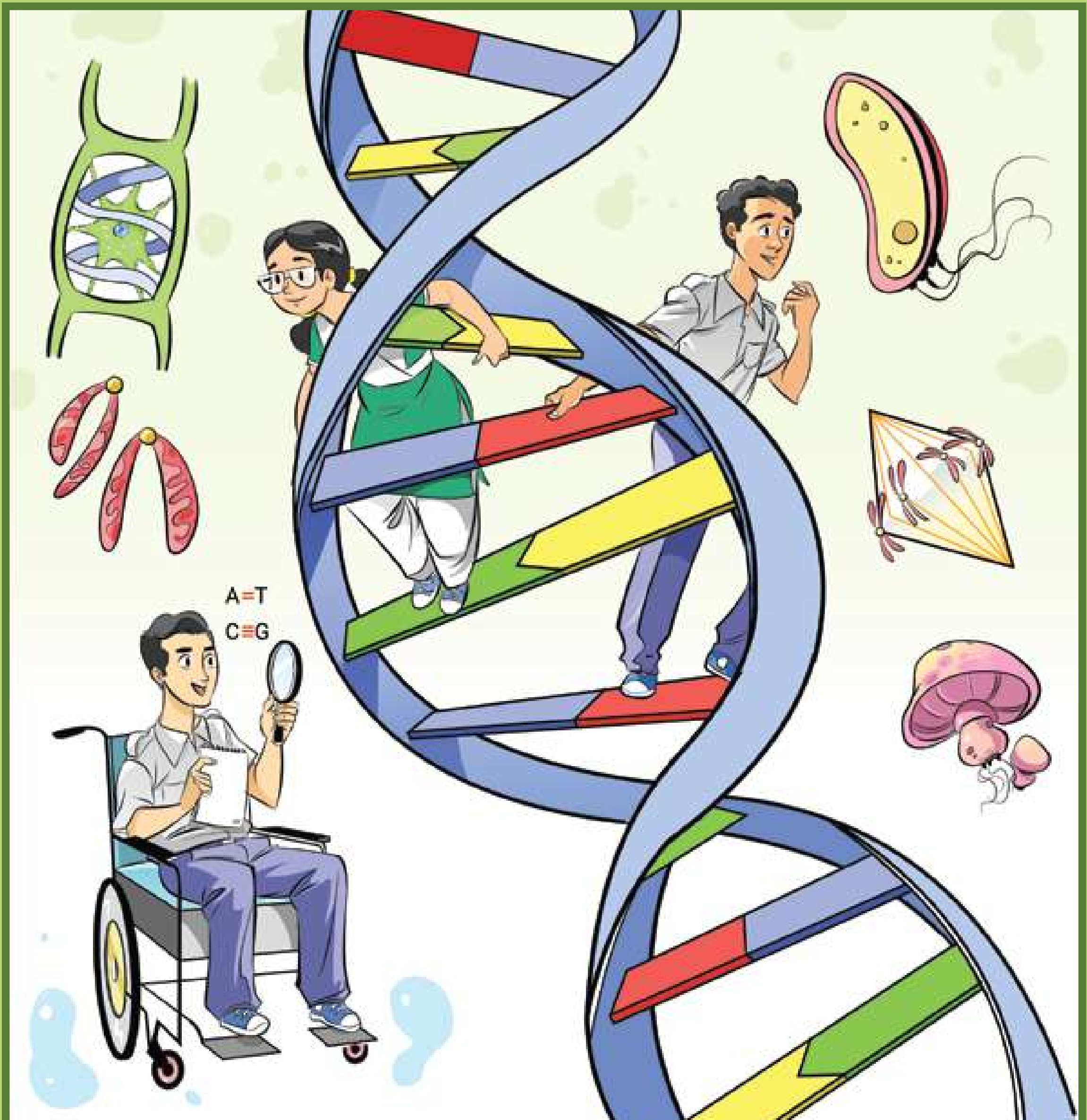
Biology

Classes Nine and Ten



National Curriculum and Textbook Board, Bangladesh

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Biology

Classes Nine and Ten

Revised for the year 2025

National Curriculum and Textbook Board, Bangladesh

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Preface

The importance of formal education is diversified. The prime goal of modern education is not to impart knowledge only but to build a prosperous nation by developing skilled human resources. At the same time, education is the best means of developing a society free from superstitions and adheres to science and facts. To stand as a developed nation in the science and technology-driven world of the 21st century, we need to ensure quality education. A well-planned education is essential for enabling our new generation to face the challenges of the age and to motivate them with the strength of patriotism, values, and ethics. In this context, the government is determined to ensure education as per the demand of the age.

Education is the backbone of a nation and a curriculum provides the essence of formal education. Again, the most important tool for implementing a curriculum is the textbook. The National Curriculum 2012 has been adopted to achieve the goals of the National Education Policy 2010. In light of this, the National Curriculum and Textbook Board (NCTB) has been persistently working on developing, printing, and distributing quality textbooks. This organization also reviews and revises the curriculum, textbook, and assessment methods according to needs and realities.

Secondary education is a vital stage in our education system. This textbook is catered to the age, aptitude, and endless inquisitiveness of the students at this level, as well as to achieve the aims and objectives of the curriculum. It is believed that the book written and meticulously edited by experienced and skilled teachers and experts will be conducive to a joyful experience for the students. It is hoped that the book will play a significant role in promoting creative and aesthetic spirits among students along with subject knowledge and skills.

The main goal of **Biology** is to acquire theoretical and practical knowledge about life and its environment. To understand Biology, emphasis is given here on scientific concepts and theories at the same time their practical applications. Thus, students will contribute to human welfare by applying their acquired knowledge in practice. Each chapter of the textbook includes a variety of tasks for the students so that they can easily understand the given text through hands-on work. Eventually, hands-on work will build confidence in students and develop their thinking skills and creativity.

It may be mentioned here that due to the changing situation in 2024 and as per the needs the textbook has been reviewed and revised for the academic year 2025. It is mentionable here that the last version of the textbook developed according to the curriculum 2012 has been taken as the basis. Meticulous attention has been paid to the textbook to make it more learner-friendly and error-free. However, any suggestions for further improvement of this book will be appreciated.

Finally, I would like to thank all of those who have contributed to the book as writers, editors, reviewers, illustrators and graphic designers.

October, 2024

Prof. Dr. A K M Reazul Hassan
Chairman
National Curriculum and Textbook Board, Bangladesh

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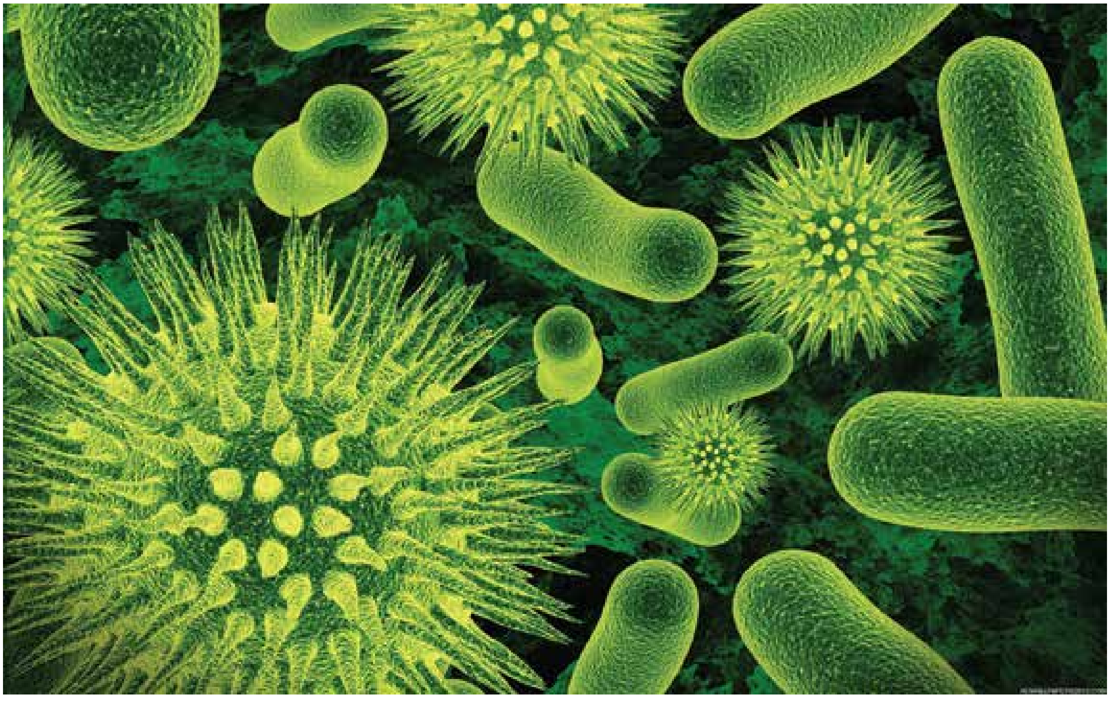
Chapter One
Lessons on Life



In flourishing human civilization the production of food, development of medical science and the protection of existance of all living beings in adverse conditions are the challenges of the present century. The role of biology is indispensible in this regard. In this chapter, the definition of biology, names of its branches and naming system of organisms are discussed.

At the end of the chapter, we will be able to–

- explain the concept of biology;
- describe the main branches of biology;
- explain the concept of the classification of organisms;
- evaluate the necessities of the classification of organisms;
- describe the systems of the classification of organisms;
- explain the concept of Binomial Nomenclature of organisms and its significance;
- become conscious about the necessity of the classification of organisms in practical life.

1.1 Concept of Biology

In nature, we generally find two types of objects: non-living things and living organisms. Those who have life, they are living organisms and those who have no life, they are non-living things. The characteristics of non-living things are usually discussed in Physics and Chemistry. Biology is the branch of scientific knowledge concerning life and characteristics of organisms. But it is really difficult to find the very faint line of difference between living and non-living. In fact physics and chemistry embody the principles of fundamentals of life, even the non-living. So, in order to understand living organisms, it is necessary to know about the physical sciences i.e. physics and chemistry. But it is wrong to think that it is not necessary to study biology if we have knowledge of physical sciences. Rather, life may be considered a complex combination of many non-living things in which some new characteristics occur. For example, the properties of water do not resemble that of hydrogen and oxygen, though it is made up of these two elements. So, although living organisms are constituted of a specific combination of non-living things, new properties originate in them that do not always resemble that of their non-living components.

Biology is one of the fundamental branches of science. The term 'biology' is derived from the Greek words, 'bios' meaning life and 'logos' meaning knowledge. As biology plays an important role in agriculture and medicine, from the beginning of civilization it was practiced in different regions including Greece, Egypt, Middle East, India and China. However, this practice cannot be considered as science in terms of modern science but it was necessary then to flourish this branch of knowledge.

1.2 Branches of Biology

When we look around us, we see two types of living things-plants and animals. Based on this, for a long time biology was divided into two branches - Botany and Zoology. This trend is still in force. However, the field of biology has expanded so much that it is not enough to confine its study to these two branches only. There are many living beings which are neither plants nor animals, such as bacteria, fungi. The classification is not appropriate when analyzing common characteristics of animals, plants, bacteria, fungi, viruses etc. So now also biology has been classified into many branches. Considering its aspect, there are also two other divisions of biology- Physical Biology and Applied Biology. In physical branch the investigation on the basis of theory gets more importance than applied side. On the other hand, applied side gets more importance in applied branch.

1.2.1 Physical Biology

In the field of Physical Biology, theoretical concepts are usually discussed. The following subjects are the general fields of its concern.

1. Morphology: This deals with the form and structure of organisms. It is usually divided into two branches - external and internal morphology. The external description of the body is called external morphology and the internal description of the body is called internal morphology.

2. Taxonomy: Classification of organisms and related principles are discussed in this branch.

3. Physiology: This branch of biology deals with the biochemical activities of different organs of organisms, such as respiration, excreation, photosynthesis etc. Detailed description of all the physiological process of organisms is found in it.

4. Histology: The microscopic structure, arrangement and function of plant and animal tissues are studied in this subject.

5. Embryology: The branch of biology that discusses the origin of gametes, the origin of embryo of fertilized egg, the development of embryo, their structure, growth and development.

6. Cytology: The structure, function and division of an individual cell in a body of organisms is studied in this branch of biology.

7.Genetics: This branch of biology deals with genes and heredity.

8.Evolution: The gradual development of life and organisms over successive generations on earth is studied in this subject.

9. Ecology: It is the science of the reciprocal relationship between organisms and their environment.

10. Endocrinology: The field of science that deals with the study of endocrine glands and hormones secreted by them.

11.Biogeography: The branch of biology that studies the geographical distribution of organisms and their evolution. It is also related with the classification of earth on the basis of the geographical distribution of organisms.

1.2.2 Applied Biology

Applied subjects related to life are included in this category, and some of them are mentioned below:

1.Palaeontology: Science of the prehistoric life forms and fossils.

2.Biostatistics: Science of statistics of organisms.

3.Parasitology: Science related to parasitism, life process of parasitic organisms and diseases caused by them.

4. Fisheries: Science dealing with fish, harvesting of fish, management and conservation of fish assets.

5. Entomology: Science related to the study of life, merit, demerit, and control of insects including the damages caused by them.

6.Microbiology: Science related to virus, bacteria, fungi and other microorganisms.

7.Agriculture: Science concerning agriculture.

8.Medical Science: Science related to human body, diseases, treatment etc.

9.Genetic Engineering: Science associated with gene technology and its uses.

10. Biochemistry: Science connected to the biochemical process and diseases of organisms.

11. Environmental Science: Science related to the environment.

12. Marine Biology : Science related to marine living beings.

13. Forestry: Science related to forest, management and conservation of its resources.

14.Biotechnology: Science associated with the technology of uses of organisms for the benefit of mankind.

15. Pharmacy: Science dealing with the technology and industry of medicine.

16. Wildlife: Science related to wild animals.

17. Bioinformatics: Biological information based on computer technology, for example information on the analysis of cancer.

Individual Activity

Activity: Look at the pictures below, and classify them in a list under the biological branch they belong to.

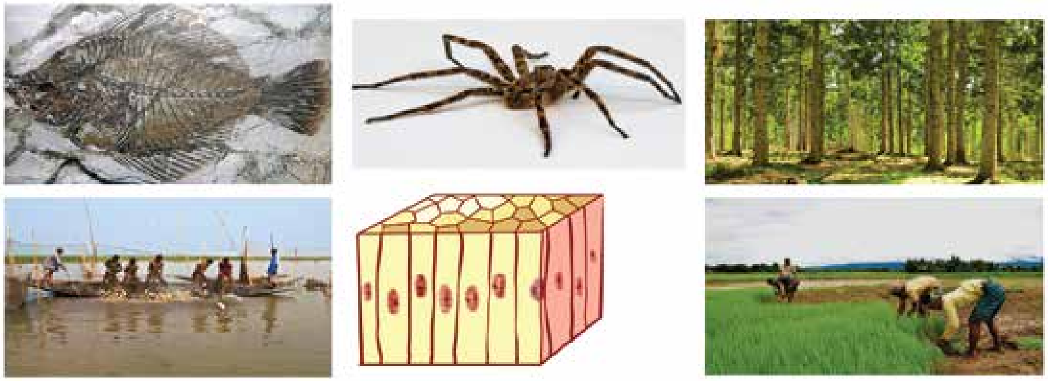


Figure : 1.01 Examples of different branches of Biology

Individual Activity

Activity : Collect news on biology from daily newspaper/magazine and make a list on the branches of biology.

Essentials: Daily newspaper/magazine, scissor/cutter, glue, art paper, sign pen.

Procedure: Divide the students into small groups of 3-5 members. Each group will look for news related to more than one branch of biology in newspapers/ magazines and make a list of physical and applied branches related to biology. Then the group will present the poster with the paper cutting and the list of branches written below it.

