartments: the **pericardial cavity** containing the heart, the two **pleural cavities**, each enclosing a lung, and the **peritoneal cavity** containing the abdominal viscera.

Skeletal System

The skeletal system of the rabbit can be distinguished into the **axial** and the **appendicular** skeletons. The axial skeleton consists of the **skull**, the **vertebral column**, the **sternum**, and the **ribs**. The appendicular skeleton consists of the **girdles** and the **bones of the limbs**.

The vertebral column has five regions: **cervical**, **thoracic**, **lumbar**, **sacral**, and **caudal**, with (7), (12), (7), (4) and (15) vertebrae respectively. Between adjacent vertebrae are intervertebral discs.

The typical vertebra has a solid oval portion called the **centrum**, which supports a **neural arch** around a **neural canal**. A **neural spine** extends dorsally and

:wo **transverse processes** extend laterally on either side of the neural spine.

Digestive System

Digestive system of the rabbit includes the digestive tract (alimentary canal) and its associated glands **(liver and pancreas).**

Digestive Tract

A complete digestive tract starts with the mouth and ends with the anus. The parts of the tract include, the mouth, the **buccal cavity, pharynx, oesophagus, stomach**, and a long coiled **intestine**, which open outside at the posterior end by the **anus**. The mouth opens into the buccal cavity.

The pharynx is formed at the posterior end of the buccal cavity. The **glottis** lies just behind the tongue on the floor of the pharynx, guarded by a cartilagenous flap, the **epiglottis**. This flap prevents food particles from passing down the windpipe. The pharynx leads into a narrow tube, the **oesophagus.**

The oesophagus passes through the neck and thorax. It then pierces the diaphragm and enters the abdomen to open into the cardiac end of the stomach.

The stomach is a wide curved sac placed across the body cavity. It can be differentiated into the anterior **cardiac** end and the posterior **pyloric** end. A sphincter muscle known as the pylorus guards the opening of the pyloric end. The pyloric end leads into the narrow **duodenum**, the anterior part of the small intestine.

The long coiled intestine can be distinguished into the **small intestine** and **large intestine**. The anterior **duodenum** and posterior **ileum** constitute the small intestine. The inner surface of the ileum raised into long finger-like projections called the **villi**. These serve to increase the absorptive surface in the intestine. The posterior end of the ileum dilates into **sacculus rotundus**. It then opens into the **colon**, the anterior part of the large intestine.

Anterior **colon** and a posterior **rectum** make up the large intestine. The latter opens outside by the anus.

There is a wide tube arising from the junction of the ileum and the colon. This tube is termed as the **caecum** and ends in a blind finger-like **vermiform appendix**.

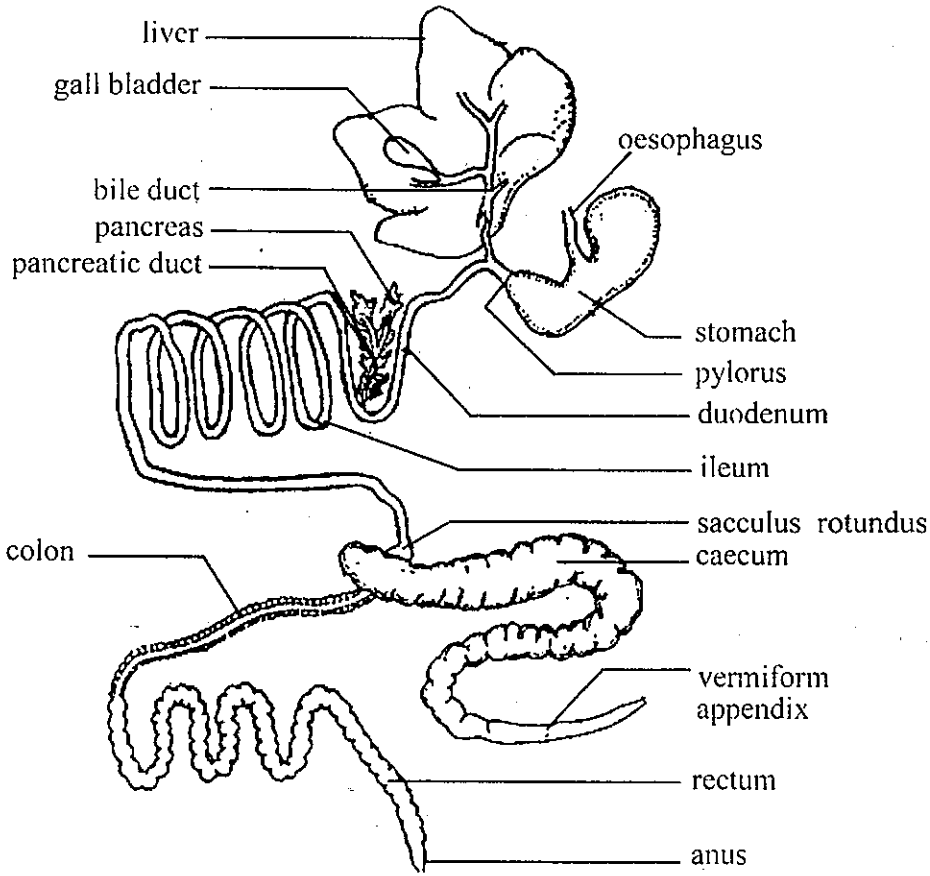


Fig. 5.2 Digestive system of a rabbit

Associated Glands

The **liver** and **pancreas** are the associated glands of the alimentary canal. The liver consists of five lobes. Embedded in the right central lobe of the liver is the pear-shaped gall bladder. Several **hepatic ducts** from the liver and a **cystic duct** from the gall bladder forms the bile duct, which opens into the dorsal side of the duodenum a short distance beyond the pylorus.

The pancreas is a pinkish body, consisting of a large number of small lobules. The **pancreatic duct** formed by the union of smaller ducts from the lobes of the pancreas. opens into the distal loop of the duodenum.

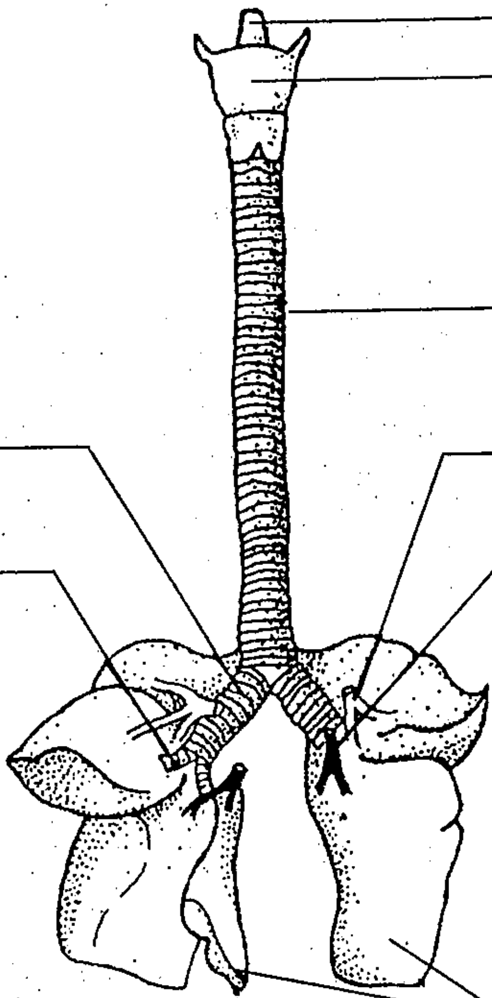


Fig. 5.3 Respiratory system of a rabbit

In rabbit, gaseous exchange takes place in the **lungs** located in the **chest** or **thorax**, whose side walls are the ribs with muscles between them, and the hind wall the **diaphragm**. The windpipe comprises the **larynx** and a long **trachea,** leading back into the thorax and dividing into two **bronchi,** which join the lungs. In these, the **bronchi** break up into numerous bronchioles ending in minute air sacs, the **alveoli.** Thus, mammalian lungs have a larger internal surface area than those of other vertebrates.

Circulatory System

The heart of a rabbit is four-chambered, consisting of two **auricles** and two **ventricles**. The right auricle opens into the right ventricle and the left auricle into the left ventricle. The two sides do not communicate with each other.

The three **venae cavae** open directly into the right auricle while the two pulmonary veins open with a common opening into the left.

Arising from the right ventricle is the **pulmonary arch** and from the left is the **aortic arch.**

Summarized arterial system

No.	Name of the artery	Part of the body to which each artery supplies the blood
1	Innominate artery	head, fore limbs
2	Common carotids	head, face and brain
3.	Subclavians (paired)	fore limbs
4.	Intercostals (numerous paired)	muscles of the ribs
5.	Phrenics (paired)	diaphragm
6.	Coeliac artery	liver, stomach and spleen
7.	Anterior mesenteric artery	small intestine, pancreas, caecum and colon
8.	Renals (paired)	kidneys
9.	Posterior mesenteric artery	hinder part of the rectum
10.	Genitals (paired)	sex organs
11.	Caudal artery	tail
12.	Common iliacs (paired)	hind limbs, pelvic cavity, bladder, uterus in females

F-7B

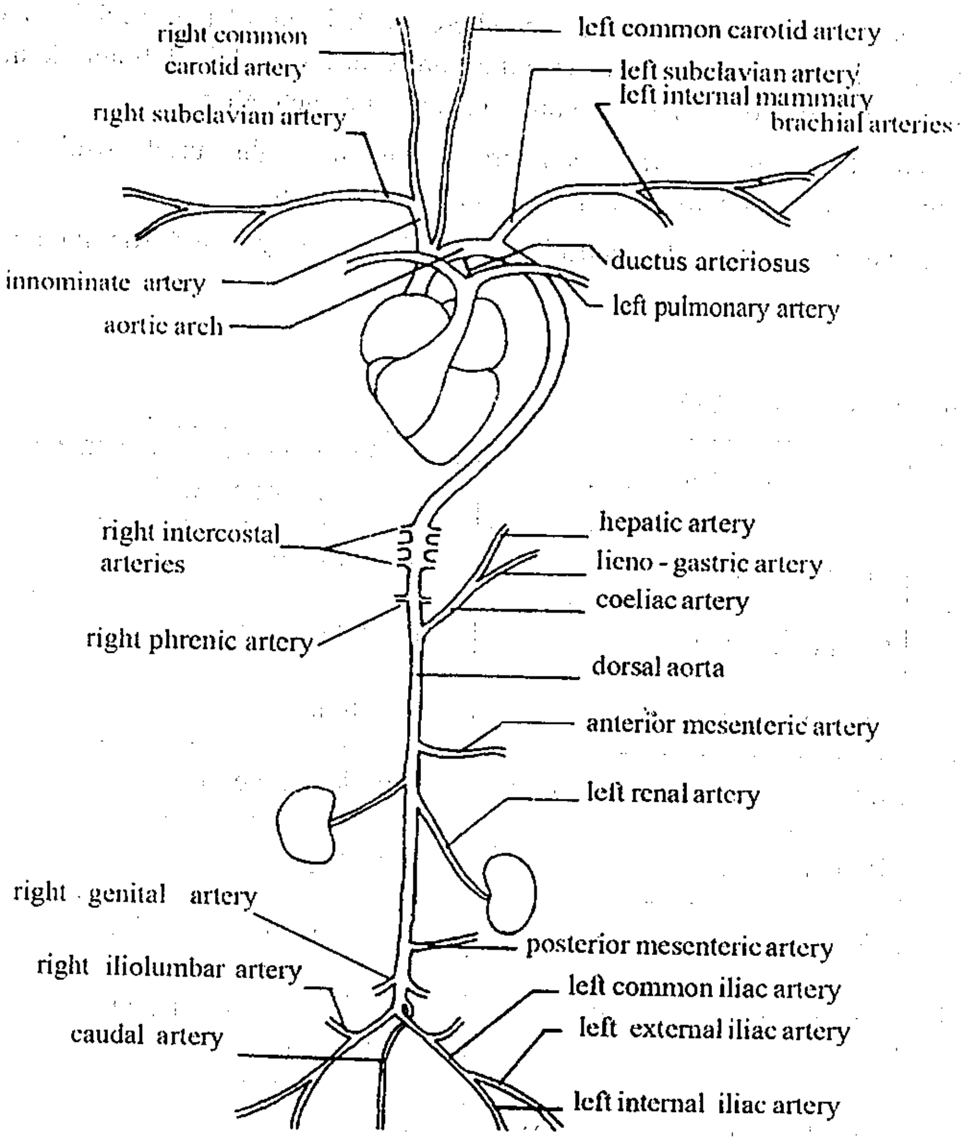


Fig. 5.4 Arterial system of a rabbit

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Summarized venous system

No.	Name of the vein	Part of the body from which each vein brings the blood
1	Right and left external jugulars	surface of the head and neck
2	Right and left internal jugulars	brain
3.	Right and left subclavians	shoulders and fore limbs
4.	Right and left internal mammary or anterior epigastric	ventral wall of the thoracic cavity
5.	Right and left anterior intercostal veins	four or five anterior intercostal spaces
6.	Azygos vein (only on the right)	the rest of the intercostal spaces of both sides
7.	Internal iliacs	back of thigh and pelvis

No.	Name of the vein	Part of the body from which each vein brings the blood
8.	External iliacs	hind limbs and part of the pelvic region
9.	Iliolumbars	hinder region of the abdominal wall
10.	Genitals	reproductive organs
11.	Renals	kidneys
12.	Hepatic vein	liver
13.	Phrenics	diaphragm
14.	Lienogastric vein	stomach and spleen
15.	Duodenal vein	duodenum
16.	Anterior mesenteric vein	ileum, caecum, colon and greater part of the rectum
17.	Posterior mesenteric vein	hindermost part of the rectum
18.	Pulmonary veins	the lungs

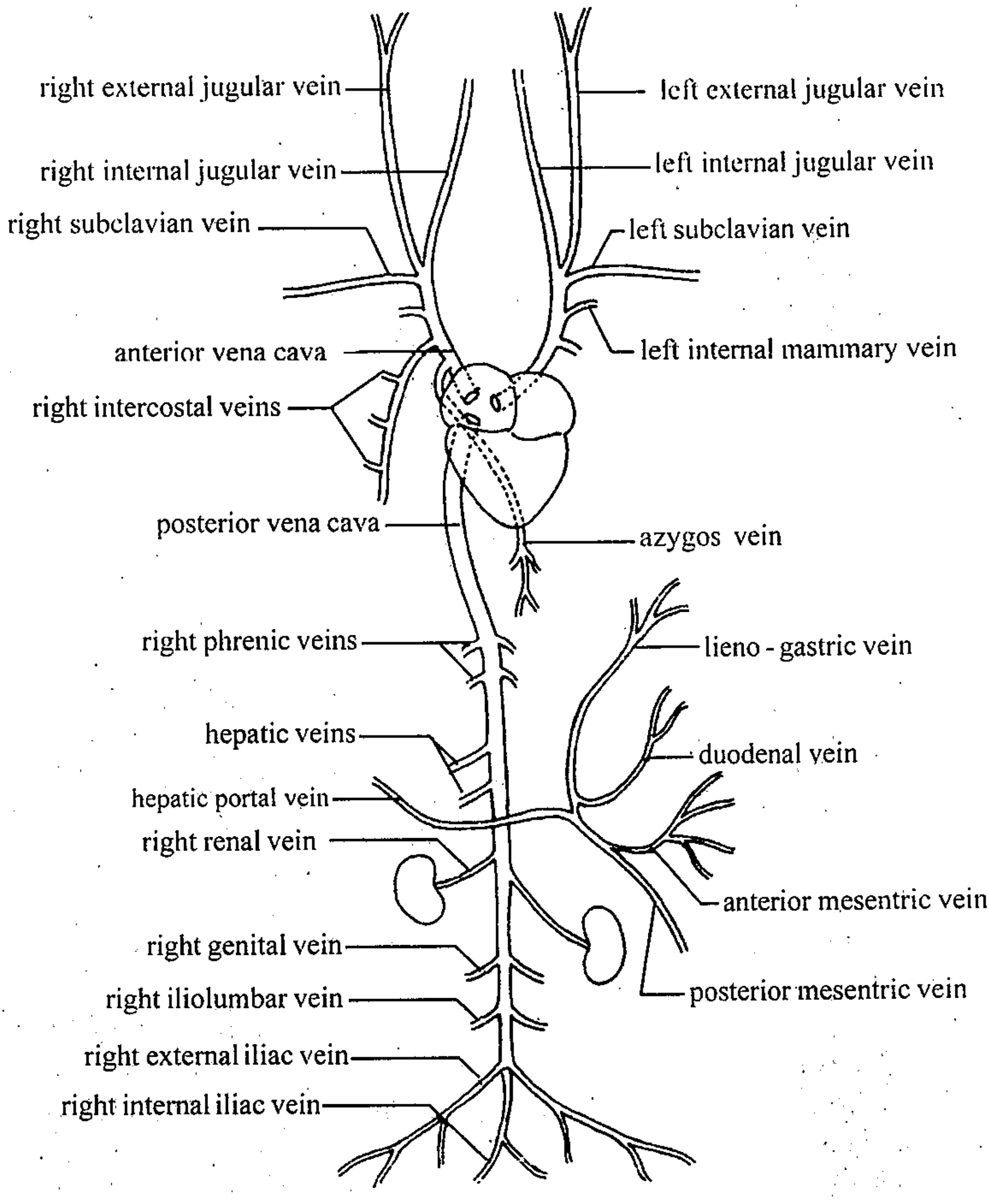


Fig. 5.5 Venous system of a rabbit

Excretory System

The main organs of the excretory system are the two bean-shaped kidneys in the upper part of the abdominal cavity, one on each side of the vertebral column. The right kidney is a little anterior to the left and is quite close to the diaphragm.

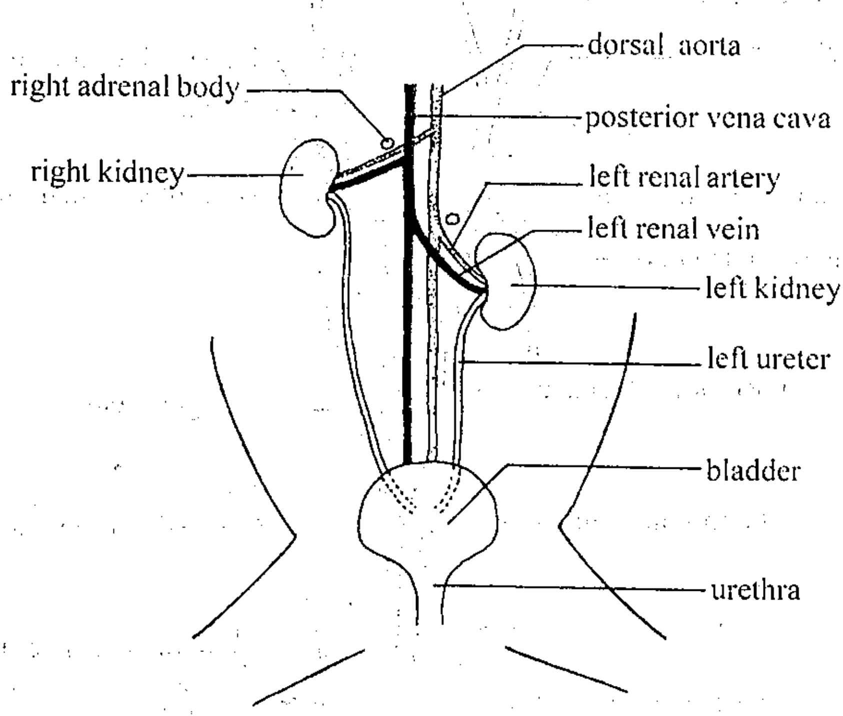


Fig. 5.6 Excretory system of a rabbit

The outer surface of the kidney is convex and the inner concave. A depression in the middle of the concave surface is termed as the hilum where the renal artery enters, and the renal vein and the ureters leave the kidney. The renal arteries transport dissolved urea to the kidneys for removal (excretion), while the renal veins leave the kidney with very little or no dissolved urea in the blood. The ureters are the tubes, which drain urine from the kidneys to the bladder, a storage sac, increasing in size as it accumulates urine. Sphincter muscles control the flow of urine at intervals into the urethra, through which it is passed to the exterior.

Essential Regions of the Kidney

The two main zones as seen in the longitudinal section through a kidney are the outer **cortex** and the inner **medulla**. The inner border of the medulla region is extended into several conical pyramids which project towards the pelvis, a small funnel-shaped cavity.

There are million of minute excretory units in the kidney. These units are termed as **nephrons**. Each nephron includes a **malpighian** body and a **uriniferous tubule**.

The malpighian body consists of a cup-shaped **Bowman's capsule** and a **glomerulus**. The bowl of Bowman's capsule contains a glomerulus; a tight knot of blood capillaries formed from the branching of the **renal artery**. After leaving the glomerulus the blood vessel forms a complex network of capillary loop around the other parts of the kidney tubule. These capillaries unite to form the **renal vein**.

Each uriniferous tubule can be distinguished into three portions. In two of these, the tubule is twisted around itself forming the first and second coiled tubules. Between these coiled portions, the tubule forms the loop of Henle; two straight pieces of the tubule linked together in a U-shaped loop. At the end of the second coiled tubule, the union of several kidney tubules from one region forms the collecting duct. This passes towards the pelvis. The pelvis leads into the ureter.

Bowman's capsule and coiled tubules are in the cortex, the loop and collecting duct are in the medulla.

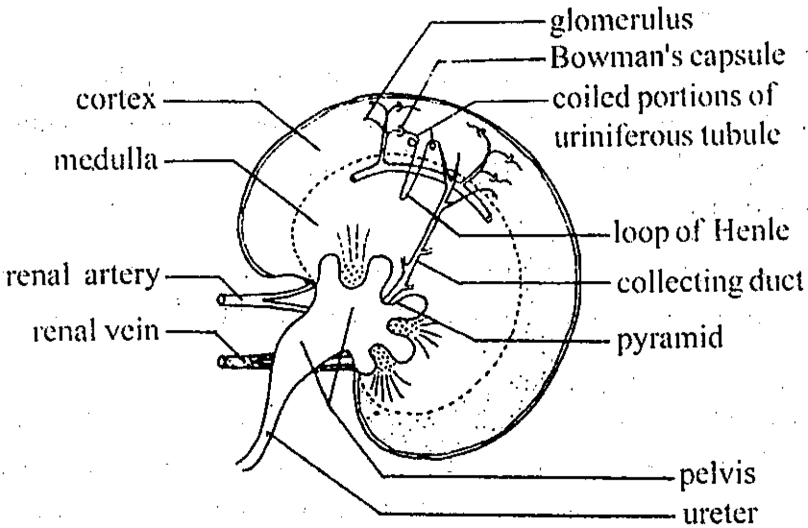


Fig. 5.7 L.S. of kidney

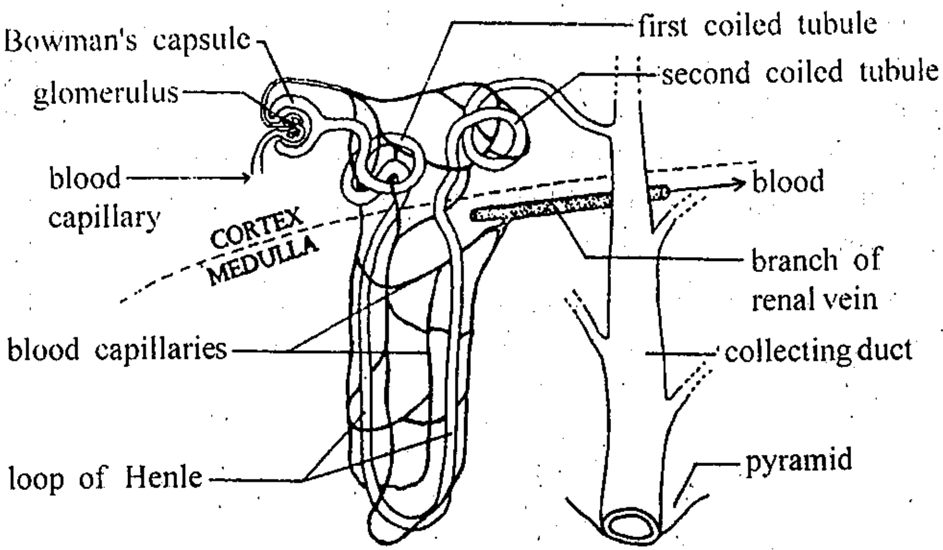


Fig 5.8 A nephron

The Reproductive System

Male reproductive system

The male reproductive system consists of a pair of testes. Each testis lies within the **scrotum**, which is a pouch of the body wall. From each testis, the spermatozoa are gathered in a network of minute tubules in the **epididymis** to enter the sperm duct or **vas deferens**. This passes forwards out of the **scrotal sac**, curves over the ureter and passes backwards again to enter the base of the **urethra**, which is a common **urogenital canal** through the male reproductive organ or **penis**. During copulation, sperm is transferred through this organ.

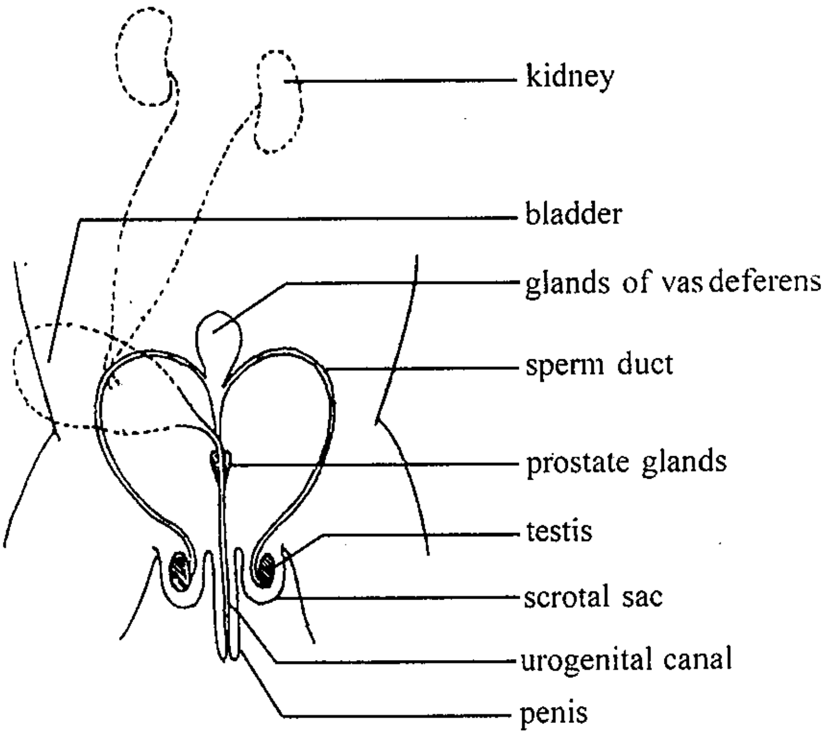


Fig. 5.9 Male reproductive system of a rabbit

Around the base of the urethra are two small **accessory glands**, known as the **prostate glands**, which pass their secretion into the urethra. Behind the prostate are **Cowper's glands**, the secretion of which helps in the transfer of sperms.

Female reproductive system

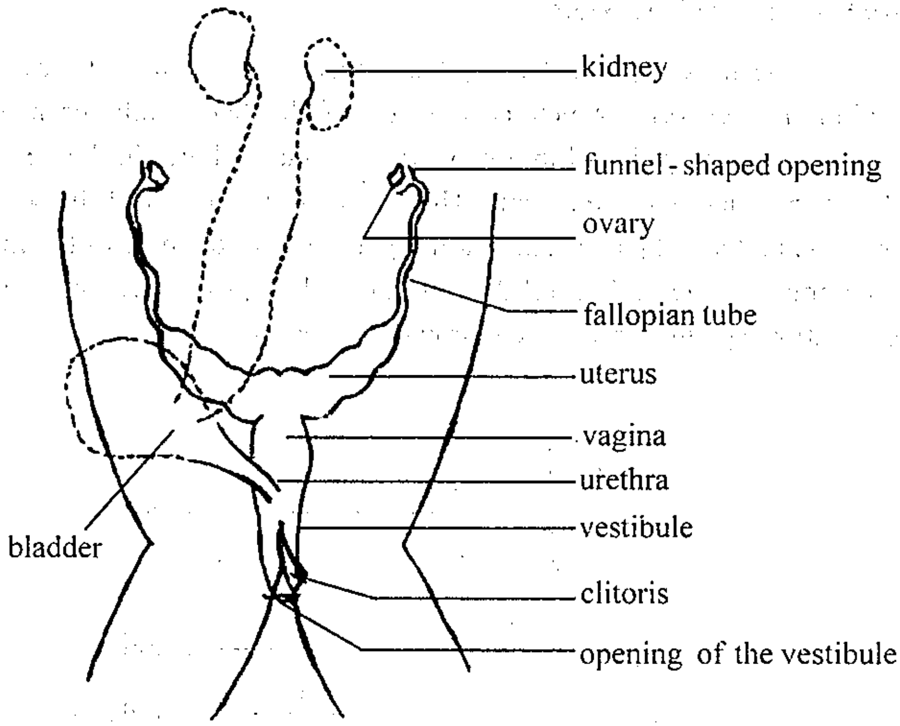


Fig. 5.10 Female reproductive system of a rabbit

The female reproductive system consists of two **small ovaries**, attached behind the kidneys to the dorsal abdominal wall. The oviducts open into the abdominal cavity by wide funnel-shaped openings just outside the ovaries. The first section of each duct is gently sinuous and is termed as the **fallopian tube**. The fallopian tube runs backwards and enlarges to form the uterus, which joins with its counterpart. The uterus then narrows to form the **vagina**. The vagina extends between the bladder and rectum and passes backwards within the pelvic girdle above the neck of the bladder, with which it unites to form the urogenital canal or **vestibule**. The vestibule opens at the **vulva**. Small rod-like **clitoris** lies on its ventral wall and two small Cowper's glands on the dorsal wall.

Nervous system

The nervous system of a rabbit consists of **central nervous** and **peripheral nervous systems.** The former includes the **brain** and **spinal cord** while the latter consists of the **cranial nerves, spinal nerves,** and **autonomic nervous system.** In a common mammal, the rabbit, the basic pattern of **fore, mid** and **hind brain** is found. The various parts of the brain are summarized as follows:

Summarized parts of the brain (the rabbit)

Parts of the brain	Location	Prominent features
Olfactory lobes	in front of the cerebral hemispheres	club-shaped
Cerebral hemispheres	behind the olfactory lobes	well-developed surfaces with narrow grooves, **sulci,** each hemisphere with a **lateral fissure** on the side about the middle of its length
Diencephalon	in front of the optic lobes	covered by the **anterior choroid plexus** (thin vascular membrane); stalked **pineal body** and **pituitary body**
Optic lobes	behind the diencephalon concealed by the cerebral hemispheres	solid, each lobe divided into the anterior large lobe and posterior small lobes
Cerebellum	in front of the medulla	prominent with three lobes central **vermis** and the two lateral **floccular** lobes
Medulla oblongata	hindermost part of the brain	dorso-ventrally flattened and passes behind as the spinal cord; its roof is formed by highly vascular **posterior choroid plexus**

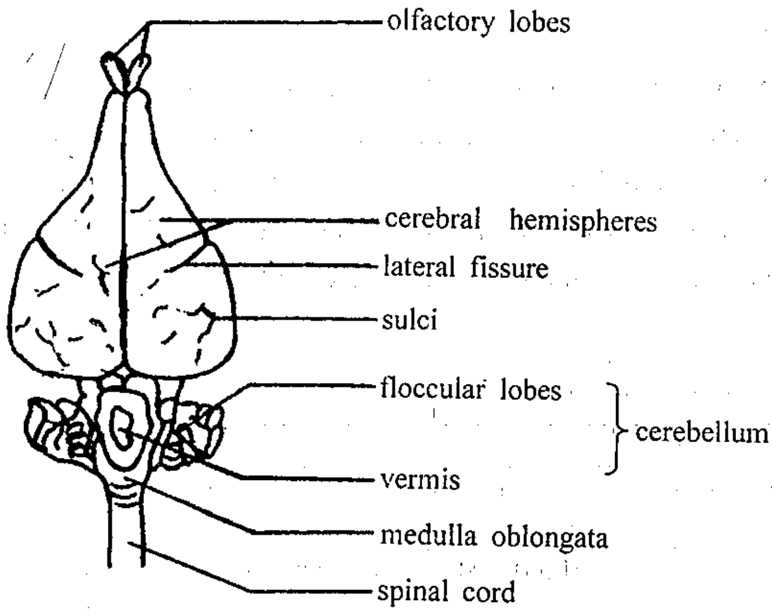


Fig. 5.11 Brain of the rabbit (Dorsal view)

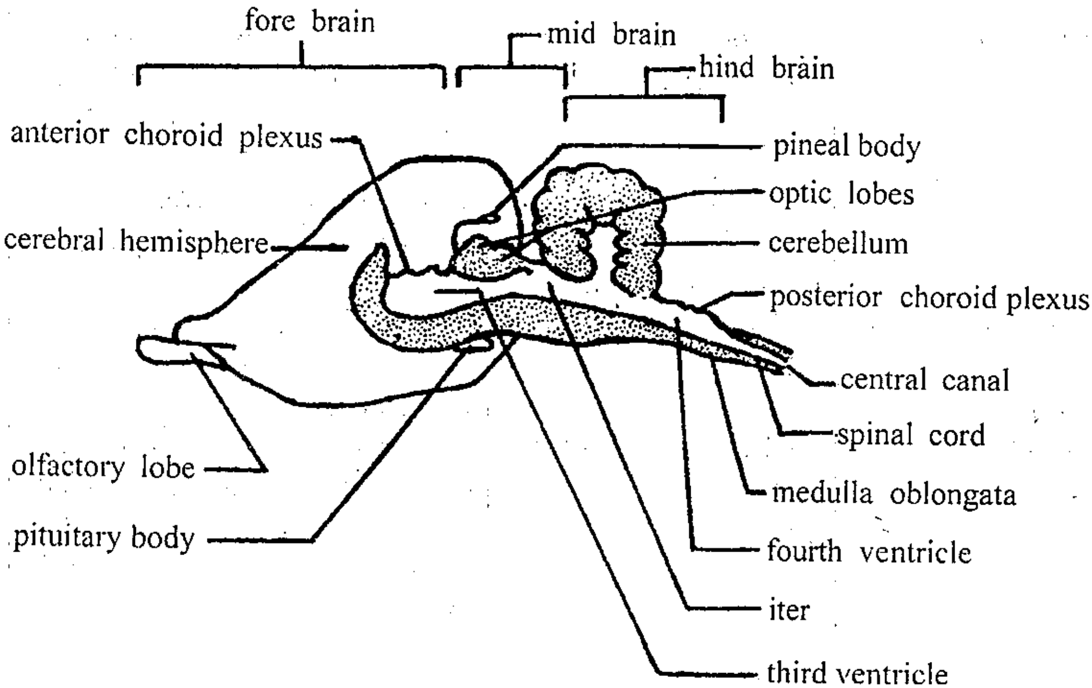


Fig. 5.12 Brain of the rabbit (Right half of the brain)

Ventricles

The cavity of the diencephalon is the **third ventricle.** The cavity of the medulla is the **fourth ventricle.** A narrow passage, the **iter** connects the third and the fourth ventricles.

Spinal Cord

The spinal cord lying in the vertebral column is continuous with the medulla oblongata. It forms a thick-walled tube, consisting of three parts, an **inner canal, grey matter** and **white matter.** The inner canal is the **central canal**, continuous with the series of ventricles in the brain. The canal and the ventricles contain the **cerebro-spinal fluid,** which circulates slowly in the ventricles acting as nutritive medium for the cells bordering the ventricles. The grey matter lies immediately external to the central canal and consists of **adjustor neurones** and cell bodies of **motor neurones** while the cell bodies of **sensory neurones** are located in the dorsal root **ganglia** of **spinal nerves.** The white matter lying external to the grey matter consists of bundles of medullated fibres connecting the various parts of the brain and the cell bodies of the spinal nerves and adjustor neurones. The spinal cord relays impulses to and from the body and the brain, and is the centre of a large number of **spinal reflexes.**

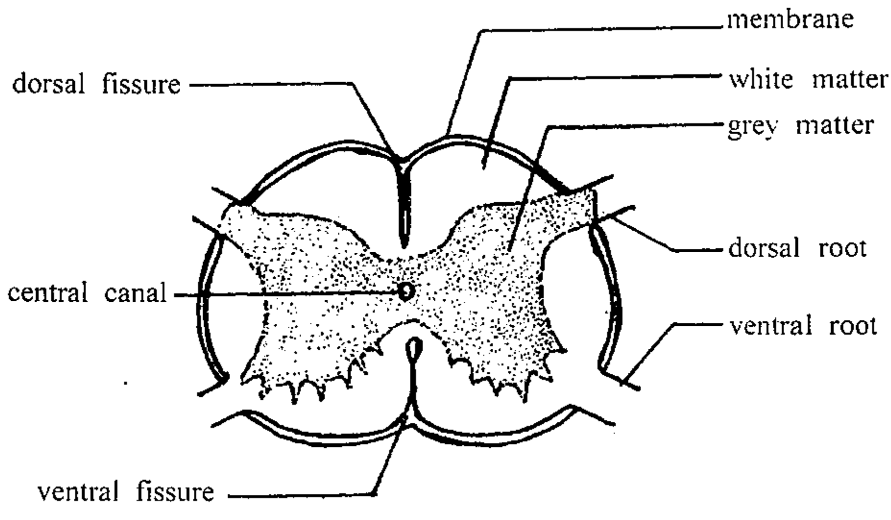


Fig. 5.13 Transverse section of spinal cord

Cranial Nerves

The **cranial nerves** are paired nerves arising from the **brain**. They include sensory nerves to the **sense organs** of the head, motor nerves to the **eye muscles** and the **facial muscles**, and nerves, which make up part of the autonomic nervous system.

Spinal Nerves

Paired **spinal nerves** arise from the **spinal cord** at regular intervals. Each consists of **sensory** and **motor nerve fibres** running to and from the spinal cord. The nerve fibres may be **somatic**, supplying mainly the skin and voluntary muscles, or may be **visceral**, supplying the gut, involuntary muscle structures and various glands. The visceral motor fibres make up the autonomic nervous system.

SUMMARY

The characteristics of mammals are key points to associate with systems of the rabbit and the accounts given for mammals in the following chapters. The accounts given for the typical mammal (rabbit) are basic knowledge to associate with the life processes given in the following chapters: Digestive system with animal nutrition; respiratory system with gaseous exchange in mammals; circulatory system with transport in animals; reproductive system with reproduction in mammals; nervous system with reflex arc.

CHAPTER VI

NUTRITION

Plant Nutrition

Photosynthesis

Photosynthesis (photo = light, synthesis = manufacture) - the process by which green plants use light energy to manufacture glucose.

The summarized equation for the process of photosynthesis is as follows:

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{12H_2O} \xrightarrow[\text{light energy}]{\text{chlorophyll}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} + \underset{\text{Water}}{6H_2O}$$

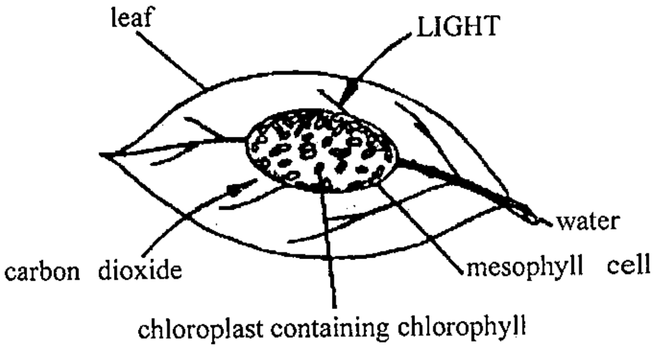


Fig. 6.1 Process of photosynthesis

Green plants take in carbon dioxide and water and in the presence of light, form glucose. Chlorophyll absorbs light energy for the chemical change. This energy becomes locked in the produced glucose molecules. Glucose thus becomes a source of potential energy for the plant to make all the other complex compounds that it needs to live, grow and reproduce.

Autotrophic nutrition (auto = self, trophic = feeding)

The nutrition of green plants is termed as autotrophic nutrition because green plants are capable of synthesizing their own food requirements from simple materials.

Role of chlorophyll in photosynthesis

Chlorophyll - is a pigment that absorbs light of particular wavelengths (mainly blue and red). Chlorophyll in green plants spread out on stacks of membranes in the chloroplasts.

Chloroplast - a membrane bound organelle containing chlorophyll and other pigments. Plant cells that contain chloroplasts are green in colour. This is because chlorophyll reflects mostly the green portion of light. The other wavelengths of light (blue and red) are almost totally absorbed by chlorophyll and are transformed into chemical energy.

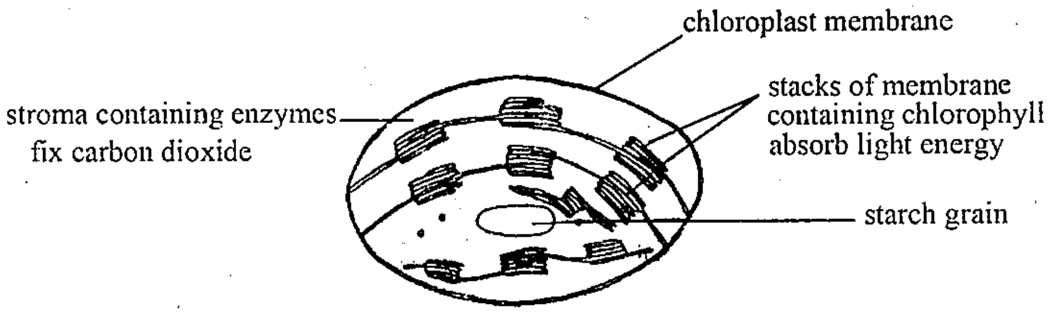


Fig. 6.2 Chloroplast

The energy breaks apart the molecules of water and carbon dioxide. The atoms are then rearranged to form glucose molecules. This is carried out through a series of reactions controlled by enzymes. Chemical energy is stored in the bonds of the molecules.

Oxygen is released from the splitting of the water.

1. The release of oxygen is therefore an indication of photosynthesis.
2. The glucose formed during photosynthesis is stored temporarily as starch in leaves. Starch is another visible evidence of photosynthesis. If a leaf that has been in the light, is boiled first in water, then in alcohol, and tested with iodine solution, it will show a black or blue-black colour.

The starch test

A leaf can be tested for starch in the following manner.