1.3 Classification of living beings

About four million different plant species and thirteen million of animal species have been named and described till today. This number is not yet final, because the more and more new species are being added to it almost every day. It is assumed that the number will reach a crore in future when the description of all the organisms will be ended. A large number of organisms are needed to be grouped systematically to know, understand and learn them in an easy manner. Many years back natural scientists felt the necessity to classify living world following a natural system. From this necessity, a distinct branch of biology, taxonomy, had emerged. The main aim of classification is to know the vast and diverse living world accurately and classify them quickly and easily.

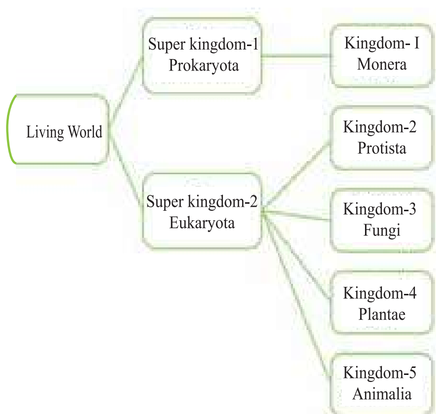
The contribution of Swedish naturalist Carolus Linnaeus (1707-1778) in the field of taxonomy is worth mentioning. In 1735 he received his doctoral degree in medicine from the University of Uppsala, and in 1741 he was appointed Professor of Anatomy in the same University. It was the main field of his intense interest to classify organisms from his botanical and zoological observations that he assembled from his many expeditions. He classified living world into two kingdoms- Plant and Animal by observing the characteristics of numerous sample organism.

Aim of Classification

The aim of classification is to acquire knowledge of the groups and subgroups of organisms, to maintain documentation of the accumulated information systematically, to present the knowledge concisely, to take steps to identify the organisms and be conscious to conserve the useful organisms for the well-being of the living world.

Living World

From the time of Carolus Linnaeus up to the middle of the twentieth century, all living organisms were classified in one of the two kingdoms: Animals and Plants. With the progress of science, on the basis of data collected from time to time, for instance, the type of DNA or RNA in a cell, features and number of cell in a living body and mode of nutrition that a cell adopts, a five-kingdom classification was proposed by R.H.Whittaker in 1969. Then Margulis introduced a modified and expanded form of Whittaker's classification in 1974. She divided the whole living world into two super-kingdoms and grouped the five kingdoms under these two super-kingdoms.



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(a) Super kingdom-1: Prokaryotae

These are primitive, prokaryotic (having no structured distinct nucleus) and microscopic unicellular organisms.

Kingdom- I: Monera

Characteristics: These are mostly unicellular, filamentous (Filament is constituted by vertically connected cells one after another) or colonial. Though chromatin material is present, there is no nuclear membrane or nucleolus in their cells. No plastids, mitochondria, endoplasmic reticuli are there, but ribosome is present. The cell divides through a process of binary fission. Their chief mode of nutrition is absorption, though some of them produce food through photosynthesis.

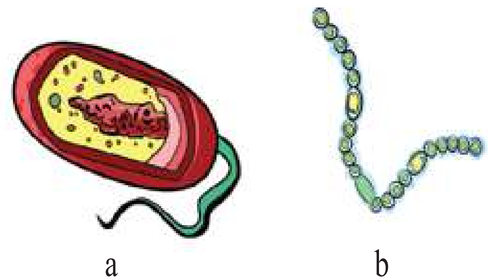

Figure : 1.02 (a) Bacteria (b) *Nostoc* (Blue green algae)

Examples: Bacteria, blue green algae.

(b) Super kingdom-2: Eukaryota

These are eukaryotic (well structured nucleus), unicellular or multicellular and live individually or in a colonial form.

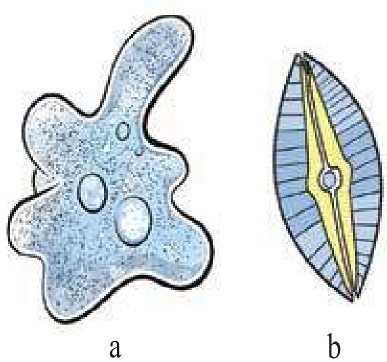

Figure: 1.03 (a) *Amoeba* (b) Diatom (Unicellular algae)

Kingdom-2 : Protista

Characteristics: They are unicellular or multicellular, individual, colonial or filamentous and the nuclei in their cells are well structured. Their cells contain nuclear materials covered by a nuclear membrane. In the chromatin material, there is DNA, RNA and protein. All types of cell organelles are present. Their modes of nutrition are absorption, ingestion or photosynthesis. They accomplish their asexual and sexual reproduction by the process of mitosis and conjugation (Union of two gametes which are structurally similar but biologically different) respectively. No embryo is developed in them.

Examples: *Amoeba, Paramecium* and algae (diatom, *Spyrogyra* etc).

Kingdom-3 : Fungi

Characteristics: Most of them are terrestrial, saprophytic or parasitic. Their body is constituted of a single cell or mycelium (narrow tape-like part). The nucleus is well organised. The cell wall is composed of chitin. Their mode of nutrition is absorption. The photosynthetic apparatus chloroplast is absent. They reproduce by haploid spores, and their cells divide through mitotic cell division.

Examples: Yeast, *Penicillium*, Mushroom etc.

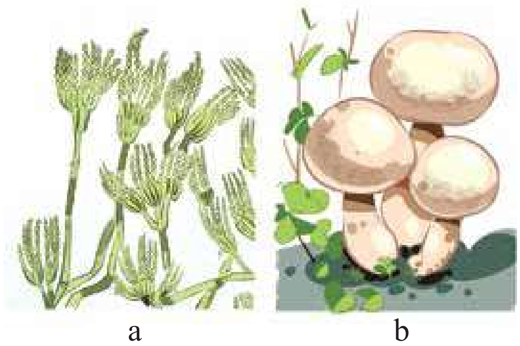

Figure 1.04: (a) *Penicillium* (b) Mushroom

Kingdom-4: Plantae

Characteristics: They are photosynthetic and eukaryotic. Advanced tissue systems are found in them. They develop embryos and diploid stage starts from it. They are mostly terrestrial but there are also many aquatic species in this kingdom. Their sexual reproduction which is happened by union of structurally and physically different gametes.


Figure 1.05: Jackfruit Tree (Angiosperm)

They are archegoniates (plants with female reproductive organs) and flowering plants.

Examples: Advanced green plants.

Divisions of plantae are shown in a chart below:

Plantae
- Bryophyta (Non-vascular plant) Namely: Moss
- Trachaeophyta (Vascular plant)
  - Fern
  - Gymnosperm
  - Angiosperm

Kingdom-5: Animalia

Characteristics: They are eukaryotic and multicellular animals. Their cells do not have non-living cell walls, plastids or vacuoles in them. As there are no plastids in their cells, they are heterotrophs, and so they depend on other organisms for their food. After ingestion, they digest their food. They have advanced and complex tissue systems. Sexual reproduction is their usual way of reproduction. Haploid gametes are usually produced in the reproductive organs of mature and diploid males and females. Embryonic layers are developed at the time of their embryonic development.

Figure: 1.06 Royal Bengal Tiger

Examples: The entire invertebrate and vertebrate animals except protozoan.

Thomas Cavlier-Smith from Oxford University divided the kingdom Protista of living world into two groups, protozoa and chromista and renamed the kingdom Monera as the Kingdom of Bacteria in 2004. In this way, he grouped the living world into six kingdoms. You will learn more about it at your higher level of education. You will be introduced gradually in the consequent chapters to the characteristics of the animals of different kingdom mentioned here.

1.4 Different steps of Classification

In classifying the organisms, codified units or ranks are used in taxonomy, which are called Taxa. The largest classification rank is kingdom, and the smallest classification rank is species. Each rank of taxonomy adds new characteristics to those of the lower rank. The higher the rank, the lower the number of characteristics, and the higher number of living organisms belonging to this rank the lower the rank, the higher number of characteristics, and the number of living beings belonging to this rank. There are seven main taxonomic ranks according to International Code.

Kingdom
Phylum / Division
Class
Order
Family
Genus
Species

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The topmost rank is a set whereas the lower ranks are subsets. The subset of Kingdom is Phylum, the subset of Phylum is Class, the subset of Class is Order... etc. This system of scientific classification is called 'nested hierarchy'. In order to avoid repetition, the common characteristics of the previous rank are often not mentioned in the next rank. If we follow the above mentioned system, the taxonomic rank of human being *(homo sapience)* is like this:

Kingdom: Animalia (cells with distinct nucleus, multicellular, heterotrophs and have complex tissue system).

Phylum: Chordata (possess notochord in any one phase of life).

Class: Mammalia (feed their young on milk and their body is covered with hair).

Order: Primate (hands with five fingers suitable to grasp and vision more developed than sense of smell).

Family: Hominidae (similarity with chimpanzee, gorilla, orangutan).

Genus: *Homo* (brain is bigger compared to the body and can walk erectly on two feet).

Species: *Homo sapience* (wide and high forehead, skull is thinner compared to other species, more intelligent).

As a student of biology, one needs to know the reasons for including a species in the respective taxonomic rank though in the traditional system, the reasons are not written separately.

1.5 System of Binomial Nomenclature

The scientific name of an organism has two parts. The first part of the name denotes the genus to which the species belongs; the second part identifies the species within the genus. The scientific name of potato is *Solanum tuberosum,* for example. Here, the words *solanum* and *tuberosum* denote the genus and species names of potato respectively. This system of scientific naming of an organism is termed binomial nomenclature. The aim of binomial nomenclature is to unambiguously identify every organism. The scientific naming of an organism is accomplished in accordance with some rules and regulations

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Figure 1.07 : Carolus Linnaeus

set internationally. The scientific name of a plant and an animal should be accorded with the declared principles of International Code of Botanical Nomenclature (ICBN) and International Code of Zoological Nomenclature (ICZN) respectively. In fact, the codes are documented in a printed form. As the scientific naming of an organism is expressed in the language Latin, these names are accepted throughout the whole world. In 1753 the Swedish naturalist Carolus Linnaeus laid the foundations for the modern system of naming organisms and effectively began the task with his book *Species Plantarum*. He defined the term species and genus, and used the ranks of classification class, order, genus and species in his work. The introduction of the formal system of naming organism by Carolus Linnaeus is undoubtedly a striking step in the history of biology. Some of the notable principles of binomial nomenclature are mentioned below:

1. The language of scientific naming of an organism would be Latin. (Young zoologist Sazid Ali Haoladar recently discovered a frog which can be found only in Dhaka. The scientific name given to the frog is *Zakerana dhaka*. The name of the Genus is given as Zakerana to show respect to the founder of the Zoology Department of Dhaka University, Kazi Zaker Hossain.

2. Every scientific name should have two parts and the genus name always comes first, followed by the species name. For example, *Labeo rohita*. This is the scientific name of ruhit fish. Here *Labeo* is genus whereas *rohita* is the name of the species.

3. The scientific name of any organism should have to be unique because a same legitimate name cannot be used for naming two distinct organisms.

4. The first alphabet of the first name would be in capital letter with the remaining alphabets in small type, and the second part of the name totally would be with small letters. For example, Onion- *Allium cepa*, Lion - *Panthera leo.*

5. At the time of printing of a scientific name, it should be written in italics. Rice- *Oryza sativa*, Katla fish- *Catla catla,* for example.

6. When a scientific name is handwritten, its two parts should be separately underlined. For example, Oryza sativa, Catla catla.

7. If the scientific name of an organism is named by several scientists, the earliest legitimate name given by the first scientist will be accepted in accordance with the rules of priority.

8. The scientist who gives the scientific name of an organism can have his/her name cited in abbreviated form at the end of the binomial name along with the year of naming. For example: *Homo sapiens* L.,1758, *Oryza sativa* L.,1753, (Here L is the short form of Linnaeus).

Binomial names of some organisms

General name	**Scientific name**
Rice	*Oryza sativa*
Jute	*Corchorus capsularis*
Mango	*Mangifera indica*
Jackfruit	*Artocarpus heterophyllus*
Water lily	*Nymphaea nouchali*
China rose	*Hibiscus rosa-sinensis*
Causal organisms of cholera	*Vibrio cholerae*
Causal organisms of malaria	*Plasmodium vivax*
Cockroach	*Periplaneta americana*
Honey bee	*Apis indica*
Ilish	*Tenualosa ilisha*
Asian toad	*Duttaphrynus melanostictus* (*Bufo melanostictus*)
Oriental Magpie-Robin	*Copsychus saularis*
Tiger	*Panthera tigris*
Human	*Homo sapiens*

Individual Activity

Activity : Suppose in your locality you have discovered a new species of grasshopper. What name will you give it? Show logic of the nomenclature.

Exercise

Short answer questions

1.What is the significance of learning biology ?

2.Write down the names of the physical branches of biology.

3.Write down the names of the applied branches of biology.

4.What is binomial nomenclature ?

5.What are the ranks of classification.

Essay type questions

1. What is the necessity of classifying organisms?

Multiple choice questions

1. In which branch of biology discusses about insects?

   a. Entomology b. Ecology

   c. Endocrinology d. Microbiology

2. The aim of classification is-

   i.to know about the sub-ranks of organism

   ii.to be able to name the units of organism

   iii.to present the information in detail

   Which one of the following is correct?

   a. i & iii b. i & ii

   c. ii & iii d. i, ii & iii

Look at the stem and answer the questions 3 & 4.

3. What is the name of the organism shown in the picture above?

   a. *Amoeba* b. Diatom

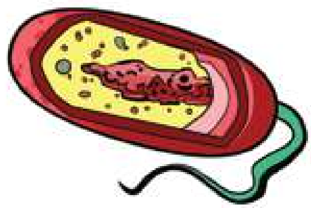
   c. *Paramecium* d. *Acterium*

4. The characteristics of the organism shown in the stem are-

i. They are able to move

ii. They are unable to produce food

iii. Their nucleus is well-structured



Which one of the following is correct?

a. i & ii b. ii & iii

c. i & iii d. i, ii & iii

Creative question

Figure-1

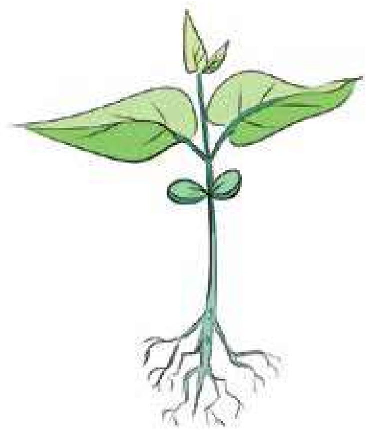


Figure-2

a. What are the units of classification?

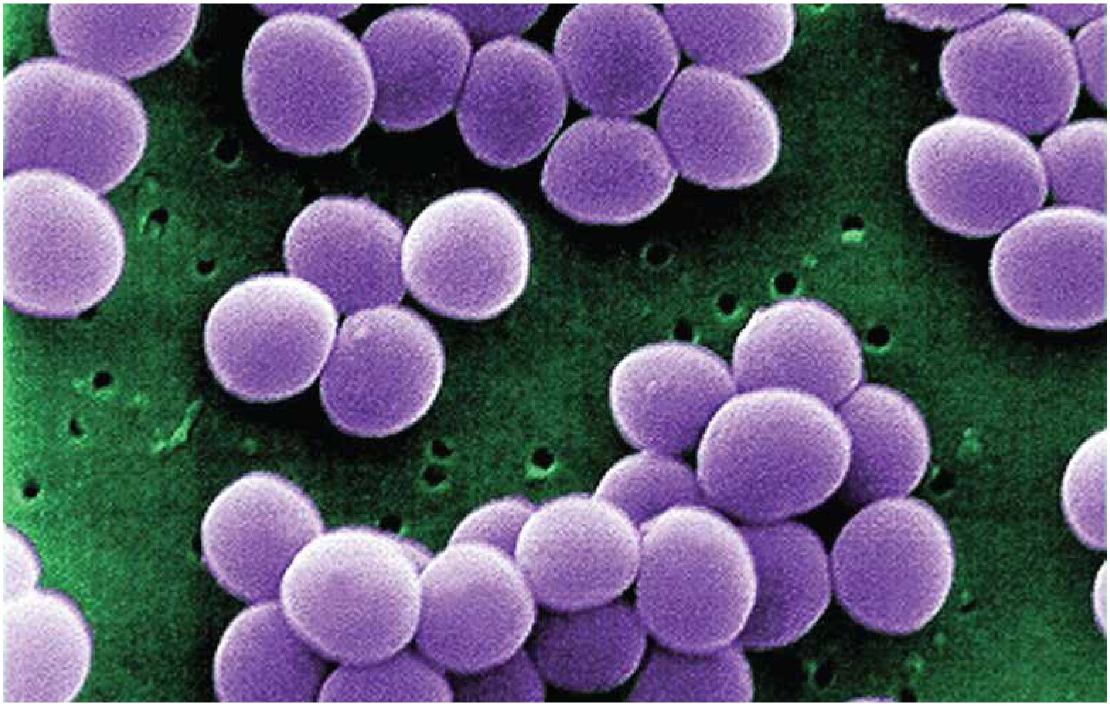
b. Why is genetics called the physical branch of biology?

c. How will you maintain continuity in naming the plant in Figure-2?

d. Analyse with reasons which organism is more advanced between the two shown in Figure-1 and figure-2.