1. The leaf is boiled in water for a minute. This kills the protoplasm by destroying the enzymes and hence prevents further chemical changes. It also makes the cells more permeable to iodine solution.
2. The leaf is next boiled in methylated spirit to remove the chlorophyll. This leaves a white leaf and makes colour changes easier to see.
3. The leaf becomes brittle because of boiling in alcohol. However, it can be softened by dipping into boiling water. It is then spread out in a petridish or on a glazed tile.
4. Iodine solution is placed on the leaf. If starch is present, the leaf turns blue. If there is no starch, the leaf is stained brown by iodine.

Conditions required for photosynthesis

The equation for photosynthesis shows that there are four requirements for photosynthesis, namely **chlorophyll, light, carbon dioxide** and **water**.

Requirement	Investigation to show the necessity in photosynthesis
Chlorophyll	A variegated leaf is taken from a plant that has been left in the light and tested. Only the green areas of the leaf show the presence of starch.
Light	A portion of green leaf is sandwiched between two pieces of black paper. The plant is then left in the light. Only the exposed areas of the leaf show the presence of starch when tested.
Carbon dioxide	Two destarched potted plants are watered and the aerial portion enclosed in transparent plastic bags. One of the bags contains soda lime or sodium hydroxide to absorb carbon dioxide and the other sodium hydrogen carbonate to supply extra carbon dioxide. Both plants are placed in sunlight for a few hours. A leaf is then detached and tested for starch. The leaf deprived of carbon dioxide will stain brown, while that from the carbon dioxide-enriched atmosphere will turn blue.

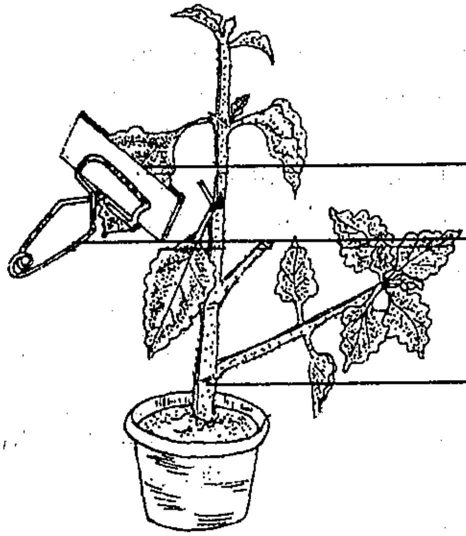


Fig. 6.3 Investigation to show that photosynthesis needs light

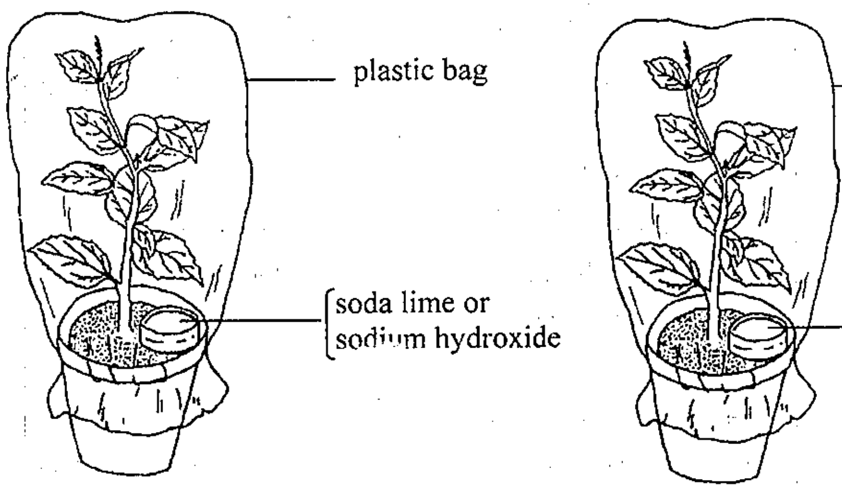
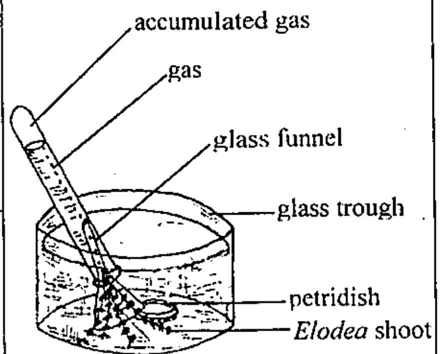


Fig. 6.4 Investigation to show that carbon dioxide is necessary for photosynthesis

In each investigation, the plants must first be destarched. This can be done by leaving the plant in the dark over a twenty-four hour period.

Factors controlling photosynthesis

Photosynthesis does not occur at the same rate all the time. Factors, such as light intensity and temperature, and carbondioxide in the environment affect the rate of photosynthesis.

Factor	Effect on the rate of photosynthesis	Investigation
Light intensity	As the light intensity increases, the rate of photosynthesis increases until it reaches a maximum rate.	A submerged aquatic plant gives off a steady stream of bubbles. Faster bubbling indicates faster rate of photosynthesis. 
Temperature	Under bright light, the rate of photosynthesis increases with a rise in temperature up to a maximum temperature of around 40° C. Beyond this maximum temperature, the rate of photosynthesis drops rapidly.	
Carbon dioxide	The concentration of carbon dioxide in the atmosphere is about 0.03%. Under experimental conditions, the concentration can be increased up to a certain level, the rate of photosynthesis increases with higher carbon dioxide concentration.	

Intake of substances required for photosynthesis

Plants get the materials required for photosynthesis from their environment.

Material	Method of intake by green plant	Next stage
Light	Light is absorbed by chlorophyll, in chloroplasts of plant cells, mainly in the leaves.	Light energy is changed into chemical energy.
Water	Water is absorbed by the roots and travels up the xylem from the root to the stem and then into the leaves.	Water is split to provide hydrogen atoms. Oxygen is released.

Material	Method of intake by green plant	Next stage
Carbon dioxide	Carbon dioxide diffuses from the atmosphere into the leaves through the stomata.	Carbon dioxide combines with the hydrogen from water. Through a series of reactions, glucose is formed and is stored temporarily in the leaf as starch.

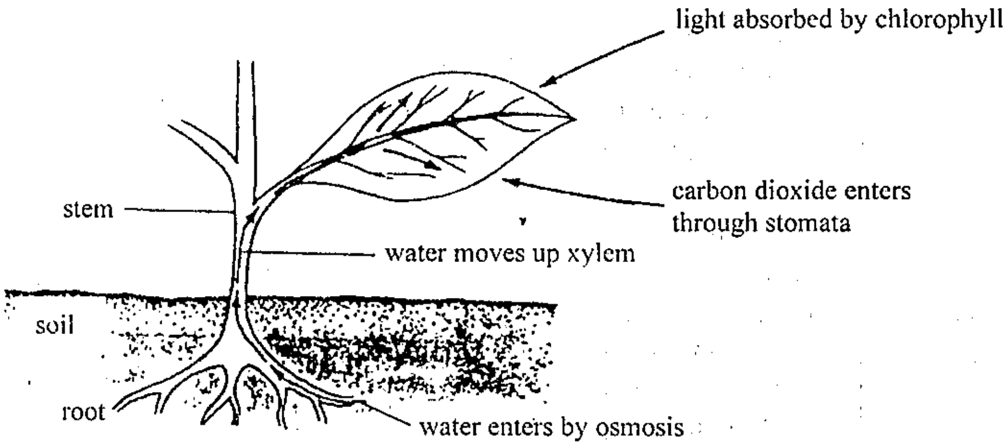


Fig. 6.5 Intake of materials required for photosynthesis

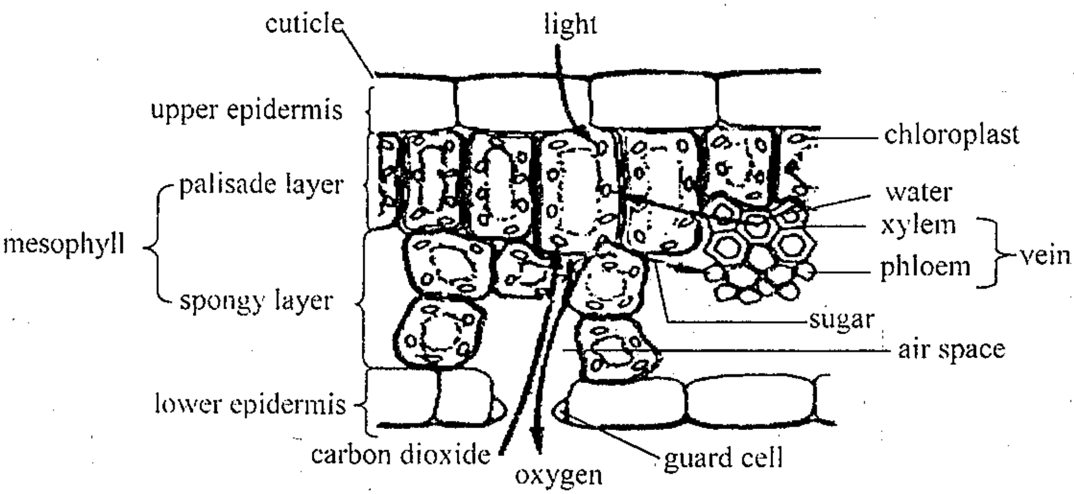


Fig. 6.6 Transverse section of a leaf

A leaf is composed of several distinct cell layers.

Cell layer	Structure	Function
Upper epidermis	Uppermost layer of cells, covered by a layer of cuticle, chloroplast absent	Protects inner layers of cells, reduces evaporation of water from leaf, and allows light penetration to inner layers
Palisade mesophyll layer	Long cells arranged vertically,contain numerous chloroplasts	Exposes many cells to light rays, photosynthesis takes place mainly in this region
Spongy mesophyll layer	Loosely arranged cells with many air spaces in between, contain chloroplasts	Allows diffusion of carbon dioxide and oxygen in and out of mesophyll cells, photosynthesis takes place
Veins	Extend throughout the leaf, branched repeatedly forming network in mesophyll layer	Support leaf
Xylem	Cylindrical hollow thick-walled cells	Carries water and minerals absorbed by roots to leaves
Phloem	Cylindrical, thin-walled cells with cytoplasm	Transports products of photosynthesis to other parts of the plant
Lower epidermis	Lowest layer of cells, covered by cuticle, **Guard cells** surround **stomata** and contain chloroplasts	Protects inner tissues, slows down water loss, regulate the opening and closing of stomata, for diffusion of carbon dioxide and oxygen in and out of leaf, photosynthesis takes place

The leaf is adapted for the process of photosynthesis.

	Adaptive features for photosynthesis
Light	Leaves attached at the end of branches are arranged to ensure minimal shading. Leaves are usually flat and broad, exposing large surfaces to light.
Water	The veins branch repeatedly within the leaf so that every mesophyll cell is close to a xylem vessel, which carries water to the leaf. The guard cells, through controlling the opening of the stomata, regulate the transpiration stream and the water supply to the leaf.

	Adaptive features for photosynthesis
Carbon dioxide	Carbon dioxide, from the atmosphere, diffuses into the leaf through stomata. Carbon dioxide dissolves in the film of water around the cell wall before diffusing into the mesophyll cells. Numerous air spaces between mesophyll cells enhance diffusion of carbon dioxide into the leaf.

The leaf also is adapted for the distribution of its photosynthetic products:

(a) Photosynthetic products are distributed by phloem, to all other parts of the plant.

(b) Oxygen and water may be used by the leaf or diffuse out through the stomata.

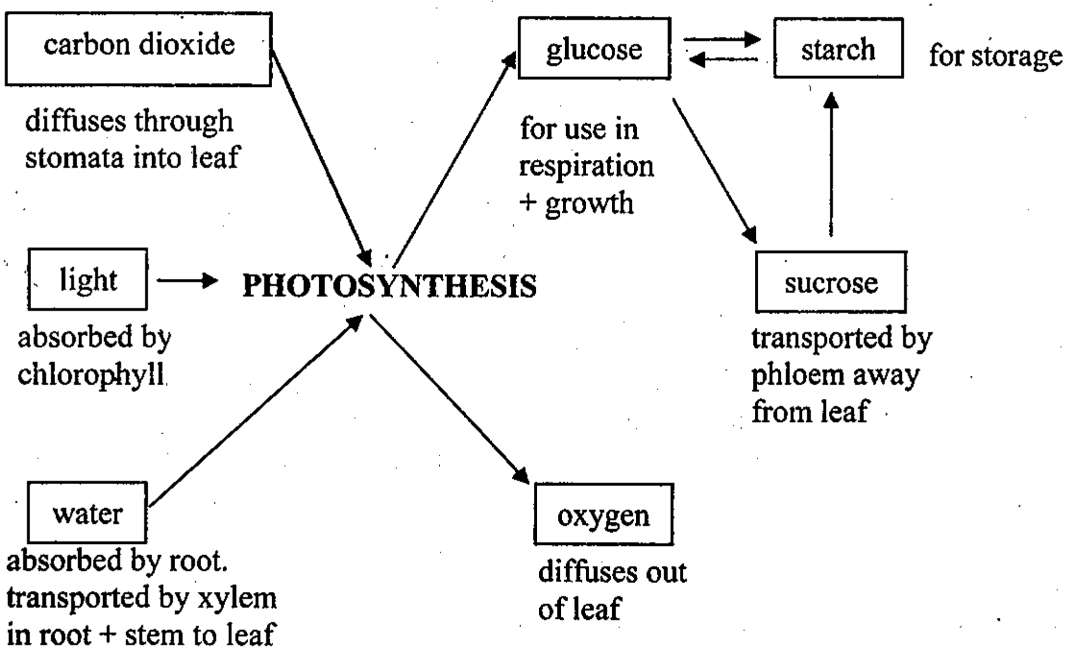


Fig. 6.7 Summarized plant nutrition

Mineral nutrition

Mineral salts are present in the soil. Roots of plants together with water absorb dissolved minerals.

Nitrogen is absorbed mainly as nitrates dissolved in soil water. It is needed for synthesis of amino acids, proteins and other nitrogen containing compounds. Insufficient nitrogen results in poor plant growth and yellow leaves.

Decay of manure and compost, and the addition of inorganic fertilizers increase the mineral content and the fertility of soil.

Animal Nutrition

Animals, unlike green plants, cannot use light energy to make their food from carbon dioxide and water. They feed either on the organic compounds synthesized by plants, or on animals that feed on the plants. They are known as heterotrophs (hetero = other, trophs = feeding).

Feeding method in a protozoan

Paramecium, one of the most specialized protozoans has various organelles to perform particular vital processes. In this organism, feeding is more organized than in *Amoeba.*

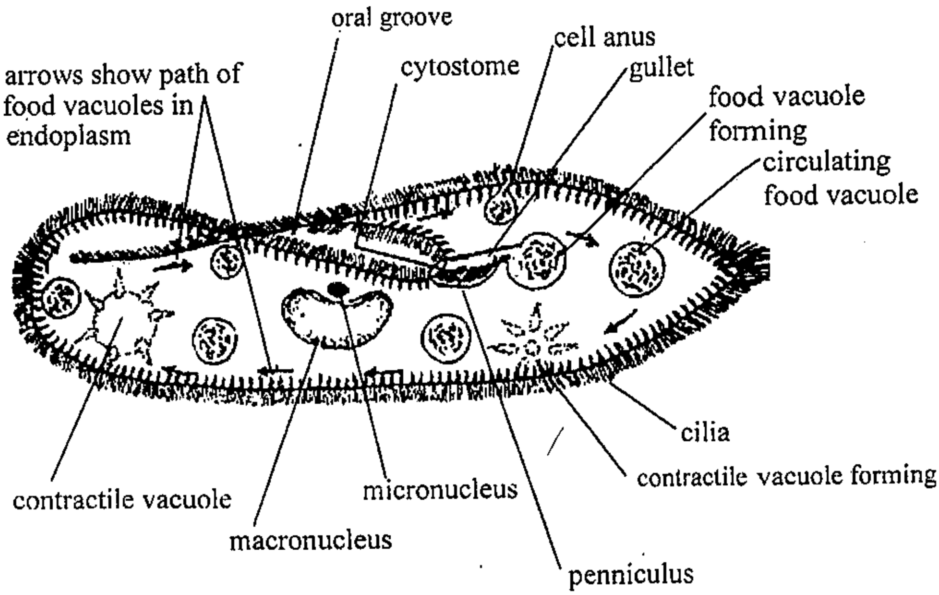


Fig. 6.8 Feeding in *Paramecium*

Paramecium feeds on bacteria, small protozoans, algae and yeast. Cilia in the oral groove beat constantly and drive a current of water containing food toward the cytostome (cell mouth), which opens into the short **cytopharynx** (gullet) ending in the endoplasm. Two bands of penniculus, fused cilia gather the food at the posterior end of the cytopharynx in a vacuole of water. The vacuole constricts off and begins to move in the endoplasm as a food vacuole. Then another vacuole forms in its place. Streaming movement of the endoplasm carries the vacuoles in a definite route, first posteriorly, then forward, aborally, and again posteriorly to reach the cell anus near the oral groove. The food is digested by the action of enzymes secreted by the endoplasm and absorbed by the surrounding protoplasm to be stored or used for vital activities and growth. Indigestible residues in the vacuoles are egested at the cell anus.

Diet

Diet is the food we eat every day.

1. A diet is balanced when all the different groups of food are eaten in the right proportion and in sufficient quantity to maintain a healthy life.

   (a) **Carbohydrates** and **fats**- supply the energy needed for living organisms.

   (b) **Proteins** - supply the amino acids necessary to synthesize new proteins needed for metabolism, growth and repair.

   (c) **Vitamins** - serve as coenzymes, which enable enzymes to regulate changes inside the cells.

   (d) **Minerals** - regulate metabolic reactions and to form certain body substances.

   (e) **Water** - forms part of the living protoplasm, acts as solvent in which chemical reactions can take place, and takes part in transport of materials.

   (f) **Fibres** - act as roughage for the body.

Some adverse effects of a diet that is not balanced

1. Obesity - is the result of excess food.

   Carbohydrates and fats taken in excess of immediate requirements are stored as fat in the adipose tissues around organs and under the skin. A person gains weight if more food energy is taken in than is used up each day. He may become overweight and fat (obese) when he has too much fat or too many fat cells especially under his skin.

2. Constipation - is the result of insufficient fibres in the diet.

Fibre consists mostly of cellulose cell wall of plant. Cellulose is indigestible. It passes through the alimentary canal almost unchanged and forms the bulk of the food in the intestine. It stimulates peristalsis, which moves undigested food through the large intestine. Sufficient quantity of fibres in the diet prevents constipation.

Human alimentary canal

Holozoic nutrition - the intake of solid organic food

The body system that is responsible for this function is the **digestive system.** The digestive system consists of the alimentary canal and its associated organs (salivary glands, liver and pancreas).

Alimentary canal - a long muscular tube within the body consists of specialized regions for handling the food that we eat and changing it into a form usable by the cells of the body.

General pattern of animal nutrition

Ingestion → Digestion → Egestion

Ingestion: eating + drinking

Digestion: making food soluble and diffusible

Egestion: eliminating undigested materials

Digestion ↓ Absorption: taking in soluble nutrients

↓ Assimilation: getting nutrients to where they are needed and using them.

Functions of the digestive system

Digestion - food changed into a form that is soluble and can diffuse into body cells.

Chewing - action of the teeth in cutting food into small pieces

Churning - contractions of muscular stomach wall serve to break down food mechanically into smaller particles and mix it with enzymes.

Swallowing - moves food from mouth into oesophagus. It begins as a voluntary act, which merges smoothly into an involuntary reflex.

(a) Food rolled into a **bolus** by the tongue is forced into the back of the mouth (pharynx).

(b) Voluntary contraction of muscles raises the larynx so that the epiglottis folds over the opening of the larynx. This action prevents food from entering the trachea. Breathing is temporarily halted.

(c) The muscles of the pharynx squeeze the bolus into the upper oesophagus. Peristaltic waves caused by the rhythmic contractions of the muscular wall carry the food down the oesophagus into the stomach.

Peristalsis - is alternate waves of contraction and relaxation of the muscular wall of the gut, regulated by the autonomic nervous system. Peristalsis moves food slowly through the alimentary canal.

Contractions of the muscular gut wall increase the efficiency of chemical digestion by

(a) breaking large food particles mechanically into smaller ones,

(b) bringing food into contact with the gut wall, and

(c) mixing food with the secretions of the digestive system

Absorption of food is enhanced when digested products are brought into close contact with the wall of small intestine.

Absorption - diffusion of soluble nutrients (after digestion) through the wall of small intestine into blood and lymph.

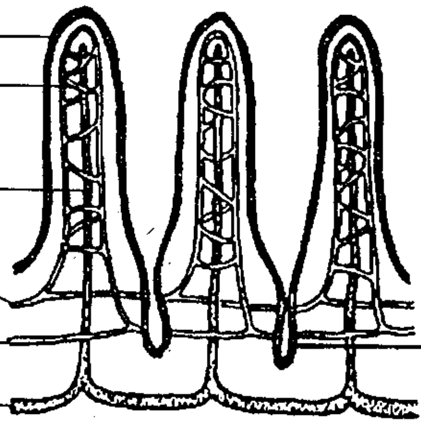


Fig. 6.9 Villi in small intestine

Egestion - the elimination of undigested materials from the gut.

Dentition

Dentition is the number and arrangement of teeth in the skull. Mammals have two sets of teeth; the milk dentition and the permanent dentition, consisting of different types of teeth, such as **incisors, canines, premolars,** and **molars** for particular functions. The initials i., c., pm., and m. in the dental formula refer to incisors, canines, premolars, and molars respectively. The numbers indicate teeth of the upper and lower jaws on one side. Therefore, they are finally doubled to obtain the overall total number of the teeth in the skull.

Function of teeth - to chew food and cut it into tiny pieces.

Chewing increases the surface areas of food. The increased surface area speeds up the action of digestive enzymes and makes digestion more rapid. This is only a mechanical breakdown of food. The food is not changed chemically.

Comparison of the teeth of mammals based on different diet

Tooth	Structure	Function	Omnivore	Carnivore	Herbivore
		Example	Man	Dog	Rabbit
		Dental formula	$i\frac{2}{2}\ c\frac{1}{1}\ pm\frac{2}{2}\ m\frac{3}{3} = 32$	$i\frac{3}{3}\ c\frac{1}{1}\ pm\frac{4}{4}\ m\frac{2}{3} = 42$	$i\frac{2}{1}\ c\frac{0}{0}\ pm\frac{3}{2}\ m\frac{3}{3} = 28$
		Food source	Plant and animal	Animal	Plant
Incisor	At the front of mouth, sharp- edged, single root.	For biting off pieces of food	Chisel-shaped	Sharp, pointed.	Chisel-shaped.
Canine	At either sides of incisors, pointed, single root	For tearing food	About same size as incisors No diastema	Long and pointed No diastema	Absent. Diastema present
Premolar and molar (cheek teeth)	At the back of mouth, with large surface	For crushing and grinding food	Surface with small cusps (points) No carnassial	Surface with sharp pointed edges. Carnassials present.	Surface flattened with ridges of enamel. No carnassial
Teeth of upper and lower jaws			Meet to grind food.	Slice scissor-like, to cut meat.	Meet to grind vegetation.
Root of teeth			Closed	Closed	Open
Lateral movements of lower jaw			Present	Absent	Present

Diastema - gap between incisor and premolar, an adaptation present only in herbivores

Carnassials - are large teeth in carnivores, (last upper premolars and first lower molars), with sharp points and flattened surface, adapted for shearing and chewing food.

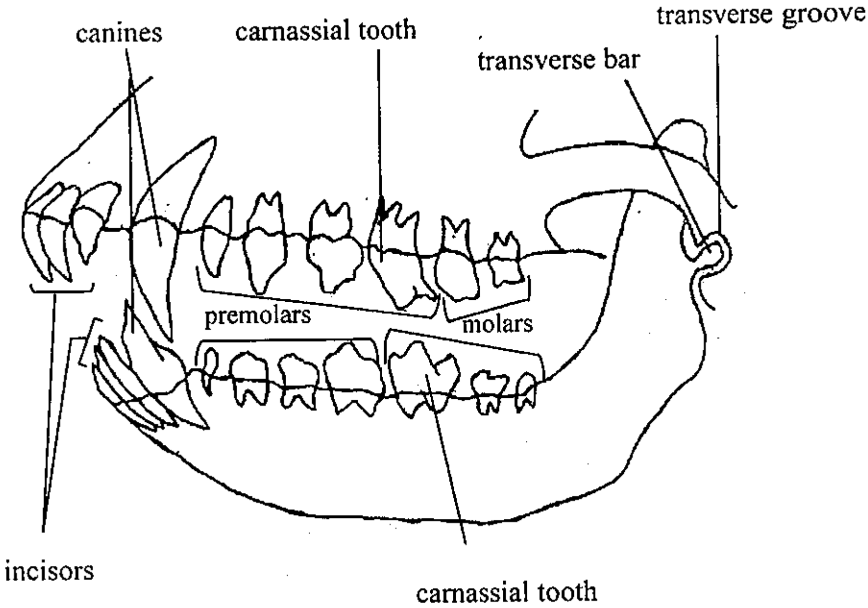


Fig. 6.10 Permanent dentition of carnivorous mammal (dog)

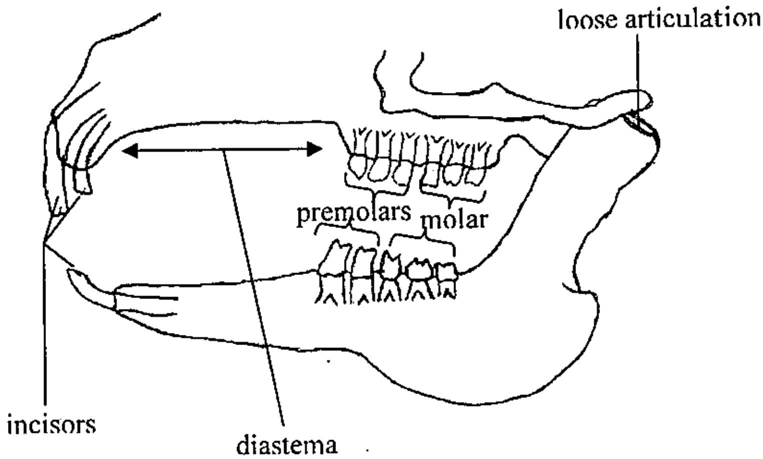


Fig. 6.11 Permanent dentition of herbivorous mammal (rabbit)

Closed root - teeth do not grow once they reach full size; roots receive small blood supply. The root firmly embeds the tooth in the jaw.

Open root- teeth continue to grow to compensate wear from grinding action; roots receive large supply of blood bringing materials needed for replacement.

SUMMARY

Photosynthesis is essential for the continuance of life because it supplies with food and energy for other living organisms.. Green plants alone can photosynthesize due to the presence of chlorophyll spread out on stacks of membranes in the chloroplasts. The equation for photosynthesis shows that organic substance, glucose is converted from inorganic substances. The requirements for the process of photosynthesis can be experimented. A green plant must be destarched by keeping in a dark over 24 hours period before exposing to light prior to the experiment.

The human digestive tract consists of the mouth, pharynx, oesophagus, stomach, small intestine, and large intestine. Only these structures actually contain food, but the salivary glands, liver, and pancreas supply substances that aid in the digestion of food. Finger -like projections (villi) in the walls of the small intestine perform the task of absorption.The teeth types are modified according to the feeding habits.

CHAPTER VII
RESPIRATION

Food contains chemical energy. Respiration is the release of this energy when food, e.g. glucose is broken down in living cells.

Aerobic respiration

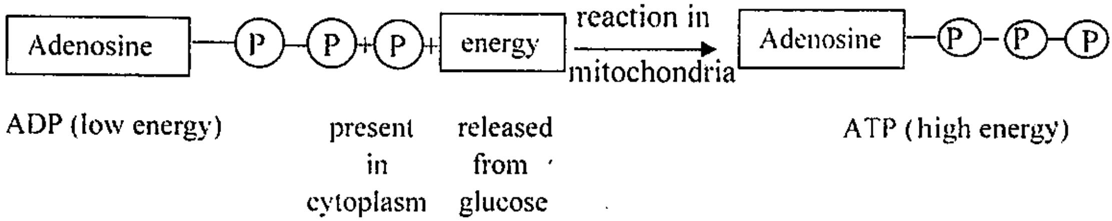
Aerobic respiration is the breakdown of glucose in the presence of oxygen with the release of energy. In this process, the glucose is completely oxidized to carbon dioxide and water, which are released as waste products.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2830kj$$

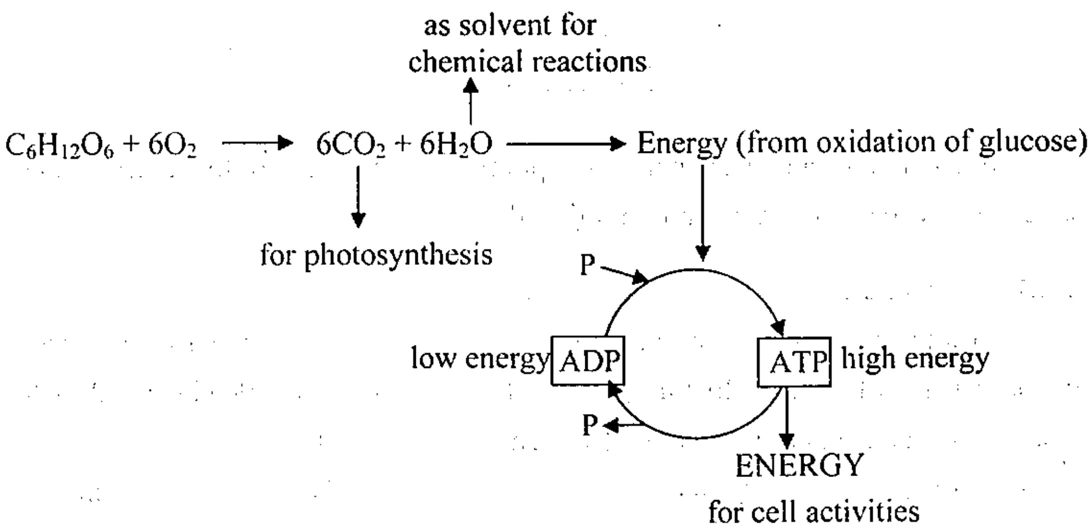
Glucose Oxygen Carbon dioxide water energy

This process is a slow, systematic oxidation, controlled by many enzymes. This slow breakdown is vital because energy release is accompanied by a rise in temperature. The energy produced is not used immediately but stored in the **mitochondria** as a chemical compound called **adenosine triphosphate (ATP),** formed when **adenosine diphosphate (ADP)** is bonded to a phosphate group and absorbs a relatively large amount of energy.

$$ADP + P + energy \longrightarrow ATP$$



The energy released from ATP can be used in different forms for many activities. This is summarized below.



The activities include:
(a) cell division and growth
(b) synthesis of proteins, fats, vitamins etc.
(c) conduction of nerve impulses and muscular movements
(d) maintenance of constant body temperature
(e) active transport

Experiment 1. To demonstrate that carbon dioxide is released during respriration

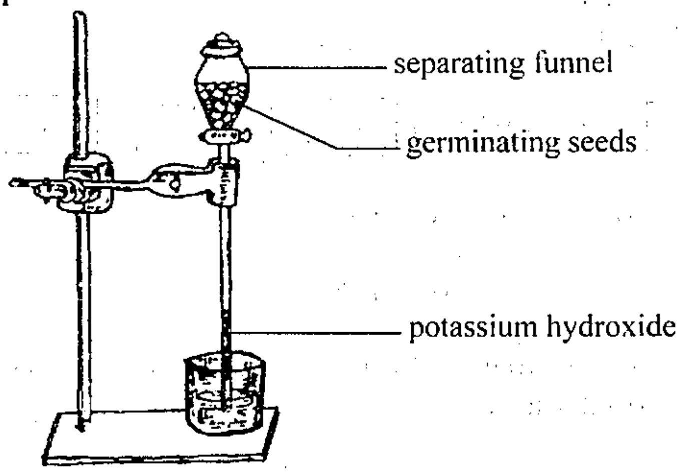


Fig. 7.1 Demonstration of the release of carbon dioxide during respiration

Germinating seeds

About 50 germinating seeds are placed in a separating funnel and the stopper firmly closed. The stopcork of the separating funnel is opened and the stem dipped into a beaker containing a solution of potassium hydroxide. A control experiment is set up with the killed germinating seeds.

Since carbon dioxide is absorbed by potassium hydroxide, a vacuum is formed and the level of solution in the stem of the funnel will rise.

There is no change in the level of potassium hydroxide in the control showing that respiration has not occurred.

Experiment 2.To demonstrate the release of energy in germinating seeds during respiration

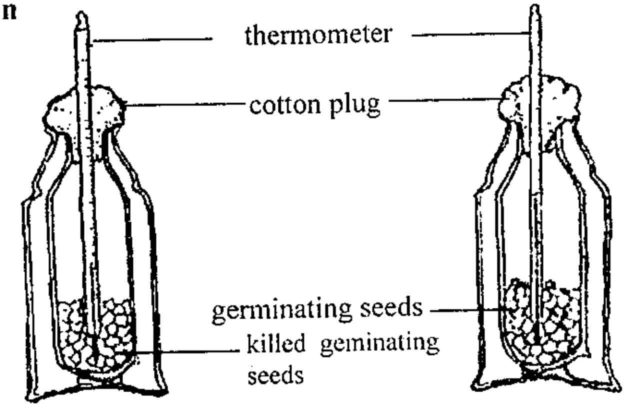


Fig. 7.2 Demonstration of the release of energy during respiration

About 100 pea seeds are soaked in water for 24 hours. Then half of them are killed by soaking in 5 percent formalin.

The seeds are then rinsed in tap water. The living seeds are placed in a vacuum flask and the dead seeds in a similar one. Thermometers are inserted and the mouths of the flasks are plugged with cotton wool.

After a few days, the temperature in the flask with the living seedlings will be higher than in the control, because heat energy is released during respiration of germinating seeds.

Anaerobic respiration

Anaerobic respiration is the breakdown of glucose into energy in the absence of oxygen. In this process, the amount of energy released is relatively small and the type of end products varies.

Yeast respires anaerobically by converting glucose into **ethanol (alcohol)** and carbon dioxide. This process is also termed as **alcohol fermentation**. Like aerobic respiration, the process takes place slowly and in a series of steps.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + 118\ kj$$

Glucose → Ethanol + Carbon dioxide + Energy

Animals including man can also respire anaerobically. During strenuous exercise, oxygen cannot reach the muscles fast enough, so the muscle cells carry out anaerobic respiration. Energy is released when glucose is slowly broken down into a mildly poisonous chemical called **lactic acid**. Accumulation of lactic acid causes **fatigue**. Thus, lactic acid must be broken down further by oxygen into water and carbon dioxide. The amount of oxygen needed to dispose of the lactic acid is termed as **oxygen debt**.

Experiment 3. To demonstrate anaerobic respiration in germinating seeds

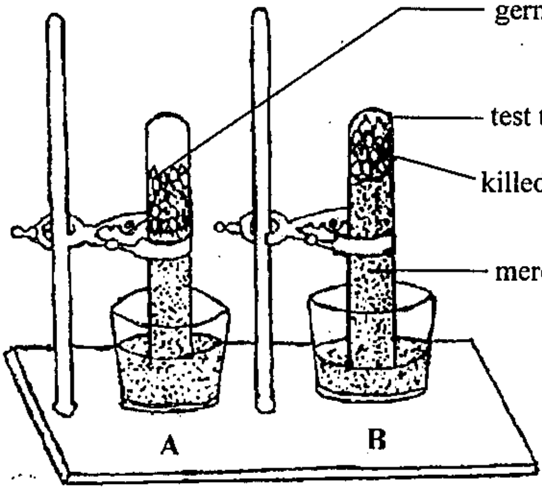


Fig. 7.3 Demonstration of anaerobic respiration

Fill a test tube with mercury and invert it over a glass bowl also containing mercury. Then introduce about 50 germinating seeds through the open end of the test tube. The seeds will rise to the top of the test tube. Killed seedlings are also used as a control.

After a few days, the level of mercury in the test tube falls because of the collection of gas. This gas can be shown to be carbon dioxide by testing with potassium hydroxide or limewater. The level of mercury with killed seedlings is not changed.

Initially the test tube was filled with mercury hence leaving no room for oxygen. The carbon dioxide produced by the seeds must be due to anaerobic respiration.

F-11A

Gaseous exchange in mammals

Function of Lungs

Two stages; **inspiration** and **expiration** occur during the process of gaseous exchange in a mammal. Inspiration is the drawing in of air into the lungs. The lungs expand drawing in air through the glottis. Then, the cavity of the thorax also expands to accommodate the expanded lungs. During this period, the ribs move outward and the diaphragm becomes flattened. These occur due to the contractions of the muscles of the ribs and the diaphragm. The air is driven out of the lungs during expiration. This takes place when the ribs and the diaphragm return to their normal state. The diaphragm is convex towards the thorax when at rest. The muscles of the ribs and diaphragm relax during expiration. Driving the air out, from the lungs is also aided by the contraction of the muscles of the belly. This causes the abdominal viscera to press against the diaphragm from behind.

The presence of a true muscular diaphragm helps the efficiency of ventilation. However, the efficiency is decreased by many problems, for example the dead space of the respiratory system.

The **dead space** can be distinguished into **anatomical** and **physiological** dead spaces. The first includes those parts of the respiratory system not vascularized for taking up oxygen e.g. the mouth, pharynx, trachea, bronchi, and bronchioles. The second is composed of those areas of the lungs, which are insufficiently supplied with blood in relation to ventilation. When standing at rest about 30-50 per cent of the lungs may be insufficiently supplied with blood but during exercise, the physiological dead space is negligible.

Control: Rhythmic discharges of nerve impulses from the respiratory control centres in the medulla oblongata of the hindbrain control the respiratory movements. These impulses travel down the phrenic nerves to the diaphragm and down the intercostals nerves to the intercostal muscles.

At the end of inspiration, when the alveoli are fully stretched, the stretch receptors in the bronchioles send impulses to the respiratory control centres, which cause the respiratory muscles to relax and this leads to expiration.

The rate of respiration depends mainly on the carbon dioxide concentration of the blood, which has a direct effect upon the respiratory centres in the medulla oblongata. For example, after strenuous exercise, carbon dioxide concentration rises and stimulates the medulla, which sends impulses, producing faster breathing movements so that carbon dioxide is removed from the blood more quickly and the blood receives a better oxygen supply.

SUMMARY

Respiration is the release of chemical energy when food is broken down in living cells. Two types of respiration, aerobic (oxygen required) and anaerobic respiration (without oxygen) occur in organisms. Glucose in the presence of oxygen is broken down to carbon dioxide and water with the release of energy during aerobic respiration. Anaerobic respiration on the other hand breaks down glucose in the absence of oxygen into energy. The process of both aerobic and anaerobic respiration is slow series of oxidation controlled by many enzymes. The energy released is in the form of ATP stored in mitochondria. Many activities use the energy released from ATP in different ways. Animals, including man respire anaerobically during strenuous exercise when oxygen cannot reach the muscles fast enough.

Air enters and exits the lungs during the process of breathing by way of respiratory tract in man. The rib cage and diaphragm bounded the chest cavity. Inspiration begins when the breathing centre in the medulla oblongata stimulated by carbon dioxide in the blood, sends nerve impulses to the diaphragm and rib cage. The diaphragm flattened and the rib cage moved outward as the muscles contract allowing sufficient space for the inflated lungs with drawn in air. Nerves within the expanded lungs send messages to the breathing centre, stopping the messages to the breathing muscles. The diaphragm becomes convex and the rib cage resumes its normal position as the muscles relax. This pushes the air out of the lungs during expiration. The belly muscles contract during expiration and aid in pushing the air out of the lungs. Respiratory rate mainly depends on the carbon dioxide concentration of the blood that has a direct effect upon the respiratory centres in the medulla oblongata.

CHAPTER VIII

WATER RELATION

Water is very important to living cells. In fact, water makes up two-thirds or more of living active protoplasm. It is utilized in living organisms for the following purposes:

1. **Solvent:** Water is the universal solvent. All the reactions of metabolism occur in solution. In addition, food, hormones and other substances are transported in solution in either the blood of animals or the sap of plants.
2. **Reactant:** During photosynthesis, water reacts with carbon dioxide. Water is also involved in hydrolytic reactions in which it is used to break down complex substances into simpler ones, e.g. hydrolysis of **sucrose** to **glucose** and **fructose,** and in digestion of food.
3. **Coolant:** Water has a high specific heat and can therefore absorb a lot of heat without much change in temperature. It removes a lot of heat when evaporated, keeping bodies cool, e.g. in sweating and transpiration.
4. **Support:** Aquatic organisms need less strong skeletons than land organisms because **Archimedes force** makes them 'lighter'. Turgor pressure in plant cells supports leaves and herbaceous plant stems. Without turgor pressure, they would wilt.
5. **Lubricant:** Water also acts as a lubricant as in the case of **synovial fluid** in joints, and the **mucus** in guts.

Diffusion

Molecules are constantly in motion because of their kinetic energy.

The random movement takes place until the molecules of the gas or liquid are evenly distributed throughout the space in which they are confined. This molecular movement of gases and liquids, which tends to result in the uniform distribution, is termed as **diffusion**.

Osmosis

Osmosis can be regarded as a special type of diffusion in which water diffuses from a weaker to a stronger solution through a semipermeable membrane. A weak solution of a salt will contain less salt and more water than a strong solution. If these solutions are in contact, the water molecules will diffuse one way and the salt molecules the other until both are uniformly distributed. However, if a membrane, which allows water but not salt to pass through, separates the two solutions only water can diffuse. This type of membrane is said to be **'semipermeable'** and the movement of water through it is termed as **osmosis**. Thus, osmosis may be defined as the diffusion of water through a semipermeable membrane from a weak solution into a strong one.

Experiment 1. Demonstration of osmosis

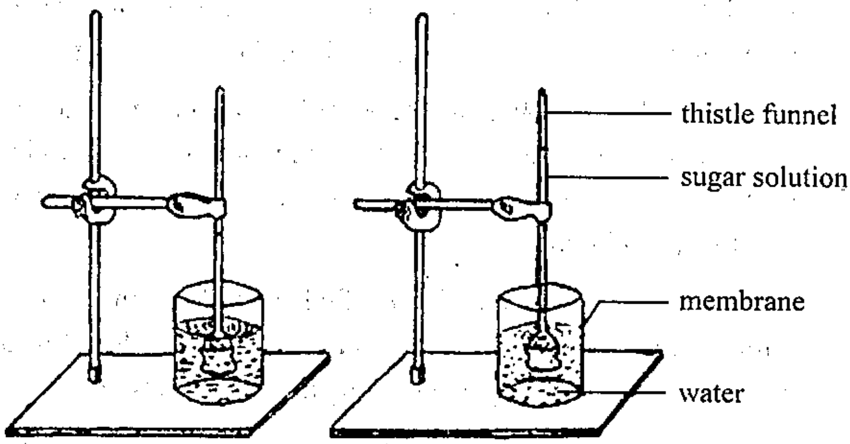


Fig. 8.1 Demonstration of osmosis

A thistle funnel with a long narrow stem is closed at the mouth with animal bladder, and filled to the neck with a strong sugar solution. The funnel is then lowered, stem upwards, into a beaker of water.