Chapter Two

Cells and Tissues of Organisms



You have already learned the concept of biological cell in your previous classes. Now, based on those ideas, you will learn more about it. Do the views of a cell of an organism appear the same under both a light microscope and an electron microscope? In this chapter, you will find the answers to these kinds of questions.

At the end of this chapter, we will be able to–

- explain the functions of main organelles of plant and animal cells;
- compare a plant cell and an animal cell;
- describe the roles of different types of cell in performing the functions of nerve, muscles, blood, skin and bones;
- evaluate the appropriateness of cell in the body of an organism;
- explain plant tissues;
- explain animal tissues;
- evaluate the functions of tissue on the basis of grouping the similar type of cells and performing the same action;
- explain the organisation of cells in tissue, organs and organ systems;
- explain the functions of tissue system;
- explain the concept and importance of organs and organ systems;
- draw and label diagrams of plant cell (onion cell) and animal cell (buccal mucosa cell) after observing them under a microscope;
- draw and label diagrams of plant and animal tissue;
- correctly use a microscope;
- understand the roles of cells in different activities of organisms.

2.1 Living Cell

You learned in your previous classes that the cell is the structural unit of an organism. What is a living cell? Some scientists describe a living cell as the unit of structure and biological function of an organism. In 1969 Loey and Siekevitz described a cell, surrounded by a selectively permeable membrane, as the unit of living activity, which can exactly duplicate itself without any different living medium.

Types of Cells

All living cells are not the same. Just as they have differences in structure, they also have differences in size, shape and function. On the basis of the organisation of the nucleus, cells can be divided into two types- prokaryotic cell and eukaryotic cell.

a) Prokaryotic cell

A prokaryotic cell does not contain a true nucleus. This is why it is called a cell with a primitive type of nucleus. The term nucleotide fits nicely in this case. Nuclear materials in a prokaryotic cell are not surrounded by a nuclear membrane. They are dispersed in its cytoplasm. Though the cell organelles such as mitochondria, plastids, endoplasmic reticulum etc. are not found in a prokaryotic cell, ribosomes are present in it. The chromosomal structure of a prokaryotic cell consists only of unwrapped DNA. Blue green algae and bacteria are constituted of this type of cell.

b) Eukaryotic cell

In this type of cell, the nucleus is well structured, meaning that nuclear materials are well organised and surrounded by a nuclear membrane. Other cell organelles, along with ribosome, are present. Chromosomes consist of DNA, histone, protein and other components. Most living cells are of this type.

On the basis of function, there are two types of cells: somatic cell and gametic cell.

i) Somatic cell: This type of cell takes part in the composition of the body of an organism. Somatic cells divide through the process of binary fission and mitotic division. Organisms grow in this way. Moreover, these cells take part in the organisation of different organs and organ systems.

ii) Gametic cell: Gametic cells are produced in the organisms in which sexual reproduction and alternation of generations occur. Primordial germ cells divide through meiotic division and produce gametic cells. In a gametic cell, the number of chromosomes becomes half of its somatic type. A new living body is commenced after the fusion of male and female gametes. Zygote is the first cell produced after the union of male and female gametic cells. Zygote undergoes repeated mitotic division to organise a body of an organism.

2.2 Main Organelles of Plant and Animal Cells and their Functions

All higher plants and animals are eukaryotic. Each cell consists of many organelles. Although most of the organelles are found in both plants and animals, there are some organelles found only in plants or in animals.

Now you will have some ideas about some cell organelles which can be seen by electron microscope.

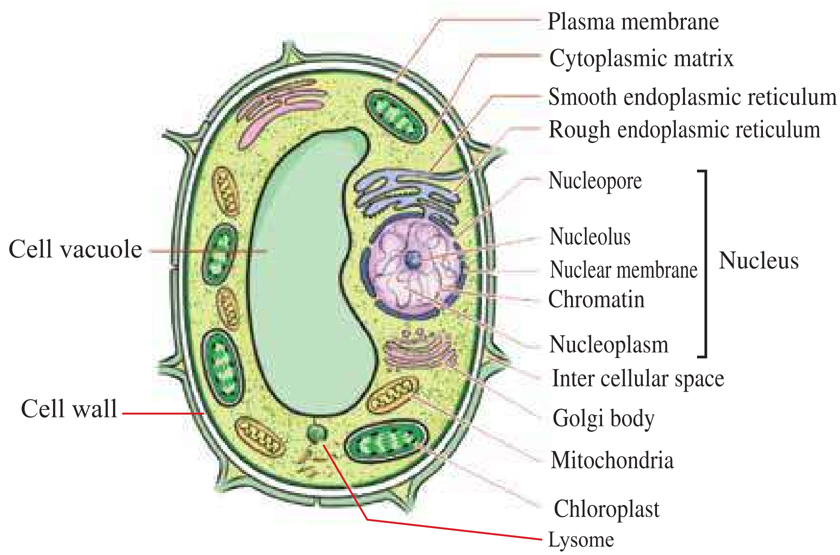


Figure 2.01 : Different parts of a typical plant cell

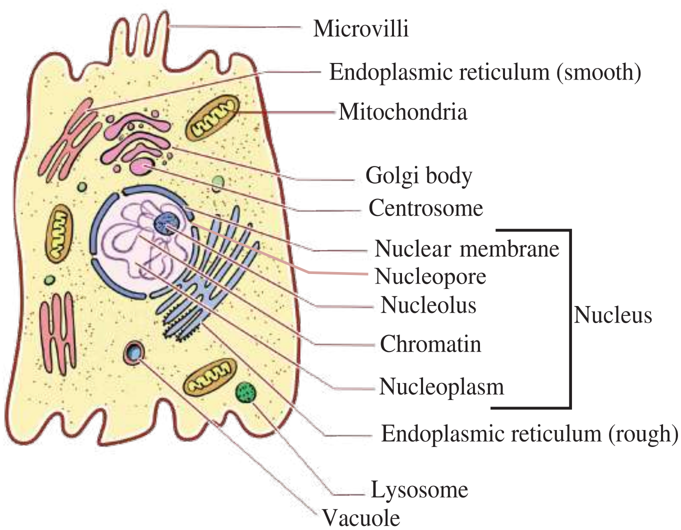


Figure 2.02 : Different parts of a typical animal cell

Cell wall: Cell wall is a unique feature of a plant cell. It is composed of inert materials. There is no cell wall in an animal cell. The chemical composition of a cell wall is complex. Cellulose, hemicelluloses, lignin, pectin, suberin are the chemical components of a plant cell wall. A bacterial cell wall is composed of protein, lipid and poly saccharide. A fungal cell wall is made up of chitin. The primary cell wall is single layered. The secondary cell wall gradually develops through the compilation of different chemical substances secreted from protoplasm on the middle lamellum. At the time of the development of the secondary cell wall, cavities are formed called pits.

These pits give a cell its rigidity. The Cell wall retains the shape and size of a cell. Plasmodesmata are formed in the cell wall to exchange materials with adjacent cells. The cell wall controls the movement of water and minerals.

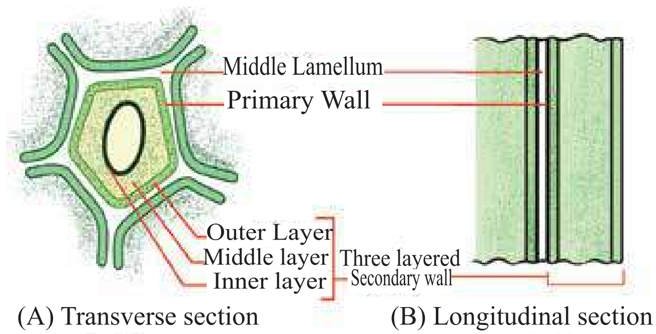


Figure:2.03 Microscopic structure of cell wall

Protoplasm: The translucent, semi fluid, viscous substance that constitutes the interior matter of a living cell is called protoplasm. Everything surrounded by the cell wall is protoplasm. Even plasmalemma is a part of it. Protoplasm also contains cytoplasmic organelles and nucleus.

2.2.1 Plasmalemma: The double layered membrane around the protoplasm of a cell is called cell membrane or plasmalemma or plasmamembrane. This membrane is very flexible. The foldings of a cell membrane are called microvilli, which are mainly composed of lipids and proteins. Because it is selectively permeable, the membrane can control the movement of water and minerals through the process of osmosis, and separates a cell from its neighbouring cells.

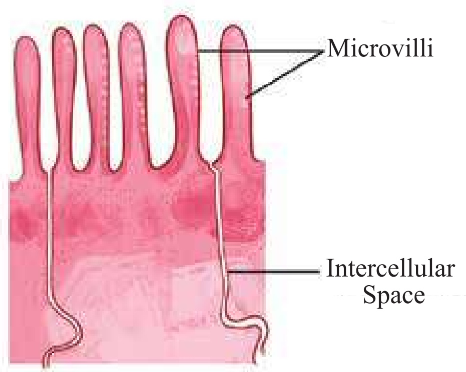


Figure:2.04 Cell membrane

2.2.2 Cytoplasmic organelles: The semi fluid, jelly like substance of a cell that is external to the nuclear membrane and internal to the cellular membrane is called the cytoplasm. The Cytoplasm contains many organelles. Though they have varying functions, they are also interdependent. Some of these organelles have membranes whereas some don't. These organelles are as follows:

Membrane-bound cytoplasmic organelles-

1. Mitochondria: Richard Altmann discovered this organ in 1886 but in others opinion it was discovered in 1894 which takes part in respiration and gave the name 'Bioblast'. However Benda, a scientist gave the cuurent name 'Mitochondria'. It is surrounded by a double-layered membrane which is composed of phospholipid and protein.

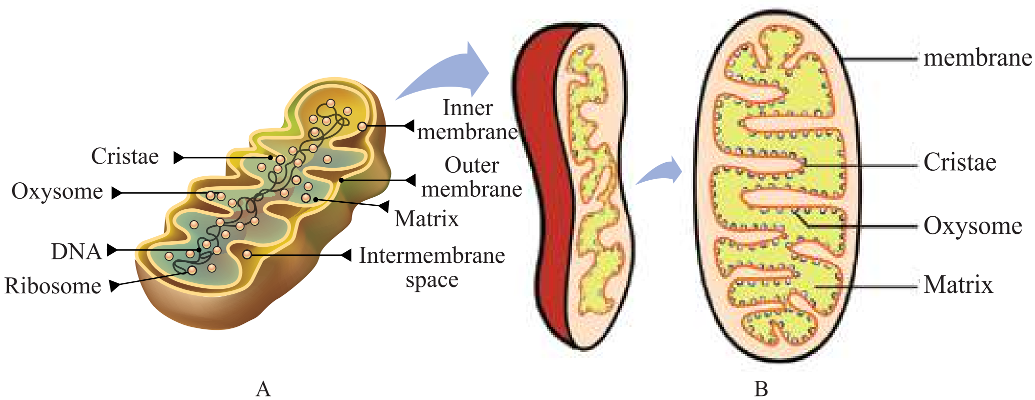


Figure:2.05 (A) Mitochondria (B) Longitudinal section

The inner membrane has infoldings like finger called cristae. These foldings are studded with small round bodies known as oxysomes. The oxysomes contain enzymes. The space enclosed by the inner membrane is the matrix. The main function of mitochondria is to help the organism in cellular respiration. You will later learn that the process of respiration has four stages: glycolysis, Acetyl-CoA formation, the Kreb's cycle and electron transport system. The reactions of the first phase i.e glycolysis do not occur in mitochondria. But the reactions of the second, third (most important Kreb's cycle stage) and fourth stages are performed in mitochondria. As all the necessary enzymes are present in mitochondria, so all the reaction of Kreb's cycle occur there. Maximum energy is produced in Kreb's cycle. This is why a mitochondrion (singular) is called 'the power house' of a cell.

An organism uses this energy to perform different functions. With some exceptions, mitochondria are found in all plant and animal cells. Mitochondria are not present in Prokaryotic cells. Some Eukaryotic cells (for example, protozoa like Trichomonus, Monocercomonoides etc.) do not contain mitochondria. It can be assumed that in course of history of evolution, mitochondria or its previous form somehow entered eukaryotic cells and then became a permanent organelle of the cell. From the data collected so far, this explanation seems to be acceptable.

2. Plastid: A plastid is an important organelle for a plant cell. In 1866 scientist Ernst Hackle discovered plastid. The main functions of a plastid are to produce and store food, and cause the appealing and colourful appearance of flowers, fruits and leaves of a plant. Flowers with appealing colours helps pollinate plants. There are three categories of plastids: chloroplast, chromoplast and leucoplast.

a) Chloroplast: Green plastids are called chloroplasts. They are found in the cells of leaves, young stems and other green parts of a plant. The grana of a plastid capture solar energy and convert it into chemical energy. With the help of enzymes in stroma this solar energy helps to produce simple carbohydrates from cellular water and carbon dioxide taken from air. This type of plastid looks green because it has chlorophyll. Carotenoids are also present in them.

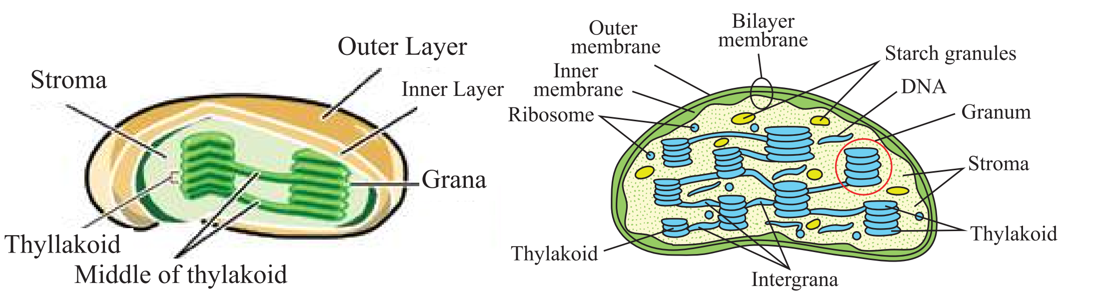


Figure : 2.06 A Plastid (Segment). Different Parts of chloroplast (Under electron microscope and simplified)

b) Chromoplast: Chromoplasts are coloured, but are not green. The photosynthetic pigments xanthophyll (yellow), carotene (orange), phycoerythrin (red), phycocyanin (blue) etc. are present in them, and so some of them are yellow, some are blue and others are red. The flowers, leaves and other parts of a plant have their attractive colourful appearance because of these pigments. They are found in coloured flower, leave and carrot root. Their main purpose is to make flowers attractive for pollination. They also synthesize and store different types of photosynthetic pigments.

c) Leucoplast: In contrast to other plastids, leucoplasts are non-pigmented. They are usually found in the cells of the plant parts where sunlight does not reach; for example, root, gamets and embryo. Their main function is the storage of food. Leucoplasts can be transformed into chromoplasts or chloroplasts when they come in contact with sunlight.