After some time, the level of liquid in the stem rises. This rise is due to the passage of water through the animal bladder (the semipermeable membrane) into the sugar solution, increasing its volume and forcing it up the stem. This rise of water is due to osmosis.

Transport in Plants

Absorption of water and mineral salts by the plant

In land plants, water is mostly absorbed through permeable part of the root. Root hairs increase the surface area for absorption.

The absorption of water from the soil by the root can be done by osmosis. The cells of the root contain relatively concentrated solution compared with water in the soil. Water, therefore, enters the cells including the root hairs. The solution inside these cells then becomes more dilute than that of cells situated nearer to the central part of the root. The result causes water to be drawn towards the central vascular bundle.

It is not clear yet how mineral salts move into the root. The absorption of mineral salts may take place partly by diffusion or by 'active transport' using energy, released by respiration.

Transpiration

Plants absorb a large quantity of water from the soil, but only a fraction of this is retained in the plant body for synthetic processes. A large part of the water absorbed is lost in the form of water vapour by a process known as transpiration. Most of the loss takes place through the leaves but evaporation also occurs from the stem and other aerial organs.

Benefits of transpiration

(a) Transpiration pull

Transpiration of water from the leaf results in the drop of turgor pressure and rise in the concentration of their cell sap, which consequently produces an increase in water potential. Cells in this condition will absorb water from neighbouring cells and eventually from the xylem vessels in the leaf. Loss of water from the xylem vessels produces a tension, and this tension draws water up the vessels of the stem from the roots. This flow of water is termed the transpiration stream and is dependent on the rate of transpiration from the leaves. The forces which pull this stream of water from the roots to the leaves is termed as the **transpiration pull**.

To demonstrate transpiration pull

A thistle funnel is filled with water and rubber stopper attaches a leafy twig to it. The bottom of the funnel is immersed in a bowl of mercury.

After some time the level of mercury in the thistle funnel rises. Loss of water from the twig (i.e transpiration) produces a vacuum in the thistle funnel and water will be drawn up. This in turn produces a vacuum at the bottom of the funnel, which is then filled by the rising mercury.

This rise of water and mercury is due to transpiration pull.

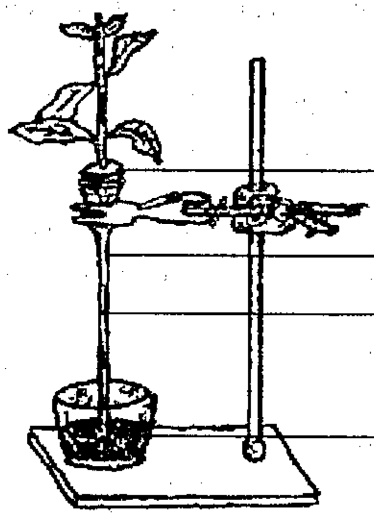


Fig. 8.2 Demonstration of transpiration pull

(b) Transport of salts

The transpiration stream also carries mineral salts from the roots to the leaves. Although salts may be carried along with the transpiration stream, the rate of uptake of these solutes from the soil does not depend on the rate of transpiration.

(c) Cooling

The effect of evaporation of water from the leaf surface is to absorb latent heat from the leaf tissues, and this in turn would cool the leaf. This cooling effect is of value in keeping the temperature of a leaf below harmful level in the direct rays of the sun.

Translocation

Translocation is the movement of dissolved substances through a plant. In general, water and dissolved salts from the soil travel upwards through the vessels of the xylem and food synthesized in the leaves passes downwards or upwards in the sieve tubes of the phloem.

When leaves photosynthesize, they produce carbohydrates. These carbohydrates are transported out of the leaf in the form of glucose or sucrose to the stem. Once in the stem, it may travel upwards to actively growing regions or maturing fruits and seeds or downwards to the roots and underground storage organs. Both upward and downward movements may take place at the same time in the phloem.

Transport in Animals

In small invertebrates, such as the protozoans and coelenterates and in some larger ones with flat bodies e.g. Platyhelminthes, there is a large surface area to volume ratio. In such cases, not all parts of the body are too far away from the surface at which the exchange of materials with the environment occurs. Therefore, diffusion is sufficient for internal transport of materials throughout the body. In larger invertebrates and vertebrates that have small surface area to volume ratio, diffusion is no longer sufficient. Instead, mechanical pumping of blood and body fluids specialized as transporting media is found. The contraction of contractile vessels or true-chambered hearts of a tubular circulatory system that flows in one direction move the blood in them.

Structure and Function of Blood Components

Blood is a fluid tissue composed of fluid plasma and cells suspended in it.

Plasma is a pale straw-coloured fluid consisting approximately of 90 percent water and 10 percent materials in solution and in suspension. Plasma proteins are responsible for maintaining **viscosity** of the blood. They include **serum albumin, serum globulins** and **fibrinogen**. Plasma calcium is bound to serum albumin. Some serum globulins are antibodies while some carry hormones and vitamins. Fibrinogen is important in clotting of the blood. Many dissolved materials are part of the plasma and others are transported materials, e.g. food such as **glucose, amino acids** and **fatty acids,** mineral salts such as **bicarbonates,** excretory materials such as **urea,** and gases such as **oxygen, carbon dioxide** and **nitrogen**.

Cells in the blood are of three types: **erythrocytes, leucocytes** and **thrombocytes**.

In many **erythrocytes** (red blood corpuscles or RBCs) are biconcave circular discs without nuclei. They are formed in the red bone marrow especially at the upper end of the femur and in the ribs and vertebrae. They contain haemoglobin, which combines with oxygen in the lungs to form oxyhaemoglobin. The later is carried around in the corpuscles to the tissues, where oxygen is released.

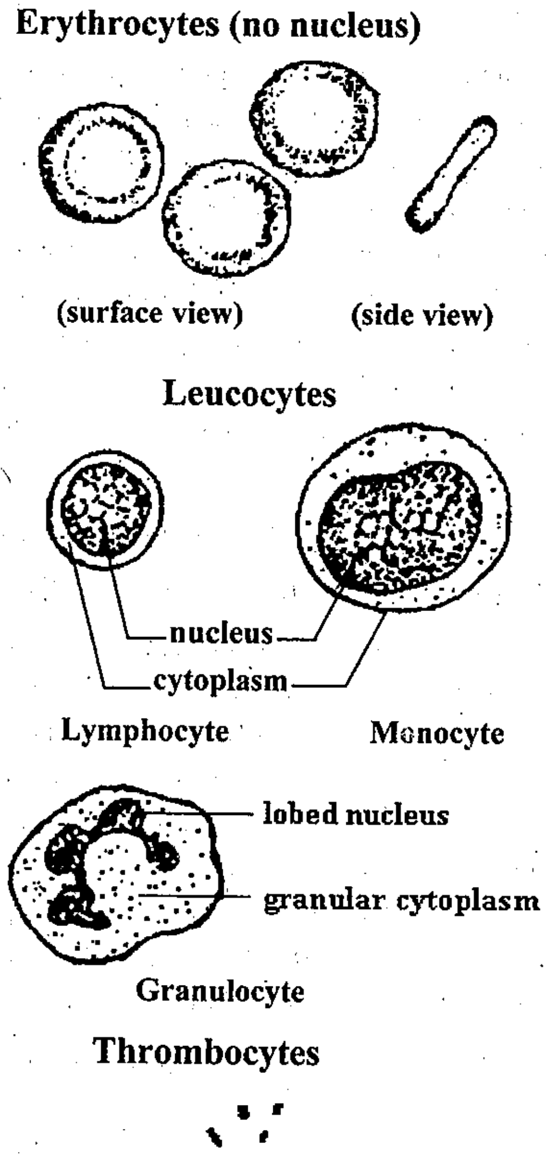


Fig. 8.3 Blood cells

Leucocytes (white blood corpuscles or WBCs) are of several types all with nuclei. Three main types are **lymphocytes, monocytes** and **granulocytes.** Each **lymphocyte** has a single large round nucleus with a thin rim of clear cytoplasm. The **lymphocytes** are formed in lymphoid tissue, spleen, thymus, and lymph glands. They are non- motile and concerned in the formation of antibodies. **Monocytes** are with a single large round nucleus with much cytoplasm. They are formed in the spleen, red bone marrow and are motile and phagocytic. **Granulocytes** are amoeboid in shape with an irregularly lobed nucleus and granular cytoplasm. They can leave blood vessels and enter tissues, defend against infection and remove foreign matter.

Thrombocytes (platelets) are small, non-nucleated, and formed in the red bone marrow. They provide the substance needed for the clotting of blood.

The Lymph System

The lymph system deals with **lymph,** which is the blood tissue fluid that enters the **lymph capillaries.** The lymph capillaries closed at one end join with the larger tube called the **lymphatics** at the other end. Lymphatics collect and pass on lymph to two main lymphatic ducts, each in turn returning the lymph into the jugular vein of its side.

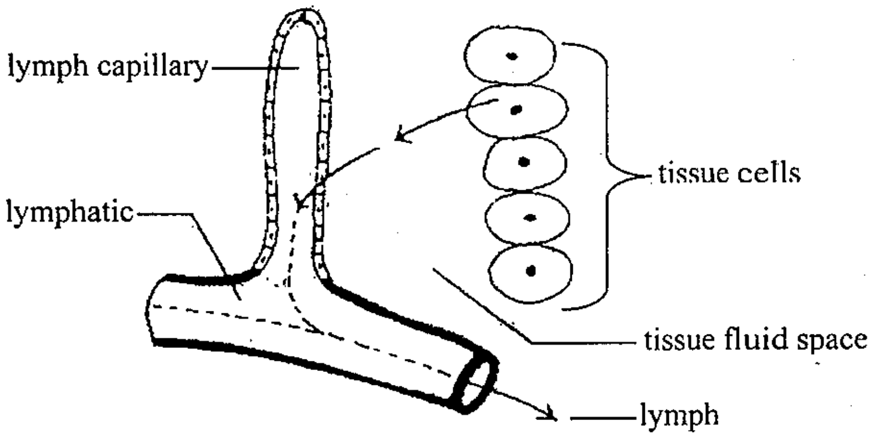


Fig. 8.4 Lymph formation

Lymphatics are similar to most veins in many ways. They have thin walls with valves and carry deoxygenated fluid towards the heart, the flow of the fluid being steady and a low pressure.

Lymphatics are unlike veins in having swellings, the lymph nodes, which are glandular in function. Each node is made up of connective tissues and cells, and produces leucocytes.

The lymph system has many functions. It returns blood plasma, which has passed out from the blood capillaries, to the blood stream, and produces certain white blood corpuscles, that defend against infections. Digested fatty materials absorbed by lacteals in the villi of the small intestine are collected by the lymph system. It removes excretory materials produced by the tissue cells and distributes secretions of gland cells. The hormone, **thyroxine,** is carried in the lymph vessels in preference to the blood capillaries.

SUMMARY

Water, vital in living cells make up two-thirds or more of living active protoplasm. All reactions of metabolism occur in solution. The purposes of water in living organisms as solvent, reactant, coolant, support, and lubricant are briefly explained with examples. Osmosis, a special type of diffusion performs the process of transport. Water diffuses from a weaker to a stronger solution through semipermeable membrane. The experiment to demonstrate the process of osmosis is given to better understand the process of osmosis. The cells of the root contain relatively concentrated solution compared with water in the soil. Absorption of water in land plants is through permeable part of the root. The process of osmosis performs absorption. The absorbed water in the root is distributed to the remaining parts of the plant. Xylem takes part in the transport of water and minerals.

Diffusion is sufficient to transport the materials throughout the body, in small invertebrates with large surface area to volume ratio. Diffusion is no longer sufficient in larger invertebrates and vertebrates with small surface area to volume ratio. Transporting media like circulatory system and lymphatic system thus become essential. Structure and function of blood components and lymph system with its functions given in this chapter will serve as basic knowledge for advanced studies.

CHAPTER IX

CO-ORDINATION

Organisms must be aware of their surroundings and respond to them, where necessary to keep alive. Organisms respond to stimuli. Plants respond to light gravity, touch, and water. Animals respond to these as well as temperature, chemicals in air (smells or tastes) and sound.

Sensory cells receive information both from an organism's external and internal environments. Messages resulting from information are of two types: (a) chemical messages carried by hormones in both animals and plants (b) electrical messages carried along nerves and found in animals only.

Plants respond to these messages by special growth, e.g. tropisms, flowering or by inhibiting growth, e.g. dormancy of seed and leaf shedding. Animals respond by movement or secretion of hormones from glands. Each response to a stimulus, unless coordinated with others, would lead to chaos.

Plant hormones

There are three main hormones known to occur naturally and to be essential for the normal development of plants. These are **auxin, gibberellin** and **cytokinin.** Two other compounds are **ethylene** and **abscissic acid** (abscissin). Others that have been suggested are **florigen,** the "flowering hormones", and **traumatin,** the "wound hormone".

Auxin

The chief growth hormone of plants is **auxin.** Chemically this hormone is **indole acetic acid (IAA).** Actively growing regions of a plant usually produce the largest amounts of auxins. The regions rich in auxins are the meristems, including shoot tips, root tips, and cambia, and young leaves, developing flowers and fruits. In such regions, auxins bring about an elongation of the individual cells.

Gibberellin

A fungus (*Gibberella fujikuroi)* parasitic on rice causes rice plants to grow tall with long yellowish leaves, to flower early, and to produce a small crop.

Cytokinin

Its main effect is in increasing the rate of cell division, but it also has important interactions with auxin in the growth and development of plants. /

Abscissin

Abscissin is similar in structure to vitamin A. It is generally antagonistic to gibberellins and cytokinins, inhibiting stem elongation, germination of seeds, and the sprouting of buds. It is also involved in leaf abscission.

Ethylene

Ethylene is synthesized mainly where there are high levels of auxin. It is important in the ripening of fruits and there is a short rise in its production in ripening fruits. It also triggers the synthesis of enzymes involved in abscission and thus hastens the process.

Motion responses

Tropisms are growth movements brought about directly by external stimuli. Tropisms may be distinguished based on the growth-inducing stimuli: light-induced phototropism, gravity-induced geotropism, contact-induced thigmotropism, chemically induced chemotropism, and water-induced hydrotropism. The response may be positive or negative, that is a plant part may grow towards or away from the stimulus. The bending of the plant towards or away from the stimulus is caused by an unequal distribution of auxins in the zones of elongation.

Phototropism

If a shoot is illuminated from one side, it curves towards the light source. This movement is termed as **phototropism.** Since shoots curve towards light, they are positively phototropic. Generally roots are negatively phototropic, i.e. they grow away from the light.

Geotropism

Primary roots are positively geotropic, lateral roots grow at right angles to gravity, and tertiary roots are insensitive to gravity. Main stems are negatively geotropic, while lateral branches grow at an angle to gravity. Modified stems such as rhizomes and runners grow at right angles to gravity.

The nervous system

The nervous system of mammals consists of:

(i) the **central nervous system** – made up of the **brain** and **spinal cord,** and

(ii) a series of **nerves** to link the system to all parts of the body.

Neurones

Neurones are nerve cells, which conduct nerve impulses from one part of the body to another. A typical neurone consists of the following two main parts.

(a) A **cell body** - contains a nucleus surrounded by cytoplasm with many cytoplasmic extensions called **dendrites.**

(b) An **axon** - a long thread-like fibre insulated by a layer of fat, the **myelin sheath.**

A **nerve** is made up of a bundle of axons, surrounded by a protective sheath.

A synapse is the junction between two neurones.

There are three types of neurones:

(i) The **sensory neurones** conduct impulses from the sense organs to the central nervous system.

(ii) The **motor neurones** conduct impulses from the central nervous system to the **effector organs,** which are the muscles and the glands.

(iii) The **intermediate** or **associate neurones** link the sensory and the motor neurones. They usually lie inside the central nervous system.

Reflex action

A **reflex action** is an automatic and immediate response to a stimulus without any conscious control, e.g. blinking. The route by which impulses travel in the nervous system brings about reflex arc.

A **reflex arc** involves three neurones - the sensory, the intermediate and the motor as follows.

1. The **receptor organ** (or any sensory organ) receives the stimulus and generates an impulse.
2. The **sensory nerve fibre** carries this impulse to the dorsal side of the spinal cord.
3. The **intermediate nerve fibre carries** the impulse from the dorsal to the ventral part of the spinal cord.
4. This impulse picked up by an outgoing **motor nerve fibre** is carried to the **effector** (muscles or glands).
5. The **effector** then responds.

The eye

Each eyeball is roughly spherical and is held in place in a socket in the **skull** by six muscles. These muscles can also move the eyeball in its socket. A thin membrane, the conjunctiva, covers the transparent front part of the eye.

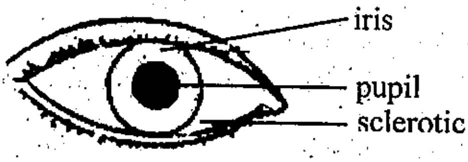


Fig 9.1 Front view of the eye

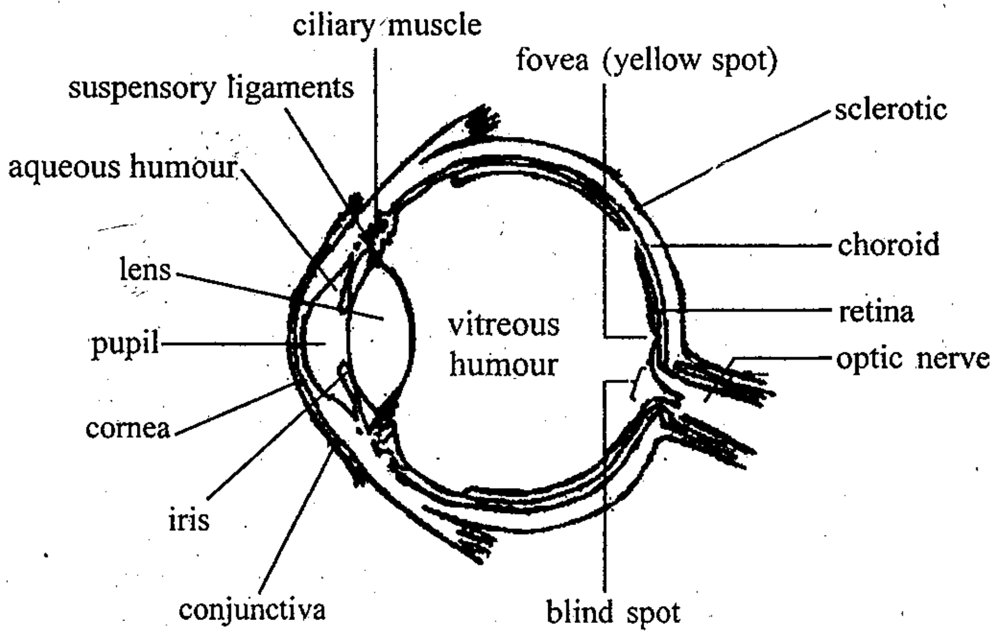


Fig. 9.2 The internal structure of the eye

Summarized internal structure of the eye

Parts	Function
Conjunctiva	Allows light to pass through; protects against entry of foreign particles
Cornea	For the refraction of light
Sclerotic	Protects the inner parts; gives shape to the eye
Choroid	Contains a network of capillaries to nourish the eye, pigmented to prevent reflection of light
Retina	To perceive light rays through receptors called **cones** and **rods**, cones work best under high light intensity and are sensitive to colour, rods work even in dim light and is unable to distinguish colour

Parts	Function
Iris	Controls the size of the pupil, thus controlling the amount of light entering the eye
Lens	To focus light rays onto the retina
Suspensory ligaments	To hold the lens in position
Ciliary muscles	To control the curvature of the lens
Aqueous humour	To maintain the shape of the eyeball and refract light rays
Vitreous humor	To maintain the shape of the eyeball and refract light rays
Yellow spot	Images can be seen most clearly because it contains mainly cones
Blind spot	The point where nerve fibres lead to optic nerve
Optic nerve	To transmit impulses from the sensory cells in the retina to the brain

The skin

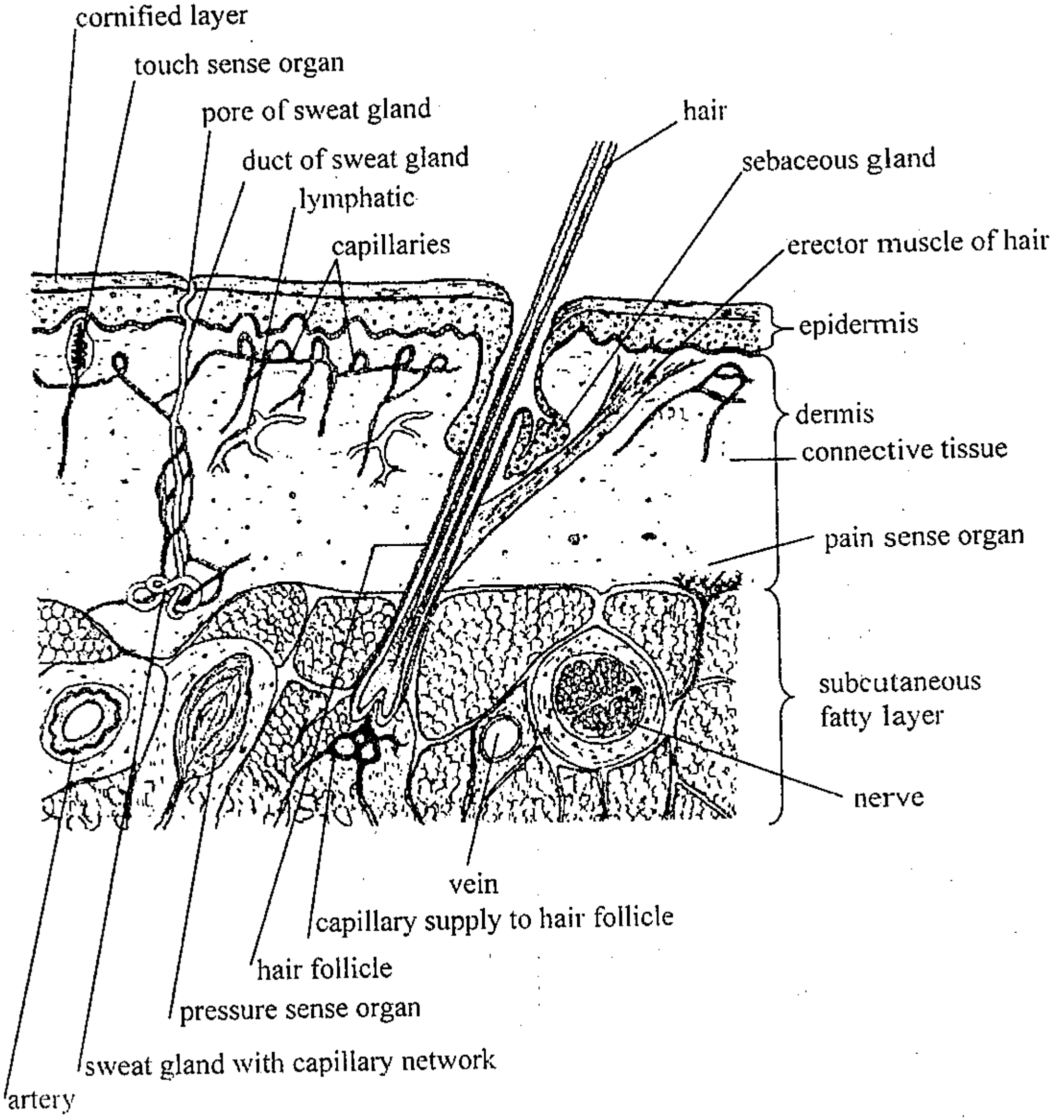


Fig. 9.3 Vertical section through human skin

Summarized account of the human skin

Structure	Function
1. **Epidermis** (a) **Horny layer** - made up of dead cells.	Makes the skin waterproof, protective against mechanical injury and entry of germs
(b) **Malpighian layer** - made up of living cells and pigmented with **melanin.**	Produces new cells, pigment melanin prevents entry of harmful ultra-violet rays
2. **Dermis** (a) **Hair** - made up of dead cells and projects from the **hair follicle.**	In fur-bearing animals, it traps air in order to form an insulating layer when cold.
(b) **Erector muscle** - attached to the base of each hair	Contracts to make hair stand upright
(c) **Sebaceous gland** - opens into the hair follicle.	Secretes **sebum** (oil) for waterproofing skin and keeping hair supple
(d) **Sweat glands** - surrounded by blood capillaries and connected to sweat pores by sweat ducts	Secrete sweat. When sweat evaporates, it cools the body.
(e) **Sense organs** - receptors connected to nerve fibres	Detect sensation of touch, pain, temperature changes etc.
(f) **Nerve fibres** - lead to and from the brain	Carry impulses from the sense organs to the central nervous system (brain and spinal cord)
(g) **Blood vessels** - with network of superficial capillaries	Dilate or constrict, to supply more or less blood to the capillaries in the skin for body temperature control.
(h) **Fat layer** - layers of fat cells found at the base of the dermis	Provides insulation against cold

Groups of muscles: Muscles of the limbs are numerous and complex. However, they can be divided according to their functions into seven groups as follows:

1. **Protractor muscles**, pull the limbs forwards.
2. **Retractor muscles**, pull the limbs backwards.
3. **Adductor muscles**, pull the limbs inwards towards the body.
4. **Abductor muscles**, pull the limbs outwards away from the body.

5. **Rotators,** swivel the whole, or part of the limb at one of its joints.
6. **Flexors**, pull two parts of the limb towards each other.
7. **Extensors,** pull two parts of the limb away from each other.

From the above groups it is quite clear that most muscles are paired, one for producing movement in one direction and the other for the opposite movement. Such pairs are termed as **antagonistic muscle**. Thus, protractors are antagonistic to retractors, adductors to abductors and flexors to extensors.

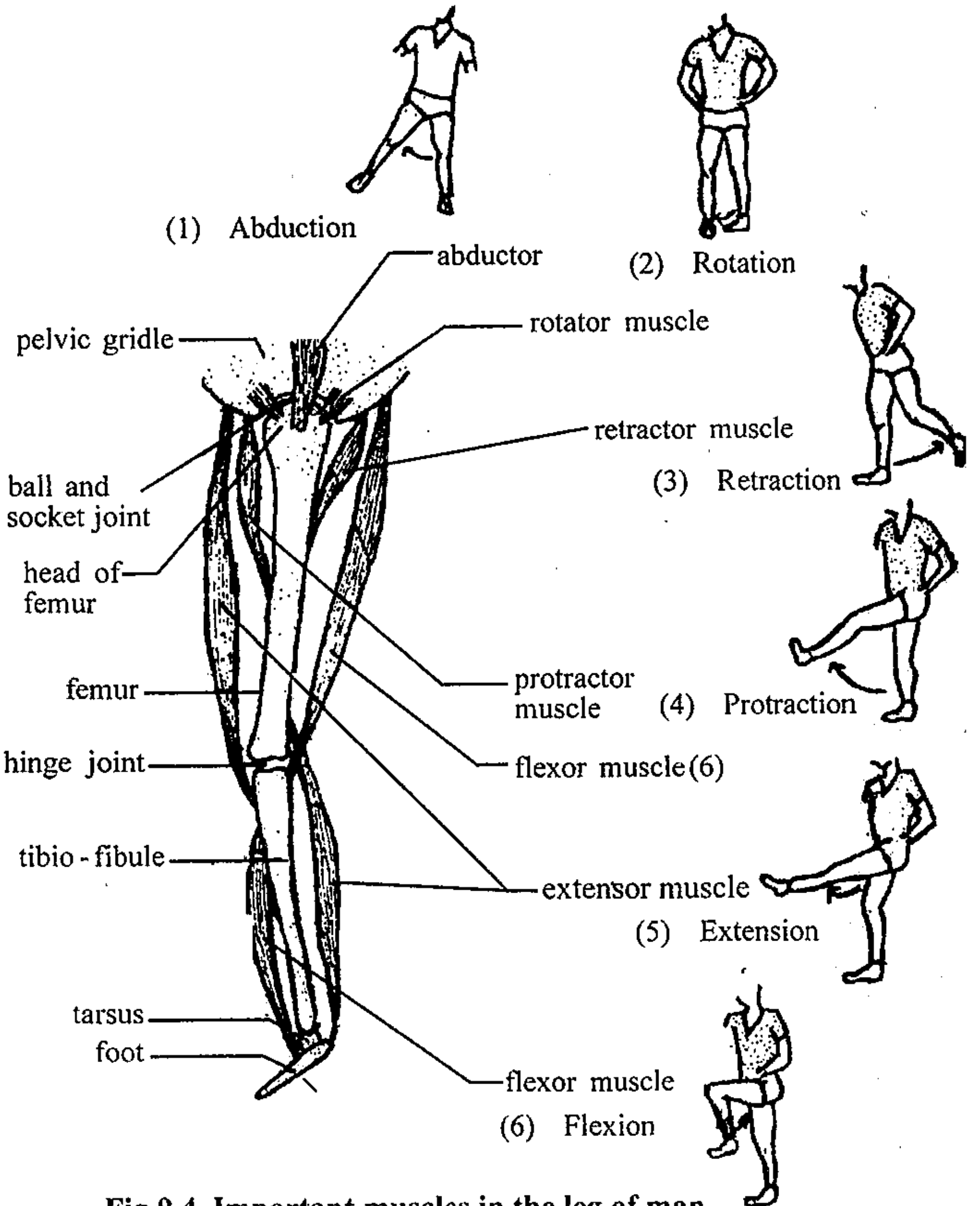


Fig 9.4 Important muscles in the leg of man

Endocrine glands in mammals

1. Hormones are chemical substances produced in minute quantities by certain parts of the body and transported to other parts where they exert a profound effect on development, structure, and behaviour.

Endocrine organs (ductless glands) secrete hormones directly into the blood stream, which then distributes them throughout the body.

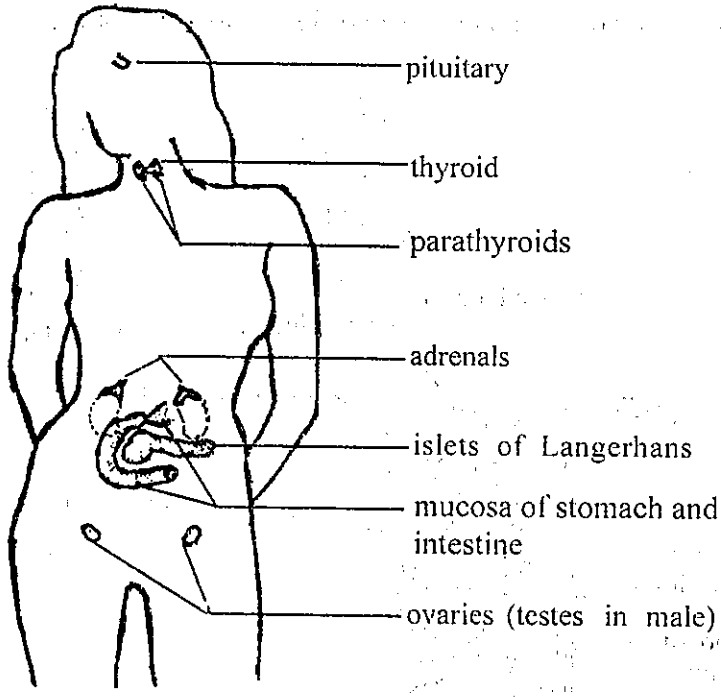


Fig 9.5 Major endocrine glands in mammals

Endo-crine organ	Hormone produced	Cause of secretion	Effect(s)	Effect of lack of secretion
Thyroid gland	Thyroxine	Hormone from pituitary gland	Regulates metabolic rate of body ensuring normal growth and mental development	Severe deficiency leads to cretinism in children, in adults, goiter develops, low metabolic rate, sluggish activity, fat
Adrenal medulla	Adrenaline	Fear, anger anxiety	Increases rate of heart beat, rise in blood pressure, glycogen converted to glucose, blood sent to muscles	
Pancreas (Islets of Langerhans)	Insulin	Rise in blood sugar level	Converts glucose to glycogen for storage in liver and muscles	Blood sugar level increases, some eventually lost in urine-diabetes mellitus; glycogen reserves drop; weakness, loss of weight occurs

SUMMARY

Organisms respond to stimuli from the surroundings to keep themselves alive. Sensory cells in both plants and animals receive the information from internal and external environments. Hormones in both animals and plants carry chemical messages. The main hormones that occur naturally in plants are auxin (chief growth hormone), gibberellin (fungus), and cytokinin (concerned with cell division) Compounds and other suggested hormones of plants are mentioned. Growth movements (tropisms) bring about motion responses in plants directly by external stimuli.

The central nervous system consists of the spinal cord and the brain. The peripheral nervous system contains cranial and spinal nerves, which contains the long fibres of sensory and/or motor neurones. The anatomical unit of the nervous system is the neurones in human. Three types of neurones are sensory, motor, and intermediate or associate neurones. Each of these is made up of a cell body, an axon, and dendrites. Cell bodies are found primarily in the central nervous system, but they are also found in ganglia. Axon and dendrites make up nerves that project from the brain and spinal cord. The nerve impulse is the same in all neurones. A simple reflex action requires the use of neurones that make up a reflex arc. A sensory neurone conducts impulse from a receptor to an intermediate neurone, which in turn transmits

the impulse to motor neurone, which conducts it to the effector. Reflexes are automatic and some do not require involvement of the brain. Nerves have long fibres surrounded by a myelin sheath.

The structures and functions of the parts of the sense organ (human eye), human skin, and limb muscles involved in the process of co-ordination are given in summarized form for easy understanding and learning.

Endocrine organs (ductless glands) secrete hormones directly into the blood stream. Blood distributes the hormones throughout the body. Well-noted hormones insulin, adrenaline, and thyroxine are summarized to give foundation for advanced studies.

CHAPTER X

REPRODUCTION

Plants and animals can reproduce both asexually, without the need for gametes, or sexually, which does require gametes.

Asexual reproduction in plants

Asexual reproduction, also known as **vegetative propagation**, is common in plants. In vegetative propagation, a portion of one plant gives rise to a completely new plant. Both plants now have identical genes. As an example, some plants have above- ground horizontal stems, called runners, and others have underground stems, called rhizomes, that produce new plants. Strawberry plants grow from the nodes of runners and gingers grown from the nodes of rhizomes. Potatoes can be propagated in a similar manner. Potatoes are actually portions of underground stems, and each eye is a node that will produce a new potato plant.

Asexual reproduction has a great deal of commercial importance. Once a plant variety with desired characteristics has been developed through vegetative propagation, new plants can be supplied to gardeners and farmers. Cuttings can be taken from the plant, and the cut end can be treated to encourage it to grow roots or a cutting can be grafted to the stem of a plant that has a root. Budding is a form of grafting most often used commercially. In this procedure, just the axillary buds are grafted onto the stem of another plant.

Sexual reproduction in plants

There is a megaspore mother cell in each ovule found in the ovary. The megaspore mother cell undergoes meiosis to give one functional megaspore that undergoes mitosis. The result is megagametophyte, which gives rise to the female gametophyte generation containing an egg cell. The anther contains microspore mother cells that undergo meiosis to give four functional microspores. Following mitosis, each is a pollen grain containing two cells. At about the time of pollination, one of these cells divides to give two sperms that travel down a pollen tube to the ovule. During double fertilization, one sperm nucleus joins with the egg nucleus and the other joins with two polar nuclei. The ovule now matures and becomes a seed that contains an embryonic plant and stored food. The seed shown here is a dicot seed with two large cotyledons.

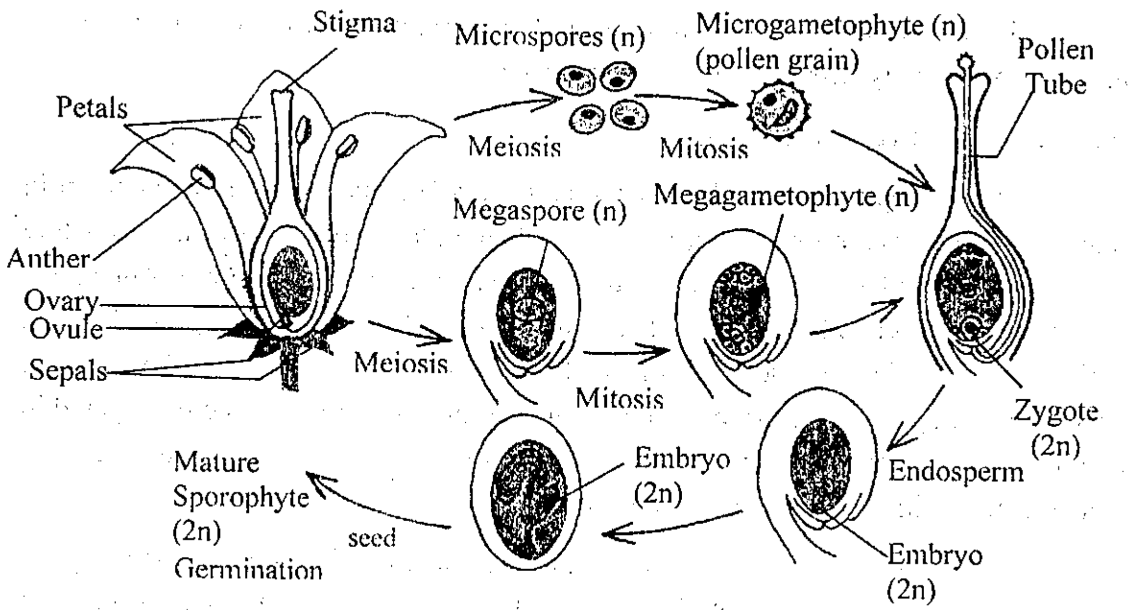


Fig. 10.1 Events leading to fertilization and seed formation in a flowering plant

Asexual reproduction in animals

Animals reproduce asexually by **fission** (binary and multiple fission), **budding** (new individual arises as an outgrowth from the older animal) and **fragmentation** (an individual breaking into two or more parts, each capable of growing to be a complete animal).

Sexual reproduction in man

Male reproductive system

The important structures and functions of the **male reproductive system** are given below.

Testes- produce sperms from their coiled tubes and male sex hormone at puberty.

Scrotum - is a sac in which a testis is located. It is suspended outside the main body cavity where sperm production is more rapid due to the cooler condition.

Epididymis - stores up mature sperms temporarily.

Sperm duct - conveys the sperms to the urethra.

Urethra - leads the sperms to the outside through the penis.

Penis - introduce the sperms into the vagina of the female during mating.

Seminal vesicle and prostate gland - produce a fluid to nourish the sperms and help them to swim vigorously. This fluid together with the sperms is termed as the semen.

Female reproductive system

The important structures and functions of the **female reproductive system** are as given below.

Ovaries - produce eggs or ova at puberty and female sex hormones.

Oviduct - leads mature eggs to the uterus, the region where fertilization of eggs by sperms takes place.

Uterus (womb)- for the attachment and development of the embryo

Cervix - connects the uterus to the vagina.

Vagina - receives sperms during mating, a birth canal for the baby.

Ovulation and sperm production

The ovaries of the female produce eggs. Sperms are made in the testes of the male.

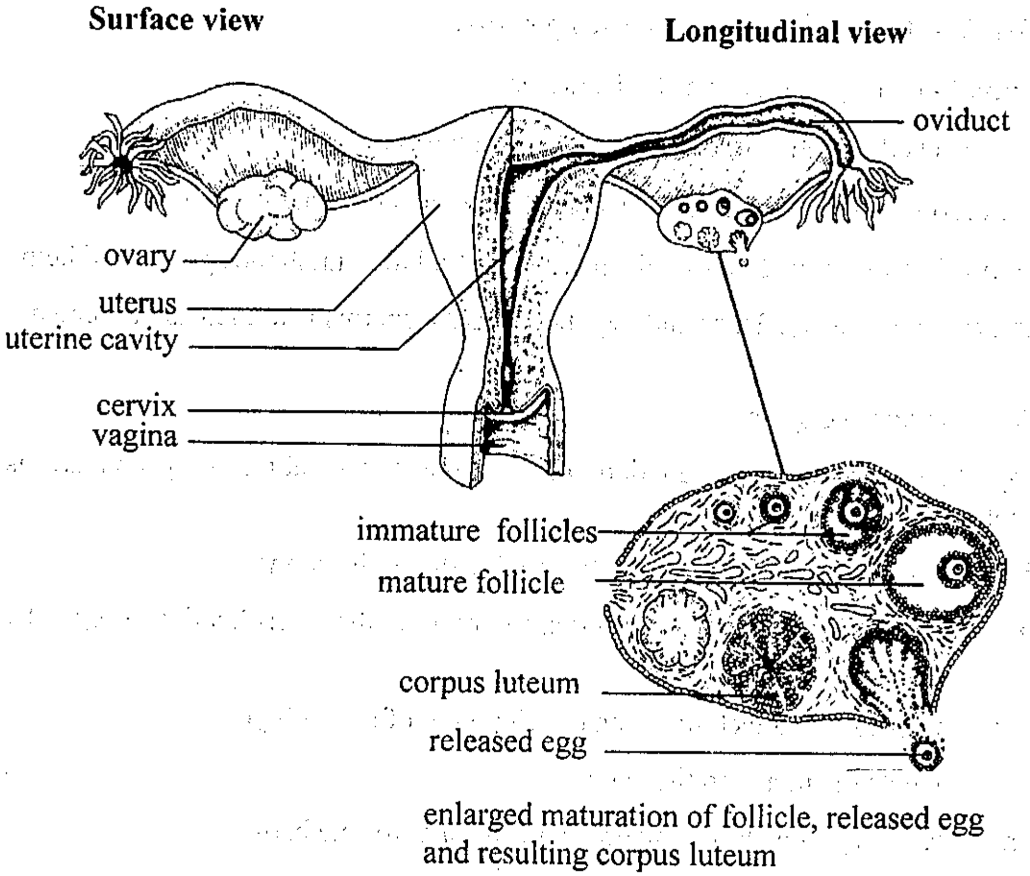


Fig. 10.2 Reproductive organs of female (front view)

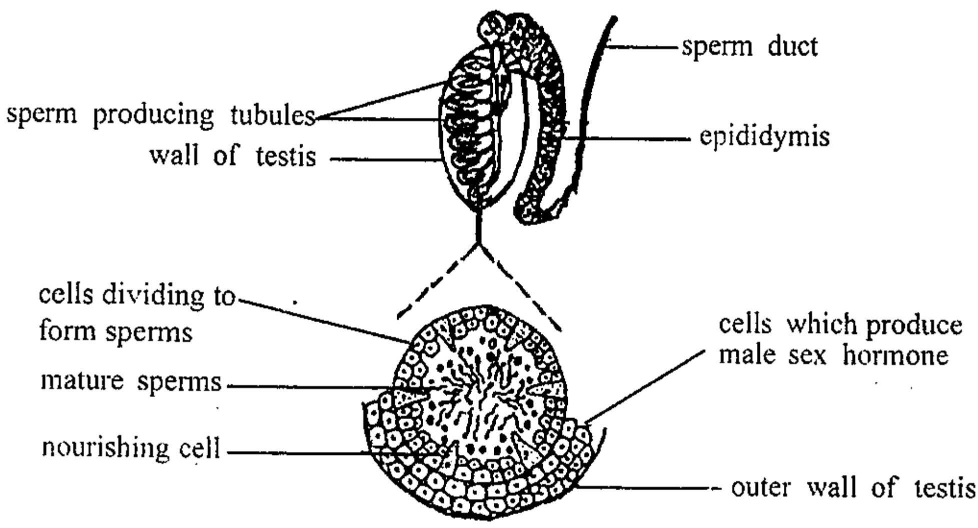


Fig. 10.3 L. S. of a mammalian testis

Comparison of eggs and sperms

(a) **Structure** - the egg is round with a nucleus in the middle. A thin membrane and a jelly coat surround it. The sperm is divided into a head, middle piece and a long tail. The nucleus is in the head. The nuclei of both egg and sperm contain thread-like structures called **chromosomes** in which are the parent's hereditary characteristics.