Individual Activity

Activity: Draw diagrams of plastids.

Essentials: Poster paper, sign pen and a picture of different categories of plastids.

Procedure: After drawing a diagram of different types of plastids, present it to the students in the classroom.

3. Golgi body: Golgi body is mainly found within the cytoplasm of animal cells. But plant cell also contain golgi body. It is composed of stacks of membrane-bound structures known as cisternae and vesicles. Hydrolysis of enzymes take place in its membrane. It is involve in the secretion of some hormones and other substances in a living cell. It also plays important roles in many metabolic activities. Sometimes, the golgi body stores protein.

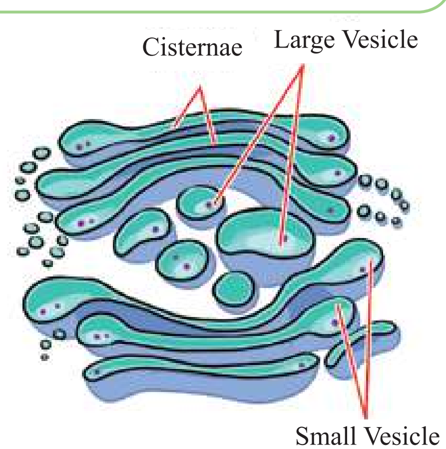


Figure : 2.07 Golgi Body

4. Endoplasmic reticulum: Ribosomes are studded with the cytoplasmic side of rough endoplasmic reticulum, and so proteins are synthesized in these places. Membrane bound vesicles from the endoplasmic reticulum shuttle proteins and other materials produced in a cell. Sometimes the endoplasmic reticulum stretches up to the cytoplasmic membrane, and thus it is assumed that enzymes for other cells and other substances produced inside the cell are transported by the endoplasmic reticulum. They also play a significant role in the development of mitochondria, vacuole etc. in a cell. Endoplasmic reticulum is found in both the plant and animal cells.

5. Cell vacuole: The hollow space which can be seen in cytoplasm is called cell vacuole. Large vacuole is a prime feature of a plant cell. Its main function is to contain cell sap. Different types of substances such as inorganic salt, protein, carbohydrate, fat, organic acid, pigment, water etc. are found in a cell vacuole. No vacuole is generally found in any animal cell. If present in any animal cell, it usually is much smaller.

6. Lysosome : Lysosome protects cells from germs. The lysosome enzyme kills germs. These enzymes are protected by a membrane so that other organelles do not get digested when they come in contact with these enzymes. The organelles adjacent to lysosomes are digested if the membrane of lysosome is destroyed due to oxygen deficiency. The cell may even be destroyed.

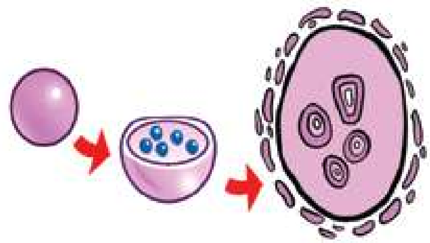


Figure : 2.8 Lysosome granules

Non-membranous cytoplasmic organelles-

1. Cytoskeleton: The cytoskeleton is a complex network of fibres that shapes the cell and holds organelles in place. It is located just beneath the plasmalemma. These fibres consist of a complex mesh of protein filaments. Actin, myosin and tubulin are some of the proteins that are used to make the fibres. Microtubules, microfilaments and intermediate filaments are some of the fibers in the cytoskeleton.

2. Ribosome: Ribosomes are found in all living cells. They lack membrane around them, and help in protein synthesis. The bondage in polypeptide chains of proteins are carried out by ribosomes. They also provide enzymes needed for the cell. Enzymes help to accelerate the speed of biochemical reactions. Note that the matrix of the mitochondria and the stroma of the plastids also contain ribosomes that participate in protein synthesis according to the signal from the organelles' own DNA, just as the ribosomes located in the cytoplasm of a bacterial cell synthesize proteins for that cell. This is also evidence that these two organelles once lived independently before becoming part of another cell in the course of evolution.

3. Centrosome: A centriole is a hollow, cylindrical organelle inside the centrosome. The thick liquid surrounding the centriole is called centrosphere. The centriole and centrosphere make up the centrosome together. These are found in most animal cells, but they are rarely found in cells of lower plants. There are two centriole in a centrosome. The centrioles in a centrosome develop astral rays, and play a significant role in constructing spindle apparatus. They participate in the formation of various types of flagella.

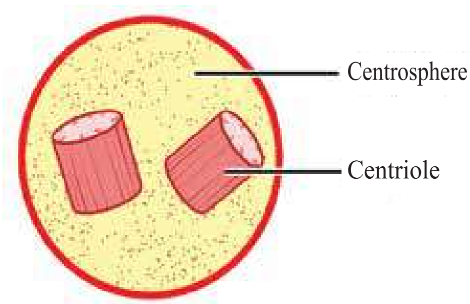


Figure : 2.09 Centrosome

2.2.3 Nucleus: The nucleus is a membrane bound prominent organelle found in eukaryotic cells and carries chromosomes. It is roughly round or spherical in structure. Nucleus is not found in mature sieve cells and red blood cells. The chromosomes of the nucleus carry the heredity information of the organism, and controls all the activities of a cell. A structured nucleus has the following parts:

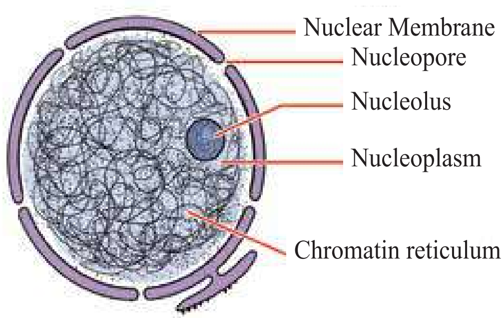


Figure : 2.10 Nucleus

a) Nuclear membrane: The membrane that encloses the nucleus is called nuclear membrane. It is a double layered membrane, and is composed of lipids and proteins. In this membrane, there are some pores called nucleopores. The nuclear membrane controls the transport system from the nucleoplasm to the cytoplasm. The membrane separates the contents of the nucleus from the cytoplasm.

b) Nucleoplasm: The jelly-like fluid enveloped by the nuclear membrane is called the nucleoplasm. It is similar to the cytoplasm of a cell. It is a viscous fluid which contains nucleic acids, proteins, enzymes and some other substances dissolved in and mixed with it.

c) Nucleolus: In a nucleus the round structure attached to a chormosome is called the nucleolus. They are attached with that portion of chromosome which is non-receiver of colour. This is composed of RNA and proteins. Its main function is to store nucleic acid and synthesize protein.

d) Chromatin reticulum: Thread-like materials are seen tangled in the nucleus of non-dividing cells. These threads are chromatin. Chromatin (also known as chromosomes in dividing cells) is a complex structure composed of DNA and proteins that acts as a medium for the transmission of genetic characteristics. Just as it is impossible to count the blades of a ceiling fan in motion, it is impossible to count the number of chromatin filaments in a non-dividing nucleus. The tangled chromatin filaments together are called chromatin reticulum or nuclear reticulum. During cell division, the tangles shorten slightly and the chromatin becomes thicker and shorter. The chromatin of eukaryotic cells can then be characterized as separate structures. Chromosomes are another name for the chromatin that becomes thicker and shorter during cell division. It is best understood at the metaphase stage of division. At metaphase, each chromosome divides to form a pair of chromosomes whose lengthwise halves are called chromatids. At the (near) center of the chromatid is a constricted region called the centromere. During cell division, the part of the centromere where the microtubules of the spindle apparatus attach is called the kinetochore. The two parts of the chromatid on either side of the centromere are its two arms. At anaphase, when the chromatid pairs separate along the centromere, each chromatid is considered a single chromosome. You will know more about this in the third chapter.

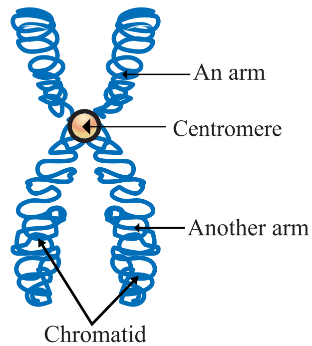


Figure : 2.11 Chromosome

Individual Activity

Activity: Present the different organelles of a cell discussed above in a chart.

2.3 Roles of different cells in proper functioning of plants and animals

Tissue cell is the structural and functional unit of organisms. The functions of unicellular and multicellular organisms are performed in different ways. From the first day of the advent of world's primitive animal protozoa performs all its activities such as digestion, growth, reproduction in a single cell till today while the multicellular organism has different organs for different metabolic activities.

2.3.1 Plant tissue

An ensemble of similar or different types of cells with the same origin and performing a specific function is called tissue. Plant tissues are of two types; Meristematic tissue and Permanent tissue. The cells of meristematic tissue are capable of cell division, but the cells of permanent tissue are not. Tissue can be grouped into three types: simple tissue, complex tissue and excretory tissue. Here we will discuss simple and complex tissues only.

Simple tissue: The permanent tissue which contains cells of the same shape, size and structure, is called simple tissue. On the basis of the nature of cell, simple tissues are divided into three types: 1) Parenchyma, 2) Collenchyma and 3) Sclerenchyma.

1) Parenchyma: Parenchyma cells are seen in almost every part of a plant. Cells of this type are living, isodiametric, thin walled and turgid with protoplasm. Intercellular space is found in parenchyma cells. The cells are thin walled, and the walls are composed of cellulose. When chloroplasts are present in this type of cells, they are called chlorenchyma. The parenchyma cells with air filled spaces are called aerenchyma, and are usually big in size and found in aquatic plants. The main functions of parenchyma cells are to organise the body or body parts of plants to produce, transport and store food.

2) Collenchyma: Collenchyma tissues are a special type of parenchyma cell. The walls of the cells become thick with the compilation of cellulose and pectin. Walls of these polygonal cells are thickened unevenly, where the corners are thicker due to pectin deposition. The cells are elongated, filled with protoplasm. Intercellular spaces may be present. The borders of the cells may be triangular, slim or oblique. Their main functions are to produce food and provide the plant with mechanical support and rigidity. They are found in the veins and petioles of leaves. This kind of tissue provides rigidity to the young and supple stems, for example, the stems of Gourd (*Cucurbita* sp) and Leucas (*Leucas lavandulifolia*). The ones that contain chloroplast produce food.

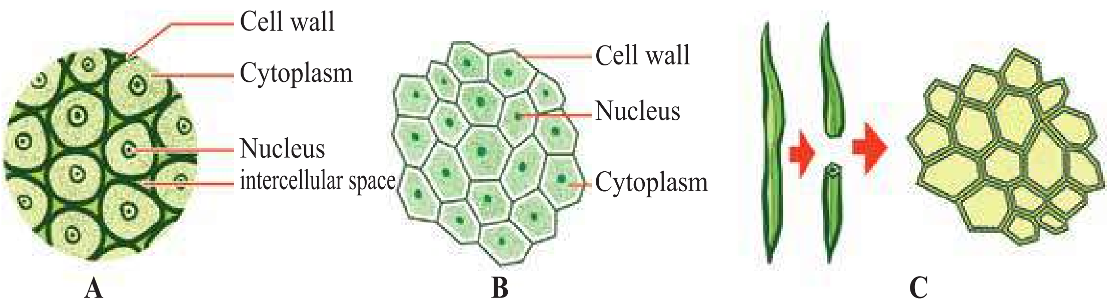


Figure- 2.12: Different types of simple tissue, A- Parenchyma, B-Collenchyma, C-Sclerenchyma

3) Sclerenchyma: Tissue composed of cells with the thickening of walls with lignin for providing mechanical support is called sclerenchyma.

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While in early stage of their development, sclerenchyma cells are alive, losing the living protoplasm when they become mature. The main functions of sclerenchyma tissue are to provide mechanical support and rigidity and to conduct water and minerals. There are two types of sclerenchyma cells, fibers and sclereids.

a) Fibers: They are elongated, slender, thick walled, and both their ends are pointed or sometimes rounded. In their walls, they have pores called pits. Based on their origin and structure, they are called by different names, such as, bast fiber, surface fibre, xylem fiber or wood fiber.

b) Sclereids: Because of their hardness, these are called stone cells. Compared with most fibers, these cells are shorter, isodiametric or sometimes long and star shaped. Their secondary cell walls are durable, thick and lignified. Mature sclereid cells are usually dead. The walls of the cells are pitted. In the cortex, fruits and seed shells of gymnosperm and dicot plants sclereids are found. In the petioles of leaves, they may be present in the cluster form associated with the epidermis, xylem and phloem.

Individual Activity

Activity: Drawing three types of simple tissue.

Essentials: Poster papers, sign pens.

Procedure: Draw the labeled diagrams of the three types of tissue, and present the differences among them.

Complex tissue

Permanent tissue composed of more than one type of cell is called complex tissue. Complex tissue conducts water, minerals and prepared food, and this is why they are also called conducting tissue. They can be grouped into two types: xylem and phloem. Xylem and phloem together form the conducting structure of the vascular bundle.

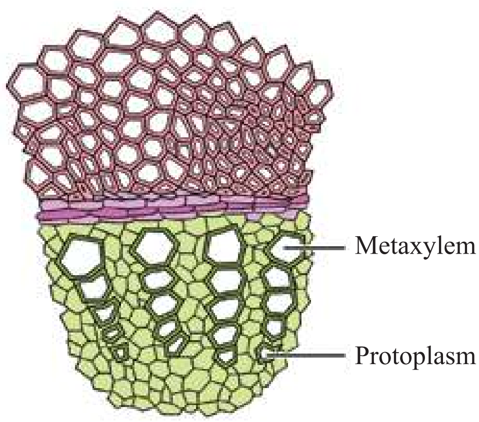


Figure : 2.13 A vascular bundle

Xylem: There are two types of xylem: primary and secondary. Xylem developed during primary growth from the procambium is called primary xylem. Secondary xylem is the xylem grown during secondary growth from the vascular cambium. Primary xylem is of two types: protoxylem and metaxylem. At the primary stage it is called protoxylem and after maturity it is called metaxylem. Metaxylem develops after the protoxylem, but before secondary growth. Protoxylem is distinguished by narrower vessels developed from smaller cells. Metaxylem cells are usually larger. Tracheids, vessels, xylem parenchyma and xylem fibers are the constituents of xylem.

a) Tracheids: Tracheids are elongated cells with slender and sharp ends. After lignification, their lumen may become narrower, and in that case transportation of water occurs mainly through the lateral paired pits on their walls. Thickening of walls is of different types, such as, elliptical, spiral, scalariform, reticulate and pitted. Tracheids are found in ferns and gymnosperms, and are also present in the primary and secondary xylem of angiosperms. Their main function is the conduction of cell sap and to provide the organs with proper rigidity. Sometimes they also store food.