(b) **Numbers produced** - usually one egg is released once in about 28 days while millions of sperms are produced at each ejaculation during mating.

(c) **Size** - the egg is about 40 times bigger than the sperm.

(d) **Activity**- the sperms are very mobile and active, swimming vigorously towards the egg in order to fertilize it. The egg, however, does not move very much. Both eggs and sperms are termed as gametes.

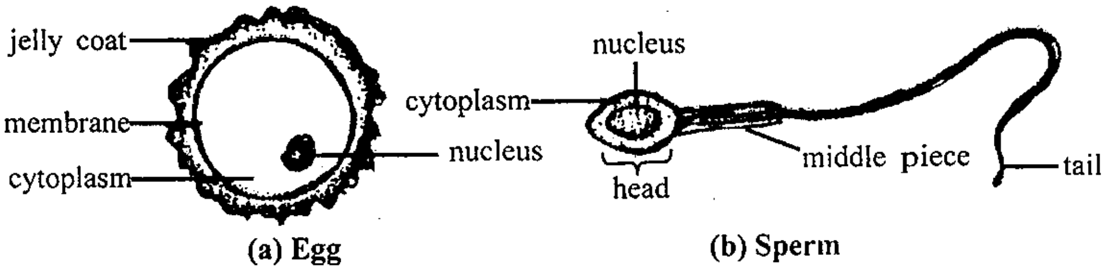


Fig. 10.4 Egg and Sperm

Fertilization

Immediately after **mating** or **copulation**, the sperms swim up the uterus through the mucus lining to the fallopian tubes. If there is an egg, one of the sperms may fuse with it to form a **zygote**. The process in which an egg unites with a sperm is termed as **fertilization**.

Implantation

The zygote divides continuously into a ball of cells called **embryo**. The embryo moves towards the uterus, becomes attached to the wall and is surrounded by the uterus lining. This process is termed **implantation**.

Gestation period

The period between fertilization and birth is called **gestation period**, and it takes about nine months in man. During this period, the following new structures are developed to keep the embryo alive and healthy.

Placenta - has numerous finger-like villi made up partly of embryonic tissue and partly of uterine wall (maternal tissue). The villi consist of maternal and embryonic capillary systems which are very closely associated, allowing easy diffusion of oxygen, nutrients and antibodies to the embryo and metabolic wastes from the embryo. The placenta also secretes hormones.

Umbilical cord - connects the embryo's body to the placenta. The two umbilical arteries and one umbilical vein, which are the first embryonic structures to develop, are found here. The arteries carry deoxygenated blood and excretory waste from the embryo to the placenta. The vein carries oxygenated blood and dissolved nutrients from the placenta to the embryo.

Amnion - a sac-like membrane around the embryo, filled with a watery fluid called amniotic fluid.

Amniotic fluid - allows the embryo freedom of movement during growth and cushions it against knocks and mechanical injury.

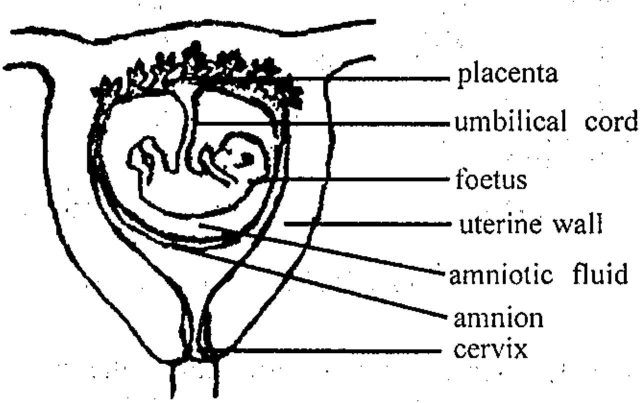


Fig. 10.5 Developing foetus in human uterus

Birth

The embryo eventually develops into a **foetus,** with recognizable human features. At the end of gestation period, the muscular uterine walls begin to contract occasionally at first, becoming more powerful and frequent. This is termed as **labour**. The amnion bursts and the amniotic fluid is discharged. The cervix opens, and the foetal head followed by its body passes through the vagina, then out of the mother's body. The umbilical cord is tied and cut; and the scar forms the **navel**.

The placenta, the rest of the umbilical cord and the amnion are all discharged as **after birth**.

The baby is now an independent organism, inflating its lungs for the first time, followed soon afterwards by the working of its digestive system, excretory system etc.

Lactation and maternal care

Lactation is the process of producing milk by the **mammary glands.** Mother's milk is definitely the best compared with bottle- feeding for the following reasons.

1. It contains all the constituents of a balanced diet.
2. It contains antibodies to fight certain diseases.
3. Breast-feeding ensures close contact between mother and baby, and maternal care.
4. It is much cheaper too.

Menstrual cycle

Ovulation occurs once in about every 28 days. If the egg is not fertilized within 36 hours, it dies and the uterus lining breaks down slowly. The dead egg together with the uterus lining, mucus and some blood are discharged through the vagina. This period of bleeding is termed as **menstruation**. Menstruation ceases once a woman is pregnant until after the baby is born.

SUMMARY

Asexual reproduction (gametes not required) and sexual reproduction (gametes required) occur in both plants and animals. Asexual reproduction in plants is commonly termed as vegetative propagation. Asexual reproduction takes place in runners, rhizomes, and tubers. Asexual reproduction in plants is of commercial value since the process of grafting can develop a plant variety of desired characteristics. Budding is a form of grafting most often used commercially. The axillary buds are grafted onto the stem of another plant in the procedure of budding. Sexual reproduction in plants is performed by the microspore mother cells in the anther (male) and megaspore mother cell in the ovule of the ovary (female) by undergoing meiosis and mitosis. The microspore mother cells produce four functional microspores after meiosis. The produced functional microspore undergoes mitosis to form a pollen grain with two cells. One of the cells divides to give two sperms about the time of pollination. One functional megaspore formed after meiosis from the megaspore mother cell in the ovule undergoes mitosis to produce an egg cell. Sexual reproduction takes place by the fusion of the sperm and the egg cell in the ovule.

Asexual reproduction in animals takes place by fission, budding, and fragmentation. This type of reproduction usually takes place in invertebrates. Sexual reproduction portrays the process that occurs in man. The important structures and functions of male and female reproductive systems are given in simplified form for easy learning. The production of sperms and egg together with respective functions are also presented. Simplified presentation of reproductive process starting from fertilization up to birth is given to give foundation for advanced studies. Mother's milk the best source to nourish the young is emphasized.

CHAPTER XI

INHERITANCE

Nucleus

The nucleus is the largest organelle within the cell. A double-layered membrane, called the nuclear envelope, encloses it. There are pores, or openings, in this envelope through which large molecules pass from the nucleoplasm, the fluid portion of the nucleus, to the cytoplasm. The nucleus is of primary importance in the cell because it is the control centre influencing the metabolic functioning of the cell and ultimately determines the cell's characteristics.

Within the nucleus, there are masses of threads called chromatin. It is indistinct in the nondividing cell, but it condenses to rod-like structures called chromosomes at the time of cell division. Chemical analysis shows that chromatin, and thus chromosomes, contain deoxyribonucleic acid (DNA) along with certain proteins and some ribonucleic acid (RNA). It is now known that DNA with the help of RNA, controls proteins synthesis within the cytoplasm and that is the function that allows DNA to control the cell.

Cell division

Cell division consists of four stages, **prophase, metaphase, anaphase,** and **telophase**. The cell cycle includes an additional stage termed **interphase**. During interphase, DNA replication causes each chromosome to have sister chromatids. These same stages take place in animal and plant cells, but there are no centrioles or asters (although there is a spindle) in higher plant cells, and division of the cytoplasm takes place by formation of a cell plate instead of by furrowing, as in animal cells.

Two types of cell division are recognized according to the behaviour of the chromosomes. In the first of these, the daughter cells contain exactly the same number of chromosomes as the parent cell. This is termed as **mitotic cell division** (or just mitosis) and is the type of cell division, which takes place during an organism's growth. In the other type of division, known as **meiotic cell division** (or meiosis) the daughter cells finish up with half the total number of chromosomes present in the parent cell. This kind of division generally takes place in the formation of **gametes**.

A cell normally contains two of each type of chromosome, the **diploid** condition. Mitosis preserves this condition. Meiosis, however, results in the daughter cells containing only one of each type of chromosome, the **haploid** condition.

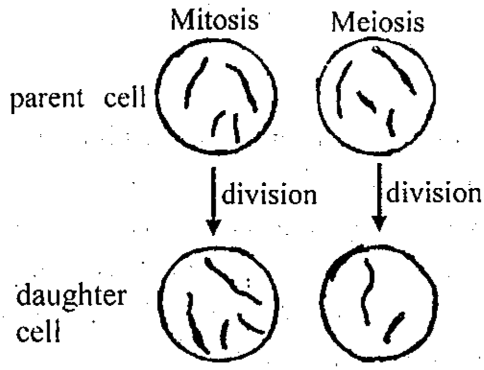


Fig. 11.1 Mitosis and Meiosis (simplified)

Importance of Mitosis

Mitosis assures that each daughter cell receives the same number and kinds of chromosomes as the mother cell, and thus mitosis assures that each daughter cell is genetically identical to the mother cell. Mitosis is important to the growth and repair of multicellular organism.

Importance of Meiosis

Meiosis is nature's way of keeping the chromosome number constant from generation to generation. In animals, it occurs prior to maturation of the egg and sperm. In higher plants, it occurs when spores are formed.

Stages of mitosis

Stage	Events
Prophase	Replication has occured and each chromosome is composed of a pair of sister chromatids
Metaphase	Chromatid pairs (dyads) are at the equator of the cell
Anaphase	Chromatids separate and each one is now termed a chromosome
Telophase	At each pole there is a diploid number of chromosomes, the same number and kinds of chromosomes as the mother cell

Mitosis versus meiosis

Cell type	Cell division	Description	Result
Somatic or body cells	Mitosis	2n(diploid) → 2n(diploid)	More body cell = growth
Germ cells	Meiosis	2n(diploid) → n(haploid)	Gamete or sex cell production

Genetics

Genetics is the branch of biology concerned with heredity and variation.

Variation - difference in a particular feature in a group of related animals or plants is termed as variation.

(a) **Continuous variation** - no clear cut distinction between the different traits of a characteristic, e.g. height, weight, intelligence, skin colour, number of seeds in a pod etc.

(b) **Discontinuous variation** - a clear cut distinction between two traits, e.g. eye and skin colour (pigmented or non-pigmented), left- handed / right-handed, ability/inability to roll the tongue etc.

Genes - the hereditary units which are transmitted from one generation to the next (inherited) are called genes.

Phenotype – the physical appearance of a hereditary characteristic of an organism as opposed to its genotype, its genetic make up, eg. red-flowered and white-flowered plants.

Genotype – the genetic constitution of an organism, e.g. the genotype of a red-flowered plant can either be **RR** (homozygous dominant) or **Rr** (heterozygous). The genotype of a white-flowered plant is **rr** (homozygous recessive), white allele being recessive to red. A recessive characteristic can appear only if the genotype is homozygous.

Chromosomes - the DNA, in conjunction with a protein matrix, forms nucleoprotein and becomes organized into structures with distinctive staining properties called chromosomes found in the nucleus of the cell.

Homologous chromosomes - two chromosomes, which are identical in shape and size are termed as homologous chromosomes.

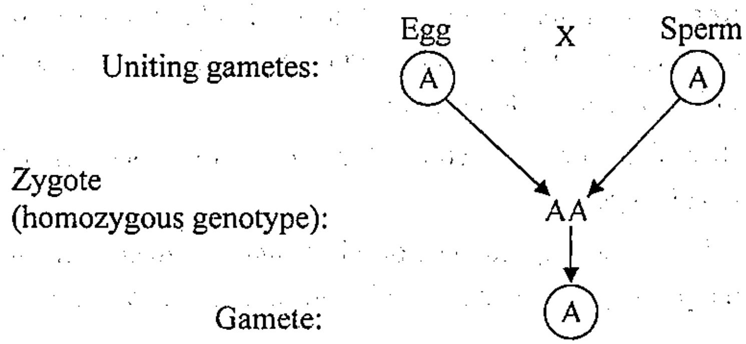
Deoxyribonucleic acid - DNA is normally a stable molecule with the capacity for self-replication.

Mutation - On rare occasions, a change may occur spontaneously in some part of DNA. This change, called a mutation, alters the coded instructions and may result in a defective protein or in the cessation of protein synthesis. The net result of a mutation is often seen as a change in the physical appearance of the individual or a change in some other measurable attribute of the organism called a character or trait.

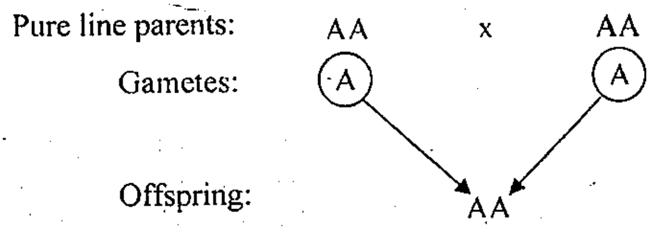
Alleles - through the process of mutation, a gene may be changed into two or more alternative forms called allelomorphs or alleles.

Gene locus - each gene occupies a specific position on a chromosome, called the gene locus (plural, loci). All allelic forms of a gene therefore are found at corresponding positions on genetically similar (homologous) chromosomes.

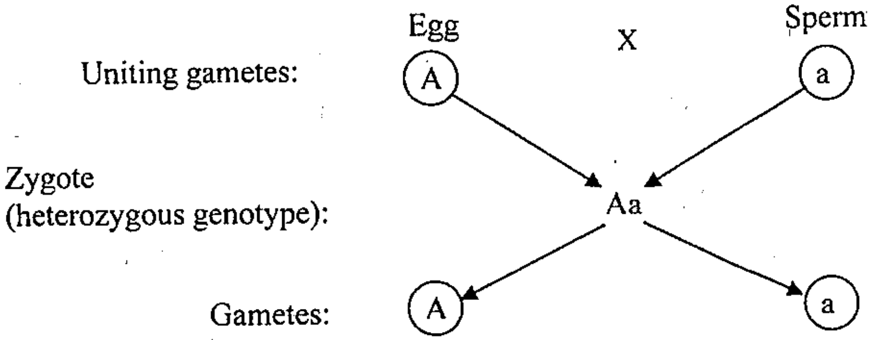
(a) **Homozygous genotype** - the union of gametes carrying identical alleles produced a homozygous genotype. A homozygote produces only one kind of gamete.



(b) **Pure Line** - a group of individuals with similar genetic background (breeding) is often referred to as a line, strain, variety, or breed. Mating between the homozygous individuals of a pure line produce only homozygous like the parents.



(c) **Heterozygous genotype** - the union of gametes carrying different alleles produces a heterozygous genotype. Heterozygote produces different kinds of gametes.



(d) **Hybrid** - the term hybrid is synonymous with the heterozygous condition.

Monohybrid inheritance - refers to the inheritance of one characteristic, e.g. length of stem (tall or short pea plant), colour of flowers (red or white petals).

Gregor mendel's rules of genetics

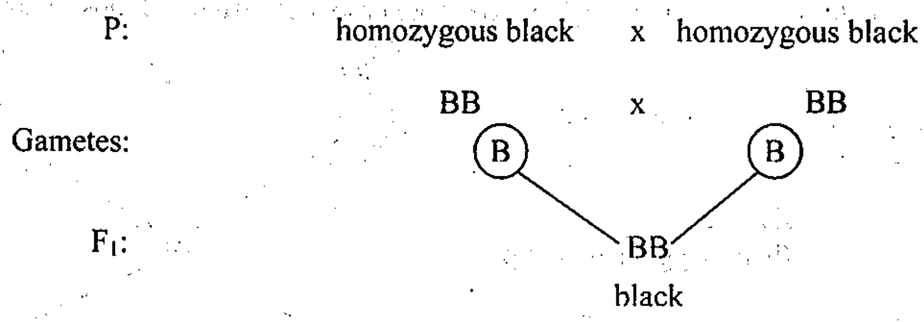
1. Hereditary characteristics are transmitted from one generation to the next by genes.
2. These genes normally occur in pairs, one of which may be dominant.
3. The paired genes separate during meiosis so that there is only one gene in each gamete. At fertilization, the genes pair up again in the zygote.
4. In a pair of genes if one is dominant, then the dominant gene will show its effect.
5. For a recessive gene to show its effect, the genotype must be a double recessive, e.g. red flowers are dominant over white. Thus for the recessive gene to show its effect the genotype for white flowers should be **rr**.

SINGLE GENE (MONOFACTORIAL) CROSSES

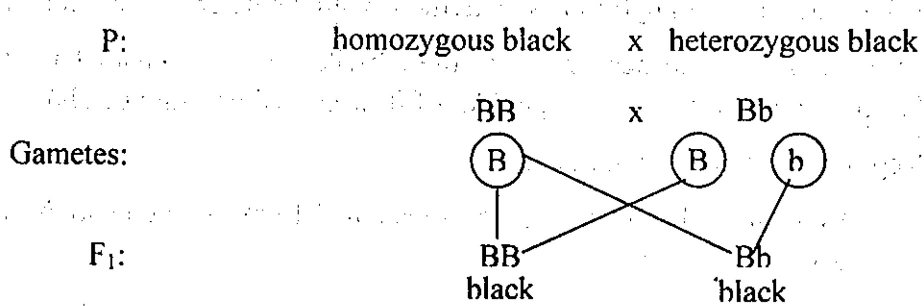
1. The Six Basic Types of Matings

A pair of alleles governs pelage color in the guinea pig; a dominant allele **B** produces black and its recessive allele **b** produces white. There are six types of mating possible among the three genotypes. The parental generation is symbolized P and the first filial generation of offspring is symbolized F_1.

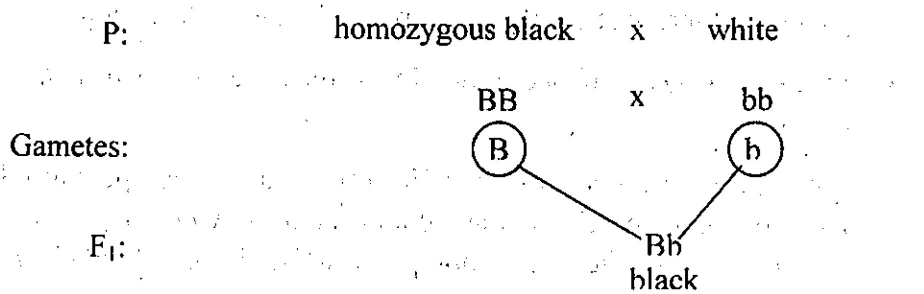
1.



2.



3.



4. P: heterozygous black x heterozygous black

Bb x Bb

Gametes: (B) (b) (B) (b)

F_1: BB Bb Bb bb

black black black white

5. P: heterozygous black x white

Bb x bb

Gametes: (B) (b) (b)

F_1: Bb bb

black white

6. P: white x white

bb x bb

Gametes: (b) (b)

F_1: bb

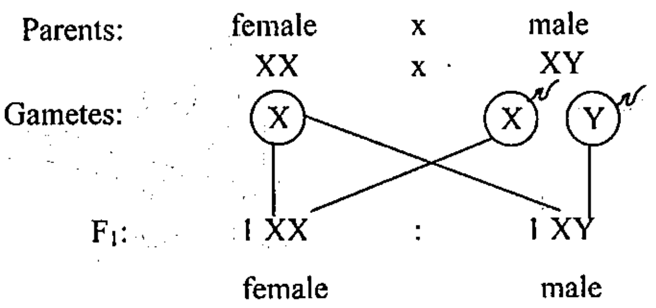
white

Sex Chromosome Mechanisms

Heterogametic Males

In man, and apparently in all other mammals, the presence of the **Y** chromosome may determine a tendency to maleness. Normal males are chromosomally **XY** and females are **XX**. This produces a **1:1** sex ratio in each generation. Since the male produces two kinds of gametes as far as the sex chromosomes are concerned, he is said to be the heterogametic sex. The female, producing only one kind of gamete is the homogametic sex. This mode of sex determination is commonly referred to as the **XY** method.