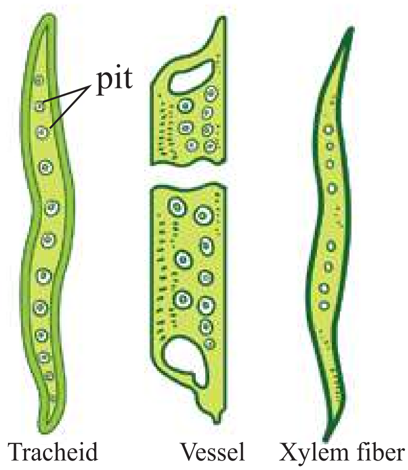


Figure : 2.14 Different types of xylem

b) Vessels: Vessels are short, tubular in structure, and are connected from end to end. Vessel cells develop a long tube when their terminal walls are dissolved. This is how a narrow continuous channel is developed for the upward movement of sap. In their early stage of development, the cells are filled with protoplasm. Eventually they die by losing protoplasm with the progression of their growth. Vessels walls also become differently thickened like tracheids, such as scalariform, spiral, elliptical, pitted etc. A vessel is several centimeters long. But they may be much longer in trees and creepers. They are found in almost all the parts of angiosperms. Some advanced members of gymnosperms such as *Gnetum* contain primary type of vessels. Their main function is to transport water and minerals and to provide the organs with proper rigidity.

c) Xylem parenchyma: The parenchyma cells in the xylem are called xylem parenchyma or wood parenchyma. Their walls may be thick or thin. The parenchyma cells in the primary xylem have thin walls, but those in secondary xylem are thick walled. Their main functions are storage of food and transportation of water.

d) Xylem fiber: The sclerenchyma cells in the xylem are called xylem fibers or wood fibers. The ends of this type of cells are tapereds. Mature cells do not contain protoplasm, and so, become dead. These cells provide plants with mechanical support. They are present in the xylem in dicots. Transportation of water and minerals, storage of food and giving mechanical support and strength to plants are their main functions.

Phloem: The phloem tissue organises the vascular bundle in association with the xylem. The xylem transports water as raw materials of food, and the phloem conducts food produced in leaves to the different parts of a plant. This type of tissue is composed of sieve tube, companion cell, phloem parenchyma and phloem fiber.

a) Sieve Cell: These are special types of cells. Sieve cells are arranged end to end and make a tubular structure called the sieve tube. The cells are separated from each other with a sieve like plate called the sieve plate. The protoplasm in a sieve cell is closer to the wall, so that a hollow lumen is developed for the conduction of food. Their walls are lignified. Mature sieve cells do not contain nucleus. Companion cells and sieve tubes are present in the phloem of all the angiosperms. Their main function is to conduct food produced in leaves to the different parts of a plant.

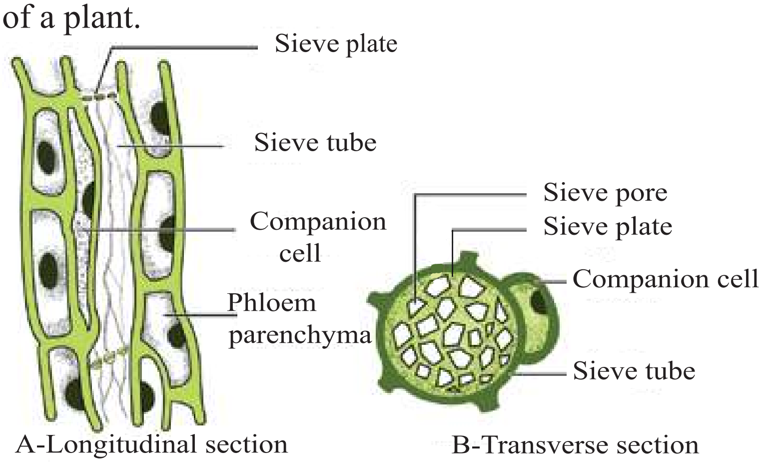


Figure: 2.15 Phloem tissue

b) Companion cell: A parenchyma cell is found along with each sieve cell and its nucleus is much larger. It is assumed that the nucleus of a companion cell controls some activities of its neighboring sieve cell. A companion cell is turgid with protoplasm and thin-walled. They are not found in the phloem of ferns and angiosperms.

c) Phloem parenchyma: The parenchyma cells in phloem are called phloem parenchyma. These types of cells are thin walled and have protoplasm like other parenchyma cells. They help store and conduct food. They are found in ferns, gymnosperms and angiosperms, but not in monocots.

d) Phloem fiber: Phloem fibers are sclerenchyma cells. These long cells are arranged end to end with each other. They are also called bast fibers. The fibers of jute are such bast fibers. These types of fibers are developed at the time of secondary growth of plant parts. Pits are present on the walls of these cells. Through the phloem tissue, food produced in leaves and stored in roots are simultaneously conducted up and down.

2.3.2 Animal tissues

In multicellular animals, many cells together may be involved in a special function. Arising from the same embryonic cell when one or more than one type of cells remain in a particular part of the animals body and collectively perform a common function, this is called Tissue. That is to say, cells of a particular tissue are similar as to their origin, function and structure. The study of the different types of tissue is called Histology. The differences between tissues and cells are specific. Cell is the structural and functional unit of tissue. For example, red blood corpuscles, white blood corpuscles, platelets are different types of cells. These are called connective tissues. The liquid connective tissue takes part in different physiological processes.

In the human body there are different types of cells, which are engaged in different activities. For exemple, nerve cells spread within the human body and form a network. These cells receive stimuli and send it to the brain and send off impulses from the brain back to the specific organs. Nerve cells in the ear and eye help in vision and hearing. Due to the lack of different kinds of nerve cells, most animals can not differentiate the exact colour of the objects unlike humans. Many animals can see only at day time or at night.

Muscle cells are used in all kinds of activities : for example, writing, walking and movement. Three kinds of blood cells are engaged in different activities. Red blood corpuscles absorb oxygen from the lungs and transport oxygen from the heart to different cells of the body through arteries and capillaries. White blood corpuscles prevent disease.

Platelets are responsible for starting the process of blood clotting. As a result, bleeding is stopped if there is a wound. Besides providing cover to the body, integumentary cells perform different functions according to their location. Hair grows from the integumentary cells of the head. Sweat is secreted from the sweat glands. Bone cells constitute bones with deposition of minerals or cartilage, which makes structure and supports the body.

Types of Animal Tissues

On the basis of nature and number of cells, and the presence or absence of the intercellular materials or matrix secreted by cells, tissue is divided into four main categories. The functions of these tissues are described below.

1. Epithelial Tissue

This tissue functions as the lining of various organs. But the function of this tissue is not only to provide cover to the organs. There are more functions: protection of underlying tissues; secretion of waste products, including protein; absorption of water and nutrients; transcellular transport of specific materials. The cells of the epithelial tissue lie closely or side by side on a base membrane. Based on the size of the cell, the location in the animal body and the nature of work, this tissue is of three types :

(i) Squamous epithelial tissue: Cells of this tissue are flat like scales. The nucleus is large.

Example : Wall of the Bowman's capsule of kidney. Besides providing cover, it is mainly active in filtration.

(ii) Cuboidal epithelial tissue: Cells of this tissue are cuboidal; i.e. the length, width and height of the cells are nearly equal.

Example: Collecting tubules of the kidney, mainly active in transportation and covering.

(iii) Columnar epithelial tissue: Cells of this tissue are narrow and elongated like a column.

Example : Found in the internal wall of intestine of vertebrates, mainly active in secretion, protection and absorption.

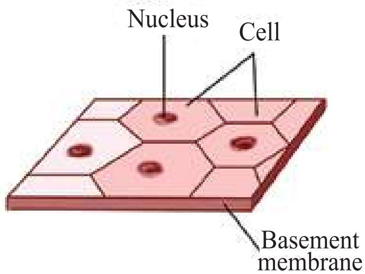


Figure: 2.16 Squamous epithelial tissue.

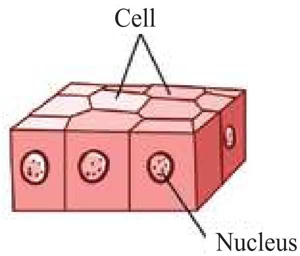


Figure: 2.17 Cuboidal epithelial tissue.

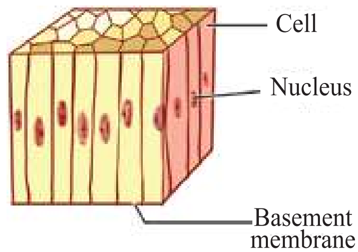


Figure: : 2.18 Columnar epithelial tissue.

Based on the number of cell layers arranged on the base membrane, epithelial tissue is of three types:

i. Simple epithelial tissue : On the base membrane cells are arranged in a single layer.

Example : Bowman's capsule of kidney, kidney tubules, wall of intestine.

ii. Stratified epithelial tissue : Cells are arranged on the basement membrane in more than one layer. There are some stratified epithelial tissues, the layers of which can change in minutes. Three or four layers can turn into seven or eight layers in a moment. That is why it is often called transitional epithelial tissue.

Example : Integument of vertebrate animals.

iii. Pseudo stratified epithelial tissue : Cells of this tissue are arranged in a single layer on basement membrane. The cells are not all of the same height, so, this tissue is stratified .

Example : Trachea.

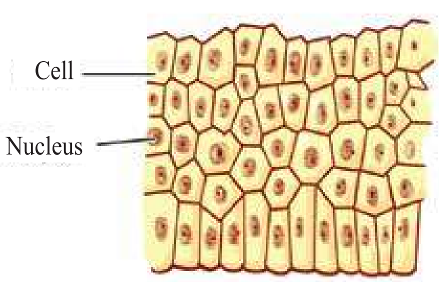


Figure: 2.19: Stratified or complex epithelial tissue.

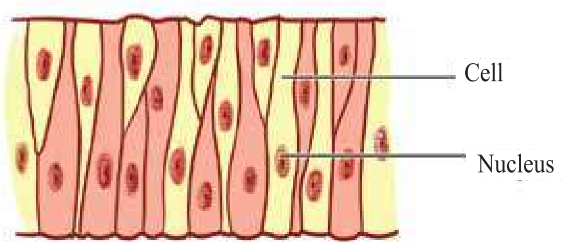


Figure: 2.20 Pseudo stratified epithelial tissue.

The cells of epithelial tissue are transformed for different functions, such as:

i. Ciliated epithelial tissue : These are found in the wall of the trachea of vertebrate animals.

ii. Flagellated epithelial tissue : These are found in flagellated muscular epithelial cells in the endoderm of *Hydra*.

iii. Pseudopodial epithelial tissue : Pseudopodial cells in the endoderms of *Hydra* and in the inter-membrane cells of vertebrate animals are the example of pseudopodial epithelial tissue.

iv. Reproductive tissue : These are specially transformed epithelial tissues which produce sperm and ovum. Taking part in reproduction, they maintain the continuation of species.

v. Glandular tissue : Epithelial tissue transformed into glandular tissue secrets necessary fluid. This tissue forms the external and internal covering of any organ or tubule. When transformed, this tissue takes part in protection, secretion, absorption, diffusion, transportation etc.

2. Connective tissue: Connective tissue, has more matrix compared to the number of cells is comparatively less. Based on structure and function connective tissue is mainly of three types :

(i) Fibrous connective tissue: This type of connective tissue lies below the body-integument and sparsely in muscles. In the matrix, different types of fibers are visible.

(ii) Skeletal connective tissue:

The internal structural tissue of the body is called the skeletal tissue. The skeletal tissue forms the skeletal system or the internal structure of the body, gives the body definite shape and firmness, helps in organ movement and locomotion, protects the soft and sensitive organs of the body (e.g, the brain, spinal cord, lungs, heart etc.), produces various types of blood corpuscles, and forms the surface for the attachment of voluntary muscles.

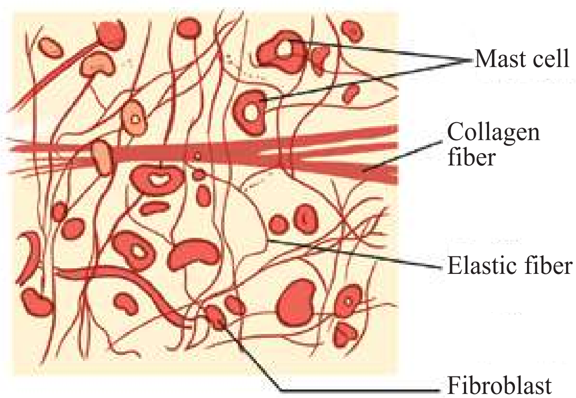


Figure: : 2.21 Connective tissue.

Depending on the formation, skeletal tissue is of two types: Cartilage and Bone Cartilage.

Cartilage : Cartilage is a kind of flexible skeletal tissue. Its matrix is firm and elastic, and the cells contain lacunae. The nose and pinna of the ear of human are made of cartilage. Besides that, in the humerus, femur etc. cartilage cover the two ends of the bone which protects the bone from rubbing.

Bone : Bone is hard, fragile and inflexible skeletal connective tissue, but the deposition of calcium within the matrix gives it strength .

(iii) Fluid connective tissue : The matrix of the fluid connective tissue is liquid and mobile. Different kinds of organic colloids are soluble in the matrix. The main function of the vascular tissue is to maintain circulation in the interior of the body, and it plays a special role in protection from diseases and blood clotting. Fluid connective tissue is of two types, blood and lymph.

Blood

Blood is a type of alkaline, slightly saline, red liquid connective tissue. Flowing through the arteries, veins and capillaries, blood takes part in internal circulation. In warm blooded animals it maintains body temperature balance. Blood is formed of two components: (i) Plasma (55%) and (ii) Blood cells or Blood corpuscles (45%). Plasma is the liquid part of blood. It is yellowish in colour. It contains 91-92% water and 8-9% organic and inorganic materials. The organic substances include various types of blood protein and waste materials. Blood cells are of three types: Red blood corpuscle (RBC) or Erythrocyte, White blood corpuscle (WBC) or Leucocyte, and platelets or Thrombocyte. Red blood corpuscles contain an iron compound called haemoglobin. The red colour of blood is due to the presence of haemoglobin. Haemoglobin easily mixes with oxygen to form the oxyhaemoglobin compound, which carries oxygen to the different parts of the body. Leucocytes destroy harmful microorganisms and protect the body against diseases. There are various kinds of white blood cells in the human body. Thrombocytes take part in blood coagulation or blood clotting. It will be discussed in details in the sixth chapter.

Lymph

A yellow coloured and slightly alkaline liquid stored within the intercellular spaces of the human body is called lymph. This is collected by small ducts and forms an independent system and is called the lymphatic system. Lymph contains lymphocyte cells and is called lymphoid cell.

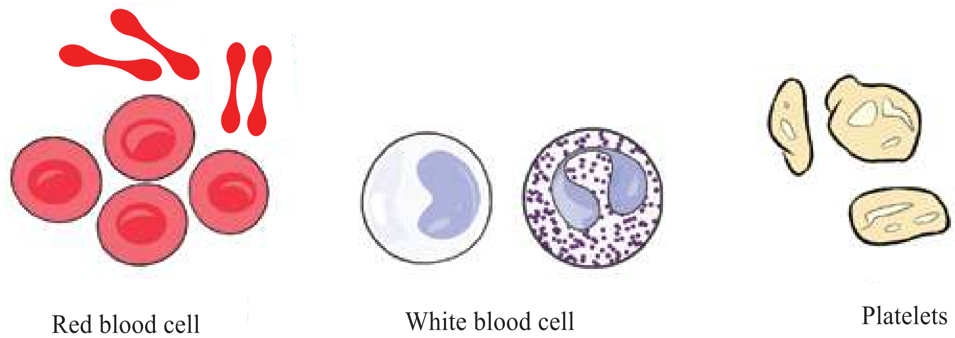


Figure 2.22 : Different types of blood cell

3. Muscular Tissue

Growing from the mesoderm of the embryo, the particular type of tissue capable of contracting and expanding to affect movement and tissue forming the muscles of vertebrate animals is called Muscular tissue. Matrix is nearly absent in muscular tissue. Muscle cells are delicate, elongated and fiber-like.

Myofibril with transverse striations are called striated muscles and those without striations is smooth muscle. Through contraction and expansion, muscle cells take part in organ movement and internal circulation.

Based on location, structure and functions, muscle tissue is of three types: voluntary muscular tissue, involuntary muscular tissue and cardiac muscle.

i. Voluntary or Striated muscular tissue : This can be contracted or expanded at the will of the animal. The cells of the voluntary muscle tissue are tubular, unbranched, and have transverse striations. These generally have more than one nucleus. This muscle can contract or expand quickly. Since the voluntary muscle is adjacent to the bone system, thats why it is also called skeletal muscle. For example, muscles of the hand and leg of human beings.

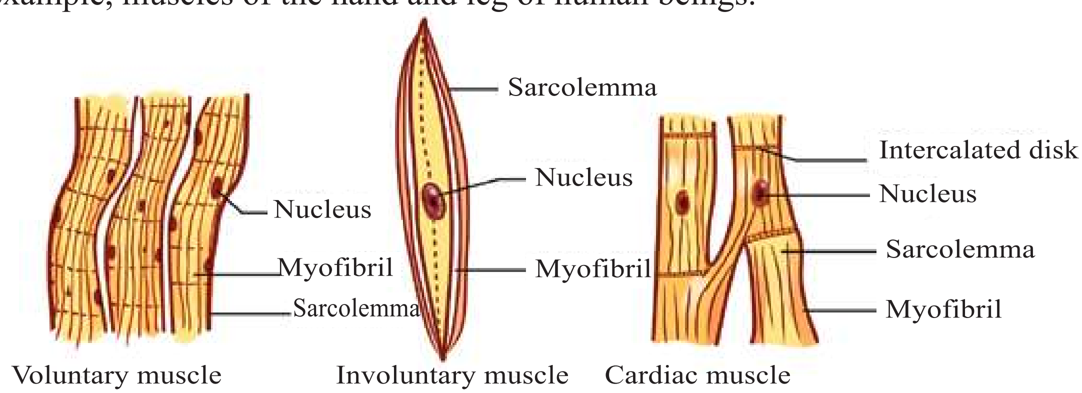


Figure 2.23 Different types of muscles

ii. Involuntary or Smooth muscle : The contraction and expansion of this muscle tissue does not depend on the will of the animal. This muscle tissue is spindle shaped and faintly branched. Transverse striations are not present. That is why this muscle is called unmarked smooth muscle. Involuntary muscles are found on the walls of blood vessels, alimentary canal, etc. of vertebrate animals. Involuntary muscles mainly take part in the internal circulation of body, such as, intestinal peristalsis in food digestion.

iii. Cardiac muscle : The special type of involuntary muscle that forms the heart of vertebrate animals is called the cardiac muscle. The cells of this muscle tissue are tubular (very similar to those of voluntary muscle), branched, and have transverse striations. Between the cells of this tissue, intercalated discs are present. The contraction and relaxation of this tissue is not dependent on the will of the animal. That is, the structure of heart muscles is like that of voluntary muscles, and the function is like that of involuntary muscle. So it is also called voluntary non-voluntary muscle. The cells of heart muscles remain joined together by branches, so they all contract and relax together. Through rhythmic contraction and relaxation, the cardiac muscle control the circulation of blood within the body from a certain stage of the embryonic condition till the last moment of death.

4. Nerve tissue : The particular type of tissue which forms the nervous system is called nervous tissue. It consists of numerous neurons. You will learn about its structure in chapter ten. It receives stimulus from the environment, such as : heat, touch, pressure, etc. The nervous tissue can transmit these stimuli within the body and according to that, can make the appropriate response. The special type of cells which form nervous tissue are called nerve cells or neuron. An ideal neuron has two parts – cell body or soma and neuronal process or neurite; the neurites can be of two types – axon and dendrite. A neuron cell body is polygonal and nucleated.

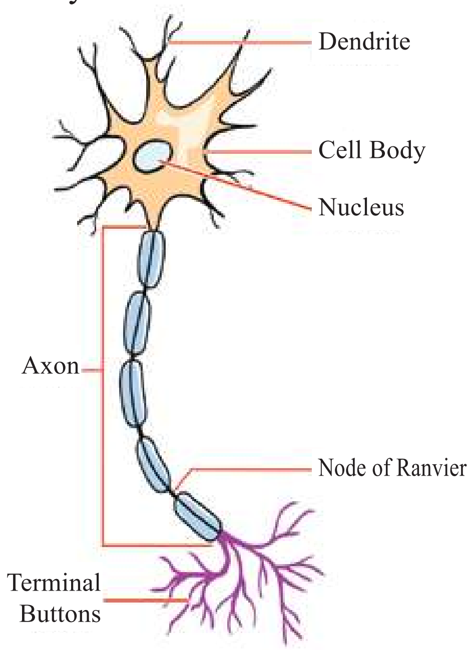


Figure 2.24 : A neuron

The cytoplasm of the cell contains mitochondria, ribosome, golgi body, endoplasmic reticulum, etc. But there is no active centriole in the cytoplasm of neuron, so the neuron cannot divide. Cell body is surrounded by many small, prolong parts. It is called dendron and the branches of dendron is called dendrite. Dendrite is one or more than one in number. From the cell body of the neuron a long nerve fiber emerges, which is attached to the dendrite of neuron. This is called an axon. A neuron has only one axon. Between adjoining neurons, a bridge is formed by the union of the axon of one neuron with the dendrite of another. This is called synapse. Through the synapse, nerve stimuli from one neuron are transmitted to the next neurons. Nerve tissue receives stimulus and transmits it to the brain, and the brain responds to it. In higher animals, nerve tissues store memory and control the work of the different organs of the body and coordination among them.

There is a common belief that we use only 10% of our brain , but this is not true. In fact in usual conditions, human beings or any other animal make 100% use of the brain. It is true that not all the parts of brain remain equally active at the same time. But we make use of all of the parts of the brain from time to time. It is also not correct that at any one time no more than 10% of the brain can be used. There is no limitation.According to evolution, there is no reason to impose such a limit.

2.4 Organ and System

A part of the animal body formed by the combination of one or more than one type of tissues performing a particular function is called an organ. That is to say, in any organ there may be one or more than one type of tissues and that organ performs a particular function. The branch of biology where organs are discussed is called Morphology.

According to location, there are two types of organs in the human body. The branch of Biology where the morphology of external organs like eye, ear, nose, hand, etc. are discussed is called External Morphology. The branch of Biology where the internal organs of the organism are discussed is called Internal Morphology or Anatomy. Stomach, duodenum, ileum, rectum, heart, liver, pancreas, spleen, lung, kidney, testis, ovary etc. are human internal organs.

To perform various physiological functions, such as digestion, respiration, excretion, reproduction, etc. several organs together form the organ system. In human and in other animals some of these systems are described below-

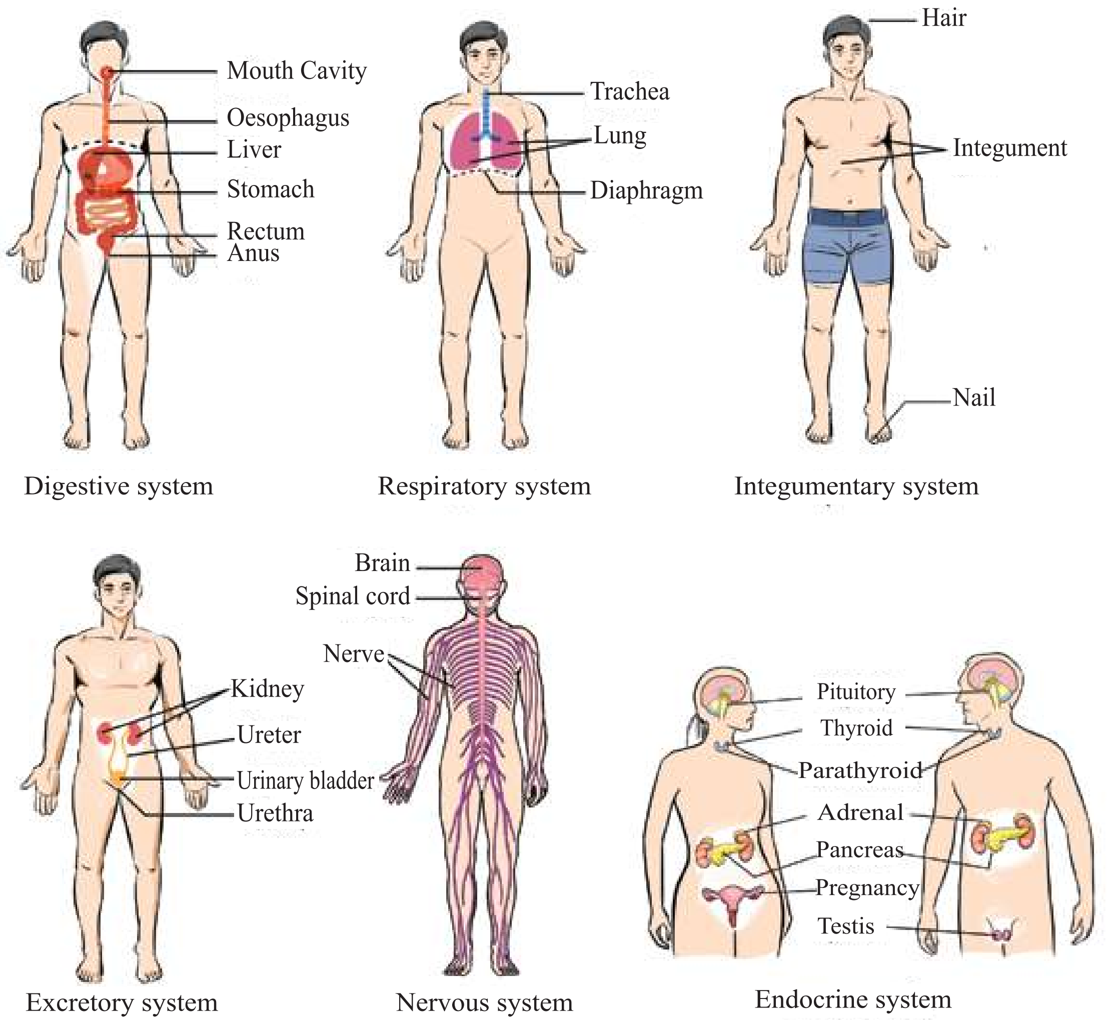


Figure : 2.25 Simplified structure of various system of human body

1. Digestive system : This system is associated with the ingestion of food, digestion, absorption and removal of undigested faecal materials.The digestive system has two main parts:

Digestive canal : This canal is formed with mouth aperture, mouth cavity, pharynx, oesophagus, stomach, duodenum, ileum, rectum and anus.

Digestive glands : The salivary glands, liver and pancreas work as digestive glands. The secretion from these gland helps to food digestion.

2.Respiratory system : In humans the respiratory system consists of the nasal aperture, pharynx, larynx, trachea, bronchus, bronchioles, alveoli and a pair of lungs.

This system uses oxygen taken from the environment to produce energy, by the oxidation of food present in the body cells. This energy helps in doing daily work.

3. Nervous system : The function of this system is to receive external and internal stimuli of the body and to create appropriate sensations. The nervous system is made up of the brain, the spinal cord and cranial nerves and spinal nerves. The nervous system has also a part named the Autonomous nervous system. This part of the nervous system controls the involuntary actions of the body.

4. Excretory system : Due to various physiological metabolic reactions some nitrogenous waste materials are produced within the body as by-products. These materials are generally toxic to the body and need to be removed. The process of removing unnecessary and nitrogenous waste materials from the body is called excretion. The system through which the excretion is performed is called the excretory system. The excretory system of humans consists of a pair of kidneys, a pair of urinary ducts, one urinary bladder, and one urethra.

5. Reproductive system: Through this system, an animal produces one or more offsprings to maintain the continuation of species. This system consists of gamete producing and embryo bearing organs. When mature, an animal becomes capable of reproducing. In humans, the males possess the male reproductive system while the female possesses the female reproductive system.

6. Integumentary system: The membrane covering the body from outside is called integument or skin. This system covers the body, and protects the body from external injury or attack of harmful microbes. It also controls the movement of various materials through outside and inside of the body. It also protects the liquid parts inside the body.

7. Endocrine system: There are a few ductless or endocrine glands within the bodies of animals. These produce hormones and have no ducts for transportation. Only blood carries the hormones from one place to another. The endocrine system is made up of endocrine glands such as Pituitary, Thyroid, Parathyroid, Islets of Langerhans of Pancreas, Suprarenal, etc.

2.5 Microscope

Just as a weapon is important to a fighter and a telescope is important to an astronomer, the microscope is essential to every student of biology. Very small objects, invisible to the naked eye, can be seen with a microscope. The compound microscope you have in your school is able to observe very small objects with the help of light. This type of microscope is called light microscope. The microscope in which electrons are used instead of light is called the electron microscope. Light microscopes are of two types: simple and compound microscope.

2.5.1 Simple Microscope

In this microscope a flat stage made of glass is set with a vertical pillar on its base. Two clips are attached on the two upper sides of the stage to hold the slide with the object to be observed. There is a sub-staged two-sided mirror set with the vertical column of the microscope to reflect light from an external source up through the bottom of the stage. A continuous tube from the base holds a lens in its arm with a ring. Setting the lens in the ring, by adjusting the screw, an object put on the slide of the stage can be focused. If needed, the task of observing an object can be started by focusing on it with the reflected light. The base, which holds the whole thing, is called the foot.

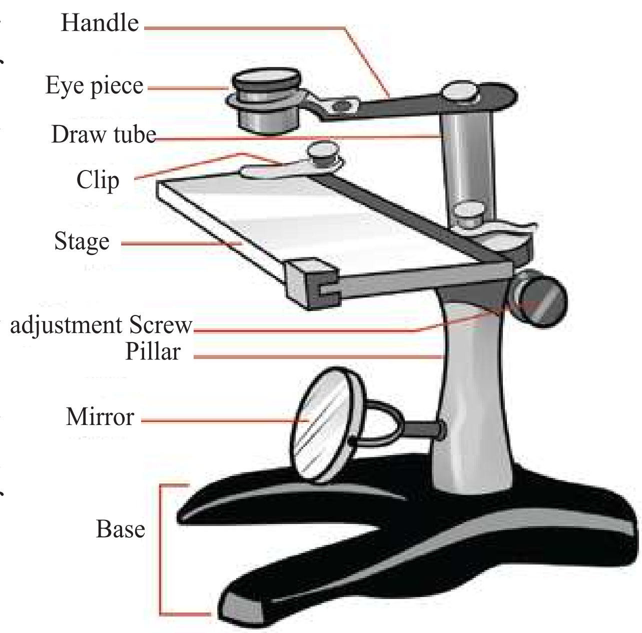


Figure 2.26: A simple microscope

2.5.2 Compound Microscope

It is useful to understand the different parts of a compound microscope before using the instrument. Take a look at the picture of it.

Stand: This is a vertical pillar on the base.
Arm: The curved part above the stand is called the Arm.
Base: The part below the stand that looks like a platform is called the base.
Stage: This remains attached to the lower part arm.

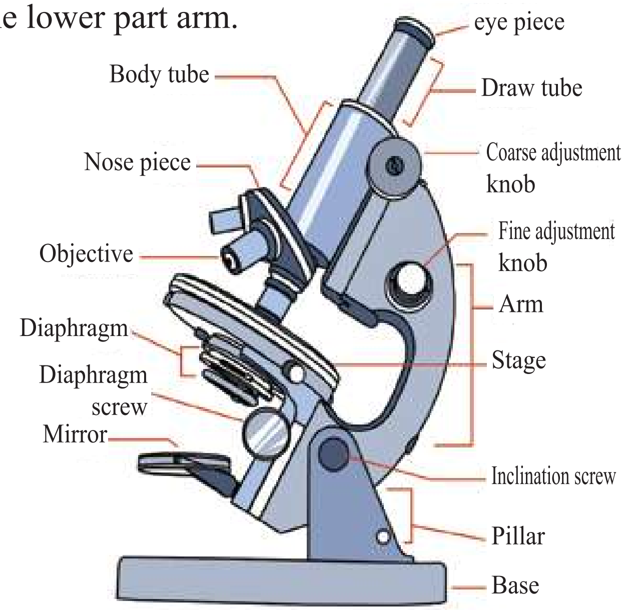


Figure 2.27: A compound microscope

Body Tube: It is the tubular part at the upper side of the microscope. One end of it holds the eye piece. The objective lenses are attached at the other end.