XY Method of Sex Determination



Selection

Variation, differences in certain features between individuals of a species may arise in the following ways.

1. Sexual reproduction (recombination of genes)
2. **Crossing-over** may occur during Prophase I of meiosis. Homologous chromosomes may twist around each other, break off, and thus change the position of the genes.
3. Fertilization is at random, thus the genes are recombined
4. Chromosome or gene **mutation**
5. Environment (not inherited)

With genetic variation, some individuals are better adapted to their environment than others are; they continue to exist, multiply in larger number, and pass on this useful adaptation to their offspring. The weaker ones may die before being able to reproduce. This **'survival of the fittest'** is said to be the mechanism for **evolution** in which nature selects the fittest and strongest individuals, in a given environment.

In **artificial selection,** however, man does the selection. Man has succeeded in breeding animals and plants with certain qualities, which would enable them to mature early, produce higher yield (e.g. milk or eggs) or produce new varieties of crops of economic value.

SUMMARY

The nucleus is a large centrally located organelle of primary importance since it controls the rest of the cell. Within the nucleus lies chromatin material that condenses to become chromosomes during cell division. Chromosomes contain DNA. The life cycle of organisms requires two types of cell divisions: mitosis and meiosis. Mitosis is responsible for growth and repair, while meiosis is required for gamete production. Cell division includes four stages: prophase, metaphase, anaphase, and telophase. The cell cycle includes an additional stage termed interphase. During interphase, DNA replication causes each chromosome to have sister chromatids. These same stages take place in animal and plant cells, but there are no centrioles or asters (although there is a spindle) in higher plant cells, and division of the cytoplasm take place by formation of a cell plate instead of by furrowing as in animal cells.

Mitosis will assures that each body cell (somatic cell) will have full diploid (2N), number of chromosomes and will be genetically identical to the mother cell. Meiosis involves two cell divisions. During meiosis I, homologous chromosomes come to lie side by side during synapsis. Chromatids making up the resulting tetrad exchange chromosome pieces: this is termed as crossing over. When the homologous chromosomes separate during meiosis I, each daughter cell receives one from each pair of chromosomes. Separation of sister chromatids during meiosis II then produces four daughter cells, each with the haploid number of chromosomes.

A consideration of gene inheritance involves a study of how individual genes are inherited. Mendel concluded that there is a pair of factors (alleles) for every trait in all body cells and that one allele may be dominant over the other. According to his law of segregation, there is one allele for every trait in the sex cells, and according to the law of independent, assortment, every possible combination of alleles (on separate chromosome) may occur in the gametes.

Certain terminology and conventions are used to indicate the genotype and the gametes of the individuals. The same alphabetic letter is used for both dominant and recessive alleles: a capital letter indicates the dominant and the small letter indicates the recessive. A homozygous dominant individual is indicated by two capital letters. and two small letters indicate a homozygous recessive individual. A capital and a small letter indicate a heterozygous individual. A heterozygous genotype produces two kinds of gametes while homozygous genotype produces only one type of gamete. The genotype of the offspring is formed by the combination of the gametes.

CHATER XII

ENVIRONMENTAL BIOLOGY

Environmental Biology

Organisms exist in almost every possible environment. There are algae that grow only in melting snow. Many animals and plants spend their lives in lightless caves. Some algae and bacteria live in hot springs.

Habitat - the places where organisms live are termed as habitats.

Ecology - the study of the interactions of organisms among themselves and with the physical environment is termed as ecology.

Ecosystem - the total of all the organisms and their interactions with each other and their nonliving environment is termed as an ecosystem.

Producers - the green plants in all ecosystems that produce their own food are termed as producers. They are the food source, directly or indirectly, for all animals.

Consumers - the animals that cannot manufacture their own food, dependent on the food sources from producers are consumers.

(a) **Primary consumers** - animals that feed on plant materials **(herbivores)** are termed as primary consumers.

(b) **Secondary consumers** - animals that feed on herbivores **(carnivores)** are termed as secondary consumers.

(c) **Tertiary consumers** - animals that feed on carnivores are termed as tertiary consumers.

(d) **Omnivores** - animals that feed on both plants and animals are termed as omnivores.

(e) **Decomposers** - organisms that feed on dead organic materials are termed as decomposers that break down the waste products and dead organisms into molecular forms.

Abiotic or Physical Factors of an Ecosystem

Each ecosystem has a particular set of abiotic or physical factors. These influence the biotic or biological factors that exist in that ecosystem. Some well-known abiotic factors are **light, temperature, water,** and **soil.**

Plants and animals adapted to their particular environments have structural and or behavioural adaptations to withstand the physical conditions of their respective environments. The lives of the organisms are disturbed when changes occur in the physical conditions of their environments.

The Biologic Environment and Interrelations of Organisms

All animals and plants live in interdependence, occupy various environments sharing living space and shelter and available food.

Symbiosis

Symbiotic relationships are close relationships between two different species.

Types of symbiotic relationships

1. Parasitism

This type of relationship benefits one party but harms the other, i.e. parasitism benefits the parasite but harms the host. The parasite derives nourishment from the host. Usually, however, the host is larger than the parasite and the parasite does not kill the host. Parasite species occur in both plants and animals. They can reduce the size of a host population that lacks a suitable defense. Parasitism can therefore be one of the factors for controlling population size.

2. Commensalism

In a commensal relationship, only one species benefits while the other is neither benefited nor harmed. Often the host species provides a home and or transportation for the benefited species.

Examples

The backs of whales and the shells of horseshoe crabs, provide as both a home and transportation for the attached barnacles.

F-17A

Epiphytes, such as orchids, grow in the branches of trees, where they can receive light, but they take no nourishment from the trees. The roots of the orchids obtain nutrients and water from the air.

3. Mutualism

Mutualism is a symbiotic relationship in which both members of the association benefit. Mutualistic relationships often help organisms obtain food or avoid from enemies.

Examples

Protozoans that inhabit the intestinal tract of termites digest cellulose, which termites cannot.

Fungi and usually cyanobacteria (also called blue-green algae, photosynthetic prokaryotes that contain chrolophyll and release oxygen) live together as **lichens** (fungi and algae coexisting in a mutualistic relationship). Lichens grow on rocks. The fungi provide moisture and dissolve minerals from the rock. The cyanobacteria carry on photosynthesis and return carbohydrates to the fungi.

Cycles in an Ecosystem

Living organisms are composed chiefly of **carbon, hydrogen, oxygen,** and **nitrogen.** In the balance of nature, the flow of these four elements, as they cycle through living organisms, is especially important. Lives of organisms are also influenced by water. Therefore, water, nitrogen, and carbon cycles are included in this section.

The Water Cycle

The group of repeated changes that water molecules undergo in the atmosphere is the **water cycle**. It includes **evaporation, condensation,** and **precipitation**. Rainwater undergoes several physical changes. Some evaporates into the air to form water vapour. Some travels from place to place and finally enters a lake or river. Nevertheless, water from a lake or river surface also evaporates into the atmosphere.

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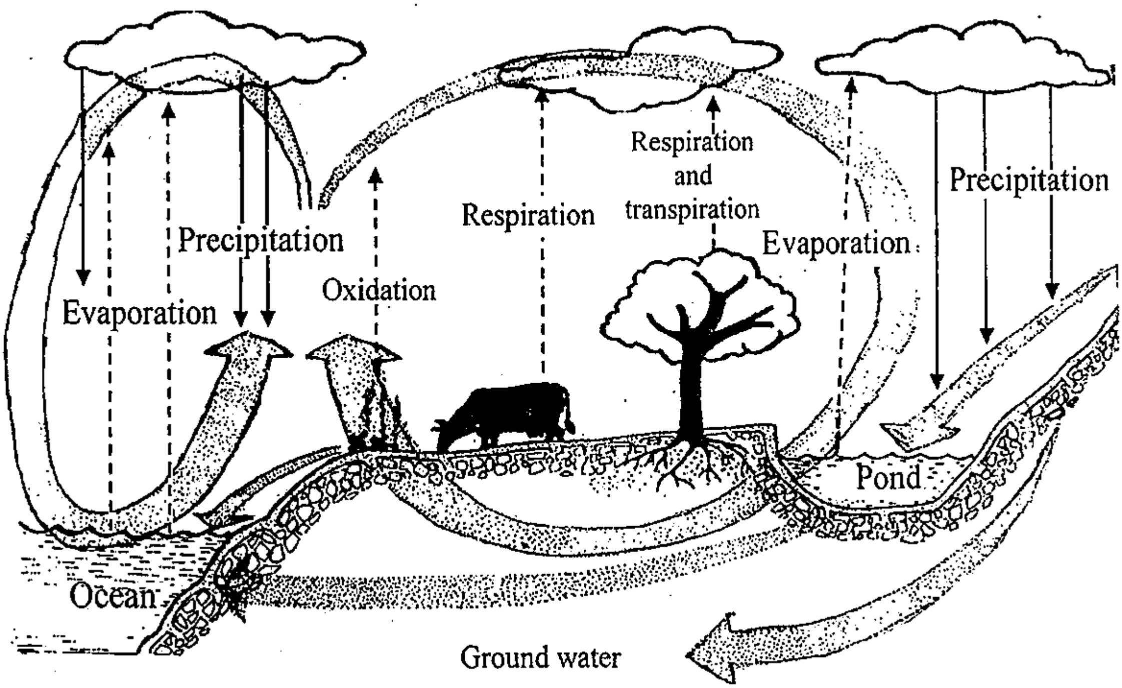

Fig. 12.1 The water cycle

Water vapour gather together condenses in a cool atmosphere to form a cloud. At a suitable temperature, pressure and saturation, water is precipitated again on to the earth. This may be in the form of rain, snow, sleet or hail.

Nitrogen Cycle

1. The atmosphere contains 78% nitrogen. However, only nitrogen-fixing bacteria and blue-green algae can use atmospheric nitrogen.

2. **Nitrogen fixation** - the process by which nitrogen- fixing bacteria forms nitrogen compounds from gaseous nitrogen, e.g. symbiotic bacteria ***Rhizobium*** (lives in root nodules of leguminous plants), and free-living soil bacteria.
3. **Nitrification** - the process of converting ammonium compounds into nitrites and nitrates. Many chemosynthetic bacteria carry out this process during their respiratory activities. Green plants absorb these nitrogenous compounds,

dissolved in soil water, as their source of nitrogen.

4. **Denitrification** - is the process of converting nitrogenous compounds into gaseous nitrogen. Denitrifying bacteria are responsible for this process, particularly when they live in soil with low oxygen content.

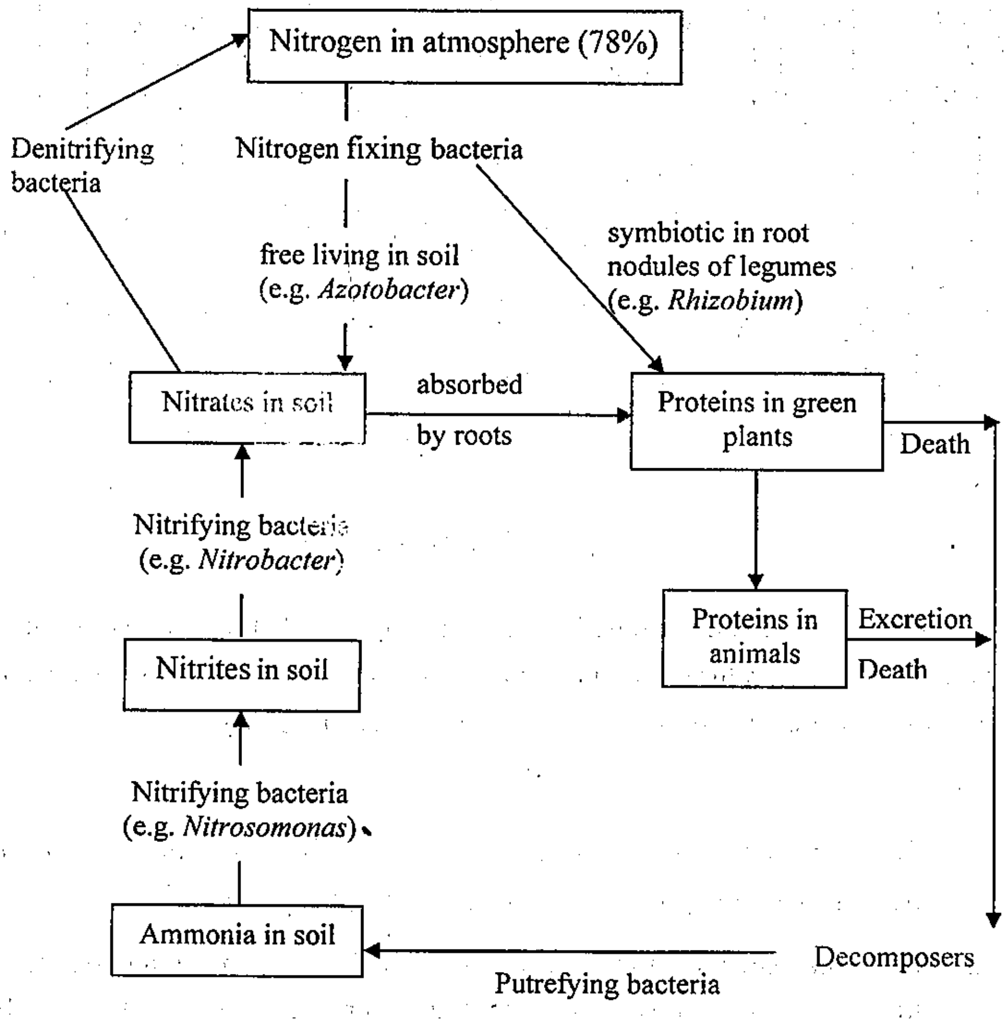

Fig.12.2 Nitrogen cycle

The Carbon Cycle

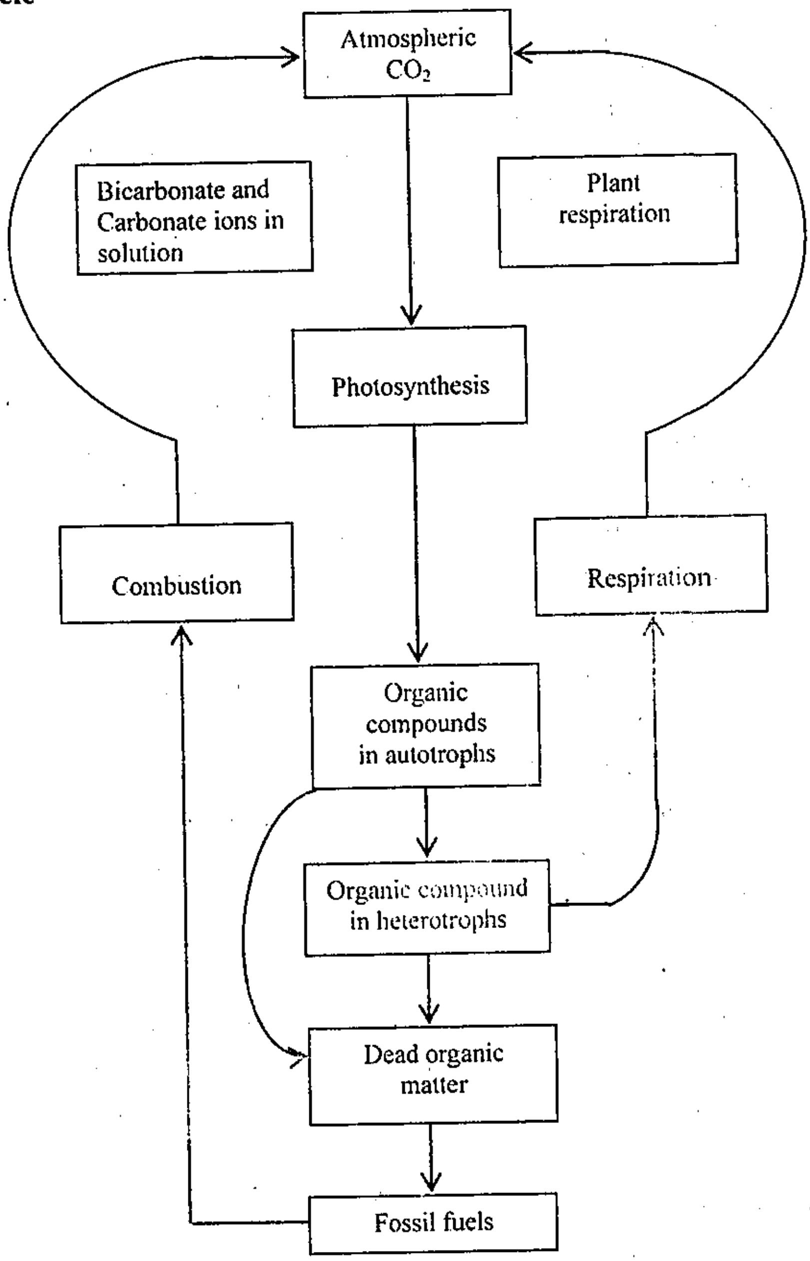

Fig.12.3 Carbon cycle

Carbon exists in the earth's crust as organic fossils, which are used as fuel. Fuel, when burned, releases carbondioxide into the atmosphere. Leaves use this carbon dioxide during photosynthesis to form organic compounds within plants.

Bicarbonates and carbonates obtained from the soil are additional organic nutrients used during photosynthesis.

Organic compounds release carbondioxide into the air during respiration, which in turn is used again in photosynthesis.

When the plants die the organic compounds formed turn into dead organic matter, which in due time become fossils required for fuel. Thus, a carbon cycle takes place in nature.

Other Factors

Bacteria, viruses, protozoa, and fungi cause not all diseases. Other factors are overcrowding, lack of social structure, and natural rhythm of daily activities and noise, which can lead to stress. Stress causes breakdowns, tension and increases the risk of contracting infectious diseases. Besides serious diseases such as asthma, duodenal ulcers and neurodermatitis may also occur. Diseases of heart, circulatory system, cancer, and mental disorders are caused by stress, lack of exercise, unbalanced diet, smoking, drinking, and exposure to pollution.

There is no doubt that smoking is the primary cause of many fatal diseases. Even passive smoking of other people's smoke carries with it an increased risk of smoking related disease. The constituents of tobacco smoke are cancer producing substances, irritant substances, nicotine, and other gases. Many laboratory experiments have shown that animals can develop cancer of the larynx and lung by inhaling tobacco smoke.

Pollution

Pollution in the environment affects both animals and plants, either by causing a loss in productivity (slower growth and loss yield) or by damage to tissues, thus causing illness or disease. In extreme cases, it can cause death of plants and animals.

Pollution can occur in the **atmosphere,** in the soil, in the **sea** or in **freshwater**. Four main ways that can cause pollution are as follows:

(a) The materials produced from industrial process released into the atmosphere or discharged into streams or rivers cause pollution.

(b) The widespread use of chemical pesticides and weed-killers cause pollution.

(c) The production of radioactive materials causes pollution.

(d) The progressive accumulation of wastes causes pollution.

Air Pollution

Pollution entering the atmosphere produces the effects in one of the two ways.

(a) It may enter the tissues of plants and animals directly, either through the stomatal pores or lungs, or at any point on the surface.

(b) It may first be deposited in the soil or in water, and then absorbed by plants in solution. These eventually reach the animals through feeding.

Land and Water Pollution

Land and water pollution is, in part, a repeat of the problems of air pollution, since air borne **pollutants** eventually make their way into the soil and water.

Water Pollution

The main effects on inland water are those due to outflow of factory waste, human sewage and the run-off nitrates from over fertilized land.

Factory wastes include:

(a) **Oil:** forming a thin, widely dispersed film on the surface reduces the uptake of oxygen by the water.

(b) **Detergents:** reduce the capacity of freshwater.

(c) **Suspended particles:** produce similar effects in water to those of soot in the atmosphere.

(d) **Poisonous chemicals:** sulphides and sulphites acting as reducing substances lower the oxygen concentration in the water.

SUMMARY

Ecosystem contains biotic and abiotic components. The biotic component consists of population that interacts with each other and with the abiotic component, or physical environment. The populations in an ecosystem form food chains in which the producers produce food for other populations by being able to capture the energy of the sun, the ultimate source of energy for the universe. Chemicals cycle through the food chain, and in time, the same inorganic molecules are returned to the producer population for conversion to organic food.

Chemical cycles typically have a reservoir and an exchange pool that supplies the chemical to producers. In the carbon cycle, carbon dioxide is removed from the atmosphere by photosynthesis but is returned by respiration. In the nitrogen cycle, nitrogen-fixing bacteria convert aerial nitrogen to nitrates and denitrifying bacteria convert nitrates back to aerial nitrogen. Nitrifying bacteria convert ammonia to nitrate, the form of nitrogen most often used by plants. Water cycle occurs by passing through three stages: evaporation, condensation, and precipitation. Water in both plants and animals evaporates in the form of vapour that condenses in a cool atmosphere to form a cloud. Water, the essential requirement of living organisms is returned back to earth by precipitation at suitable conditions.

Pollution affects all portions of the earth. Man mainly creates air pollution, land pollution, water pollution, and sound pollution. All types of pollution affect the lives of the organisms.