Nose piece and Objective: Below the body tube, the revolving part or turret is called the nose piece. Three objectives (lens) are attached to it. These are Low Power objective (10x – 12x), High Power objective (40x – 45x) and Oil Immersion objective (l00x). Some machines may have another objective named Screening objective (4x – 5x). The numbers mentioned here with x indicate how many times magnification occur by the lens or lens cooperative.

Eye piece: One (monocular) or two (binocular) eye pieces (lenses) are attached to the upper part of the body tube. Its projection power is usually 10x – 20x.

Fine Adjustment Knob: This is a small knob used for fine tuning. By rotating of these knob the stage can be ups or down and as a result slides can be taken inside or outside the focal length, causing fine tuning of the focus on the object. It is used after using the coarse adjustment knob.

Coarse Adjustment knob: This is a big round knob used for focusing on the object. By turning the knob, the object can be brought into approximate focus. By slightly rotating of this knob the stage can be moved well. Coarse adjustment is done by this knob.

Sub stage Diaphragm and Condenser: The Sub stage is below the stage and it can be elevated or lowered. A condenser is attached to it. The condenser contains a diaphragm that controls the intensity of light.

Illuminator: A source of light (such as mirror or light bulb) located at the centre of the base from which light enters the lens through the condenser.

Use of a compound microscope: To use the natural light for illumination of the object,the microscope needs to be set in a sufficient lighted place. At first, the mirror of the microscope is adjusted such that reflected light illuminates the object to be observed on the slide, passing through the hole of the stage. If an artificial illuminator is present in the microscope, it is enough to use that only. The clips on the stage are placed on the slide to hold it properly.

Now, after moving the nosepiece, the objective of lowest power would be set straight on the slide. Using first the coarse adjustment knob and then the fine adjustment knob, the object is accurately brought in focus. Now the magnified object can be viewed, keeping the eye on the eye piece lens. If required, the fine adjustment knob can be used to make vision more clear. At the time of viewing an object, both the eyes should be kept open. Though it is little hard, practice will make it easier. The eyes get soon tired if one is used and the other is closed. If the lens of higher power is required, moving the nosepiece, the expected lens can be set to focus the object but in this case, students can seek the help of a teacher.

Staining

When a fine layer of cell or tissue is observed through microscope, it becomes difficult to differentiate it from the liquid medium it is immersed in. One of the techniques to solve this problem is to use dye to define and enhance contrast of the cell or tissue. Staining can be done with such a degree of fineness that one can preferentially stain only a particular cell, a cell component, an organelle or a particular component of a tissue. This is called slide staining. Materials used for dying or staining are called Stains.

2.5.3 Electron Microscope

The shorter the wavelength of the light used, the better the resolution. Ordinarily, it is not possible to focus an objects smaller than half of the wavelength in the microscope. The wavelength of photons of visible spectrum of light is 400 – 700 nm. So even with a high quality light microscope, an object less than 200 nm cannot be well magnified even after combining a number of lenses. As a result, besides the plasmalemma, the nucleus and the cytoplasm of a cell, no other part is visible clearly in a light microscope. Organelles in the cytoplasm cannot be differentiated. In order to solve this problem, electron waves are used instead of photons as the wavelength of electrons is much shorter than that of photons. In place of ordinary lens, a powerful electromagnet is used as it can change the course of electro waves just like glass changes the course of light. This allows organelles in a cell to become clearly visible. The microscope where electron wave is used for magnification, is called Electron microscope (not electronic).We cannot directly view the image magnified by the electron wave. After being processed, the image is seen in the monitor of a computer attached to the electron microscope.

Figure 2.28 : An Electron Mıcroscope

Individual Activity

Activity-1: Observation of a plant cell (onion cell) under a microscope.

Essentials: Onion, blade, slide, cover slip, watch glass, brush, glycerine, safranin solution, dropper, blotting paper and microscope.

Procedure: Remove the outer dry scale leaves of the onion. Now, take a swollen, fleshy scale leaf. After removing a small outer layer from the surface of the scale with the help of a blade, put it in water in a watch glass. Take safranin solution in another watch glass. Now with the help of a brush pick up the surface layer of scale from the water of first watch glass and keep this into safranin solution of second watch glass. Wait for 30 seconds. After that using a brush take the surface layer from safranin stained watch glass into the water of the first watch glass. It is notable that the safranin has been used as the stain here. Take 2-3 drops of glycerine in the center of a clean dried slide. Keep surface layer into the glycerine of slide from the watch glass with the help of a brush. After that put a cover slip on it. Care should be taken so that there is no air or bubbles under the cover slip. The excessive solution and glycerine outside the area of the cover slip with the help of the blotting paper.

Observation: Observe it under the objective with the lowest power in a compound microscope. You will be able to see rectangular and thin walled cells. Now, observe them with an objective with higher power. In every cell, you will find thin, granular protoplasm, vacuole and a sided nucleus. Draw and label what you have seen.

Individual Activity

Activity-2: Observation of an animal cell (buccal mucosa cell) under a microscope.

Essentials: microscope, slide, cover slip, methylene blue solution, glycerin, dropper, blotting paper, cotton swab.

Caution: Methylene blue is harmful to health, so gloves, goggles, mask etc. should be used while working with it.

Procedure: Place 1-2 drops of water on one end of a clean slide. Then use a clean, dry finger to gently rub the inside of the cheek against the shiny lining inside the mouth, causing some of the epithelial cells to stick to it. Take teacher's help to avoid injury while doing this. Hold the side of the finger that has been rubbed into the cheek in the water on the slide and rub evenly towards the other end of the slide about three-quarters of the way to spread the water. Since animal cells do not have cell walls, rubbing with too much force can easily tear the cells, so be careful! Then spread a few drops of methylene blue solution with a dropper on the watered part of the slide. Make sure the slide is parallel to the ground while doing the work. Then wait for 2-3 minutes. Note that methylene blue has been used as a stain here. Now drop 2-3 drops of glycerine on the centre of the slide with a dropper and slowly place a cover slip on top of it parallel to the slide. Care should be taken not to allow air or bubbles to enter under the cover slip. Gently tap the cover slip so that the cells spread evenly underneath. Carefully absorb excess solution/glycerin beyond the area of the cover slip with blotting paper.

Observation: Focusing a little under the microscope will reveal many polygonal cells. No cell wall, plastid or vacuoles can be seen in them. A thin cell membrane or plasmalemma surrounds the cell and a nucleus in the centre. If the cells are not well spread, they may appear overlapping.

Note: The test can be done without using methylene blue or any other stain. In that case visualization of the cells would be somewhat laborious.

Exercise

Short answer questions

1. What is meant by cell?
2. What are the functions of plastids?
3. What is the relation between tissue and organ?
4. What is the importance of endocrine glands?
5. Which part of cell is called the 'Power house' of the cell?
6. What are the functions of blood?

Essay type questions

1. Describe the structure of a mitochondrion with a labeled diagram.
2. Make comparative discussion on the structures and functions of different types of simple tissue.
3. Discuss the structures and functions of animal tissue.

Multiple choice questions

1. Which is the function of lysosome?

   a. to produce food b. to produce energy
   c. to engulf microorganisms d. to synthesize protein

2. *Amobea* is an animal cell, because it has-

   i. well formed nucleus
   ii. pigments
   iii. cell membrane

Which one is correct?

a) i & ii b) i & iii
c) ii & iii d) i, ii & iii

Read the following stem and answer the questions 3 and 4.

On the way to his village home, Ruhit saw a man extracting fibers from a jute plant.

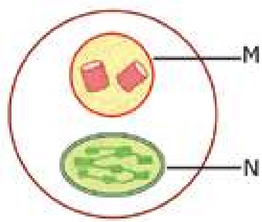
3. What kind of tissue mentioned in stem is being collected?
   a. Parenchyma b. Collenchyma
   c. Chlorenchyma d. Sclerenchyma

4. The characterstics of the tissue mentioned in stem are:
   i. cell wall is lignified
   ii. cell wall is irregularly thickened
   iii. protoplasm is absent in the cell

Which one of the following answers is correct?
   a. i & ii b. ii & iii
   c. i & iii d. i, ii & iii

Creative questions

1.



a) What is plasmalemma?
b) Why are plastids called colour forming organs?
c) Why is the organelle marked with N important for the living world? Explain.
d) What types of problem will appear in living bodies if the part marked M is absent? Analyse it.

2.

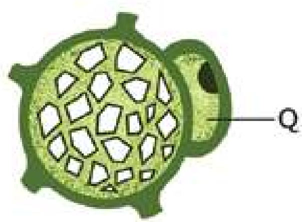


Figure A

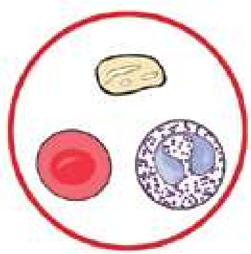
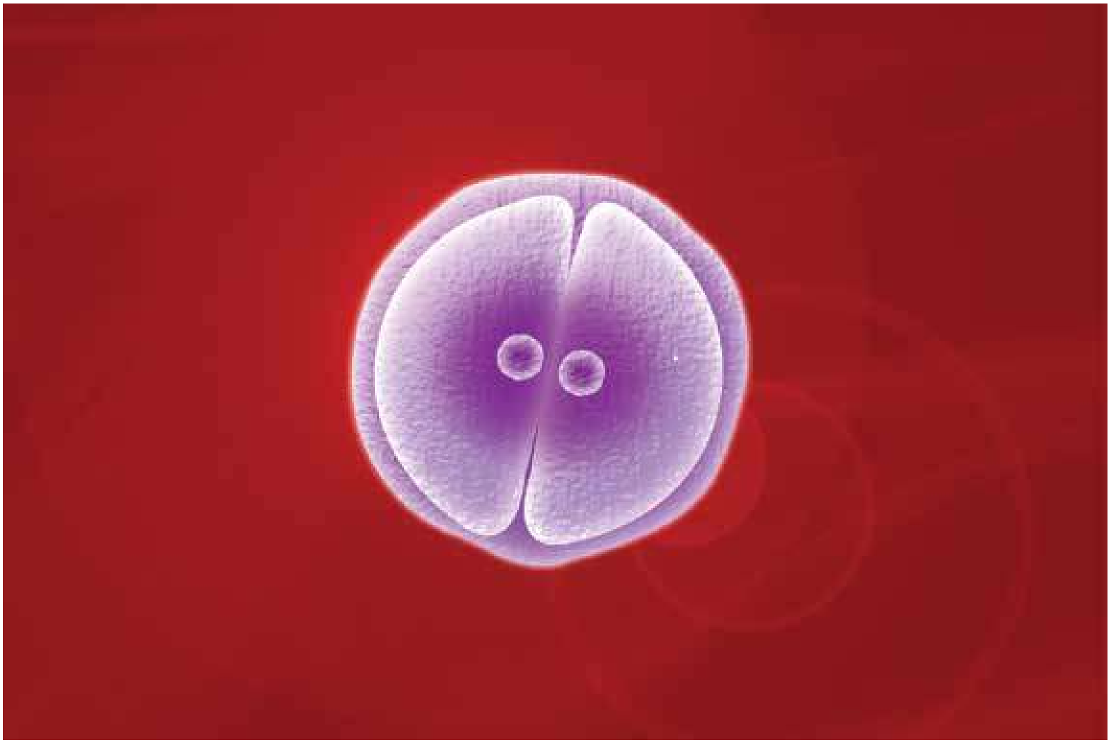


Figure B

a) What is muscle tissue?
b) How does skeletal tissue protect the brain?
c) Explain the cause of the location of part marked Q shown in figure A?
d) Between Figure A and B, which one plays an important role in physiological activities, besides conduction? Explain your answer with logic.

Chapter Three
Cell Division



Different types of cell division occur in all types of organisms from unicellular to multi-cellular. One kind of cell division causes increases in body growth of the organism, and in the other type of cell division, developed reproductive cells and in some other cases organism multiplies through binary fission. In this chapter, you will learn how different types of cell division occur.

At the end of this chapter, we will be able to-

- explain the concept of cell division;
- describe the types of cell division;
- explain mitosis;
- describe the stages of mitosis;
- analyse the significance of mitosis cell division in living bodies;
- explain meiosis;
- explain the role of meiosis in the development of reproductive cells;
- understand the role of cell division in maintenance of the continuity of life.

3.1 Cell Division and its classification

Every living body is made up of a cell or cells. The life of every organism starts with a single cell. In fact, every cell is originated from a pre-existing one. The increase of cells in number through division is very natural and important. The bodies of some organisms are composed of a single cell. They are called unicellular organisms, such as, bacteria, *Amoeba, Plasmodium* etc. These organisms multiply themselves from the division of a single cell. Other organisms are composed of more than one cell. They are called multicellular organisms. Humans, mango and banyan trees etc. are composed of crores of cells. A giant banyan tree also initiates its structure after the formation of a single cell (zygote by the union of two gametes). After the fertilization of an egg, the structure of a human is achieved with crores of cells dividing through the process of cell division. Again, male and female gametes are produced for the emergence of new generations. Cells divide through the process of cell division for the growth and reproduction of organisms.

Types of cell division:

Two important types of cell division that occur in living beings are: Mitosis and Meiosis.

3.2 Mitosis

Through this process of division an eukaryotic cell divides into two identical daughter cells. In this process, the nucleus and chromosomes are divided only once, and two identical daughter cells are produced with the same type of chromosomes in number, physical and structural features as their mother cell. This is also known as equational division. Mitosis occurs in somatic cells of eukaryotic organisms and through this division, as the number of cells increases, plants and animals grow. The process usually takes place in the body cells of animals and in the meristems of the plant parts growing, such as the tip of stems and roots, plumule and radicle, developing leaves, buds etc. This kind of cell division also occurs in lower plants and animals during asexual reproduction.

3.2.1 Stages of Mitosis: Mitosis is a continuous process. During mitosis, karyokinesis is usually followed by cytokinesis. Karyokinesis and cytokinesis represent the division of nucleus and the division of cytoplasm respectively. Before starting division, a cell has to prepare itself. This stage is called interphase. For ease of description, mitosis can be divided into five stages. They are: (a) Prophase, (b) Prometaphase, (c) Metaphase, (d) Anaphase, (e) Telophase.

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(a) Prophase: This is the first stage of mitosis. At the onset of the stage, the nucleus becomes little larger and chromatin fibers start condensing into short, thick and tightly coiled structures called chromosomes. Previously it is considered that this changes of chromosome occur due to water reduction but modern research shows that the matter is extremely complex process having no relation with water. At this stage, chromosome can be seen with a compound microscope. Though every chromosome then divides into two sister chromatids, at the centromere they remain attached. As the chromosomes are still tangled, it is difficult to easily count the number of chromosomes in a cell.

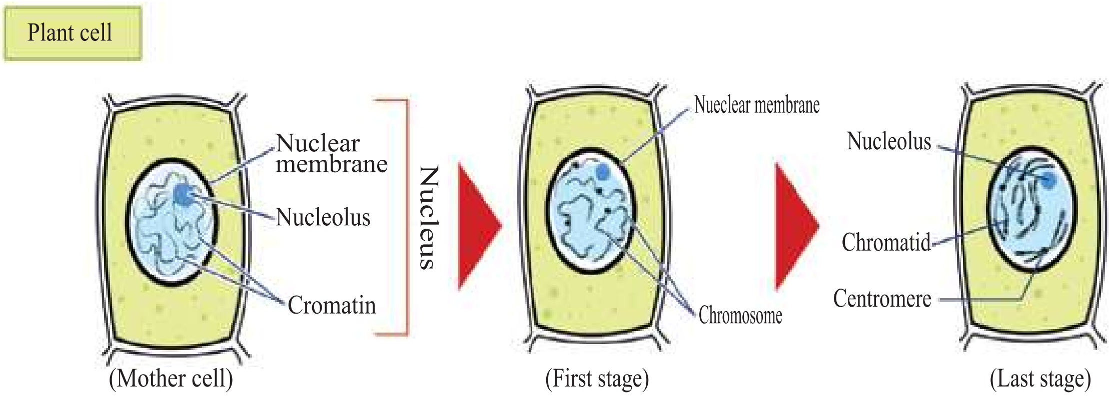

Figure: 3.01 Prophase (Plant cell)

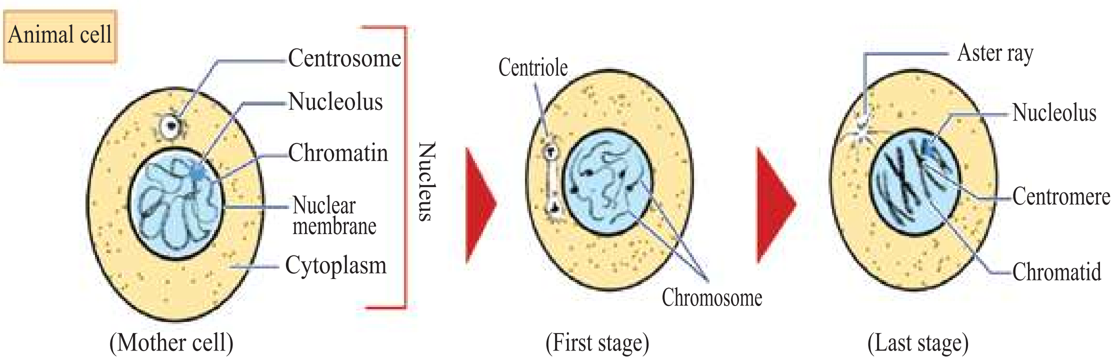

Figure: 3.02 Prophase (Animal cell)

(b) Prometaphase: Early in this stage, spindle apparatus with two poles is developed in plant cells from fiber protein. The middle plane of the spindle apparatus is called the equator. Some fibers of the spindle apparatus, made of microtibules of cytoskeleton, are stretched from one pole to the other. These are called Spindle fibers. At this stage, kinetochores in the centromeres of chromosomes attach to some fibers of the spindle apparatus. Kinetochores are

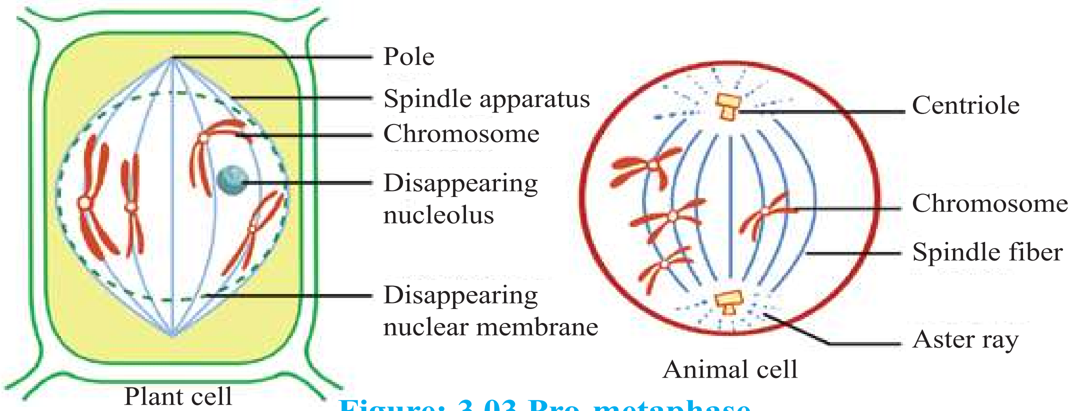

Figure: 3.03 Pro-metaphase

protein structures assembled on centromeres, and they link the chromosomes with mitotic spindles. These fibers are generally called traction fibers. They are also sometimes called chromosomal fibers as chromosomes are attached with them. Chromosomes then start assembling on the equatorial plane. The nuclear membrane and nucleolus start to disintegrate and disappear. In animal cells, the spindle apparatus is developed from centrioles, and the centrioles remain in the two poles with astral rays spreading out from them.

(c) Metaphase: At the onset of the stage, all the chromosomes assemble at the equator, from the two poles. The centromere of each chromosome remains on the equator but the two arms take positions towards the poles. In this stage, the

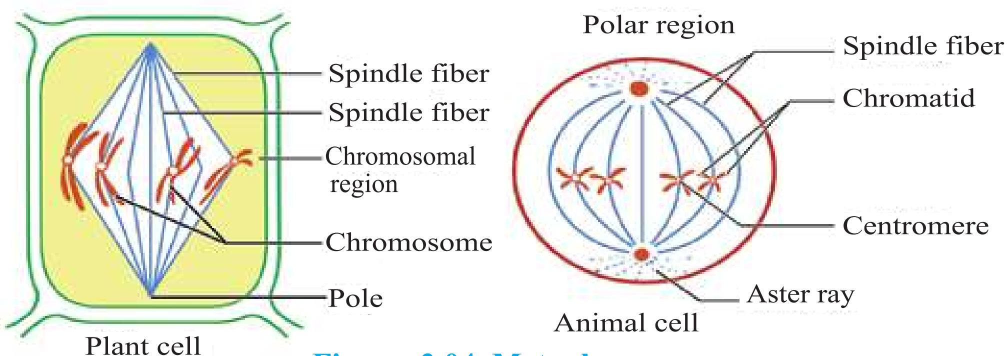

Figure: 3.04 Metaphase

chromosomes look short and thick. The two chromatids of each tend to be separated from each other. At the end of this stage, the division of the centromere starts. The nuclear membrane and nucleolus disappear completely.

(d) Anaphase: The sister chromatids become the two sister chromosomes and they are pulled apart. The cleaved centromere moves to the pole, while the chromatids trail behind. Each chromosome, splitting into two, moves to the two poles, and so the number of chromosome remains unchanged. On the

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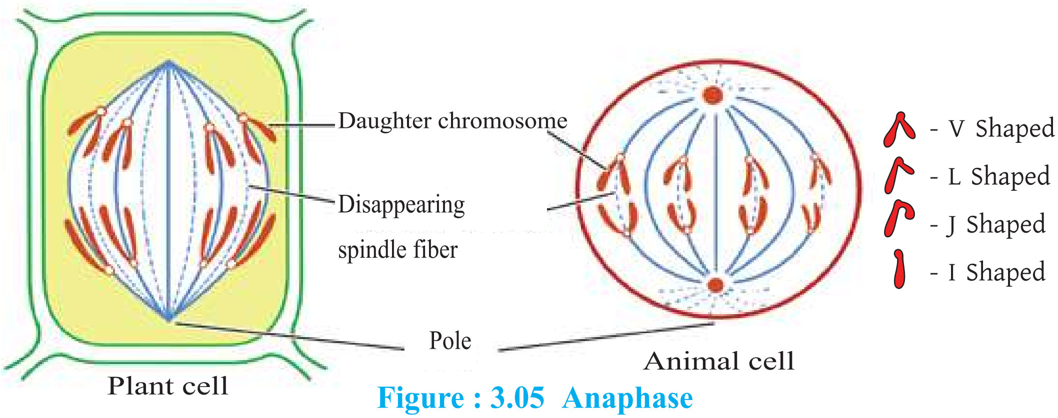


Figure : 3.05 Anaphase

centromere in the chromosome, the chromosomes look V, L, J or I shaped, and these chromosomes are called metacentric, sub-metacentric, acrocentric and telocentric respectively. At the end of the anaphase stage, the daughter chromosomes are completely pulled apart to the two poles and start their elongation.

(e) Telophase: This is the last stage of mitosis and a reversal of the prophase. Chromosome again starts to become thin and long. Previously thought that the increasing of water is the reason for this. But modern research has shown that it is a complex process and not depending on the amount of water in the chromosome. Finally they intertwined and form nuclear reticulum. The nucleolus also reappears. The nuclear membrane reappears around the nuclear reticulum. So, ultimately, two new nuclei are formed in the two poles. The spindle apparatus disintegrate and so, the spindle fibers gradually disappear.

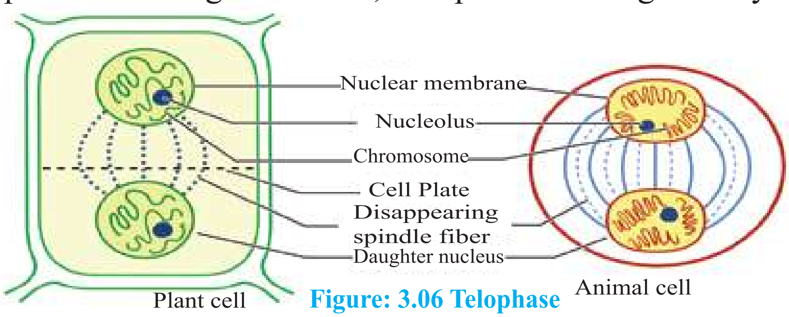


Figure: 3.06 Telophase

At the end of the telophase stage, some small parts from the endoplasmic reticulum aggregate in the equatorial plane, and collectively form the structure of the cell plate. Equal distribution of the cytoplasmic organelles is accomplished. As a result, two identical daughter cells are developed. In the case of an animal cell, a contractile ring on the plasma membrane at the equatorial plane pinches off the two nuclei.

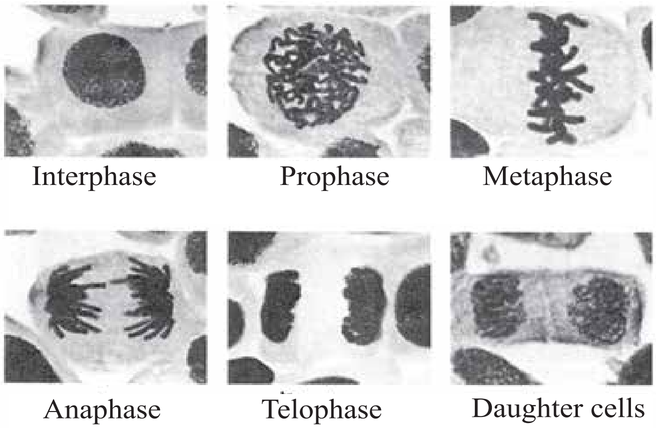


Figure 3.07: Different stages of mitosis division under light microscope

Group Activity

Activity: To prepare models of various chromosomes based on the position of centromeres.

Essentials: Rope or thread, art paper, glue, scotch tape, cutter, sign pen.

Procedure: First, we will prepare the model of a chromosome during the metaphase stage. Take two pieces of rope or thread of equal length. These two pieces will be the models of the two sister chromatids of a chromosome. Make a knot in the middle of the rope. This knot is the model of the centromere. If the knot is made properly, we will get a model of the metacentric chromosome, from whose centromere four arms seem to appear. Two of these four arms belong to one chromatid while the other two belong to the other chromatid. The length of all arms are equal.

Figure 3.08 : Different types of the model of chromatid on the basis of the position of centromere which is vissible in the phase of mataphase (from left to right)

Similarly, take two more pieces of rope or thread of equal length and prepare a model of a submetacentric chromosome by placing the knot a bit away from the center. If knots are placed near the poles, a model of an acrocentric chromosome will be made. And if the knot is placed right at the poles, then it will be a model of a telocentric chromosome. Now, use glue or scotch tape to stick these four kinds of models on an art paper. Label the models with a sign pen. Write Metaphase as the heading on the art paper.

Now, through the same process, prepare models of chromosomes seen in the Anaphase stage. First make the four models of metacentric, submetacentric, acrocentric and telocentric chromosomes of the metaphase stage. In the anaphase stage, each chromosome is divided into two parts along the centromere such that one chromatid with half of the centromere remains in each part. So here we will cut the chromosome model of the metaphase stage along the knot into two, so there is one chromatid in each part.

We will see that each of the two chromatids from the metacentric chromosome looks like the letter 'V' as the position of the centromere is at the middle of the chromatids. If the chromatid taken half from the submetacentric choromosome with the centromere a bit away from the center, it takes the appearance of English letter 'L'. Similarly, the chromatids taken from the acrocentric and telocentric chromosomes will look like 'J' and 'I' respectively. Now stick the model of these four chromatid models on art paper with glue or scotch tape. Label the model with the sign pen. Write the word Anaphase as the heading on this art paper.

Now present both art papers in the classroom. Explain how the chromosome or chromatid looks in metaphase or anaphase stage.

Significance of mitosis

The significance of mitosis in the living body of organisms is immense. The balance between the nucleus and cytoplasm of a cell in terms of volume and amount is maintained by mitosis. Through mitosis, the growth in the body of multicellular organisms occurs. All multicellular organisms start their life from a single cell zygote. The repeated division of this single cell produces innumerable cells and thus an organism grows to completion. It may seem that if the cells multiply one at a time, it would take a long time to take the complete shape of a living being (the human body has 30 trillion cells). But this is not true. All cells are capable of mitosis when provided with necessary nutrients. If each cell division takes one day to complete, the number of cells necessary for human beings can be created in 40 – 50 days.

As the number and feature of chromosomes remain unchanged in cells produced through mitosis, growth in organisms takes place systematically. Mitosis plays a role in the maintenance of the size, shape and volume of cells. Unicellular organisms reproduce through mitosis. Mitosis plays an important role in the vegetative reproduction of organisms and increasing the number of reproductive cells. It is essential to form new cells for growth and healing of injuries. The life span of some cells is predetermined and they are, accordingly, replaced through the process of mitosis. As identical cells are produced through mitosis, qualitative features of the living world remain unchanged. Mitotic errors may result in abnormal mass of cells called tumours, with or without cancer cells.

Tumour and cancer: All of us are familiar with the words ‘tumour’ and ‘cancer’. These are the results of irregular cell divisions. In mitosis, a cell divides into two, two cells divide into four and so on. The process remains controlled. If this control is lost due to any reason, cell division occurs in an irregular way. This results in the formation of a tumour.

The formation of cancer cells is also the result of uncontrolled, irregular cell division. Research has shown that various types of germs, chemicals or radioactivity can be responsible for the development of cancer cells. Two genes, E6 and E7 of the papilloma virus, produce a chemical substance that displaces two protein molecules which control cell division. As a result, the controlling factor of cell division is eliminated, and a tumour is formed. Sometimes these two genes amalgamate with those of host cell and stop the functions of protein molecules that control increase of cell. This leads to cancer cells or in other word cancer.

Cancer is a dangerous disease. Cancer can develop in the liver, lungs, brain, breasts, skin or uterus almost all organs of the body.

Group Activity

Activity: The teacher will group the students, ask them to present the different mitotic stages after drawing them on their own.

3.3 Meiosis

In this process of cell division, four daughter cells are produced from an eukaryotic cell. The nucleus divides twice and the chromosomes divides once in this process and the number of chromosomes becomes half in the daughter cells from that of the mother cell. So, the amount of DNA also become near about half. As the number of chromosome decreases this process of cell division is called reductional division.

The question is why meiosis occurs. In mitosis, the number of chromosomes in the daughter cells remains the same as that of their mother cell. Mitosis is essential for the growth and asexual reproduction of organisms. In sexual reproduction, the union of male and female gametes is required. If the number of chromosomes in the reproductive cells would be the same as the somatic cell, the zygote would contain twice number of chromosomes than that of the somatic cell. Suppose the number of chromosomes in a somatic reproductive cell of an organism is 4. In the zygote the number of chromosomes would be 8, and so the new organisms will have body cells with 8 chromosomes, that is, twice that of its mother organism. If every life cycle of an organism continues that way, the number of chromosome would be doubled again and again. In the second chapter, we learnt that chromosomes have the genes controlling the features of organisms. If the number of chromosome is increased life cycle after life cycle, the offspring will be fundamentally different. In sexual reproduction, even through the union of male and female gametes, the number of chromosomes remains the same generation after generation as the number of chromosomes becomes half in the reproductive cells than that of the mother cell. At the time of development of reproductive cells and in any stage of the life cycle of plants in lower groups, meiosis occurs. The feature of possessing half number of chromosome is called haploid. When the haploid (n) cells are fused, the state of cell having two sets of chromosome is called a diploid (2n).

As meiosis occurs, the features in the species of living organisms stay the same, generation after generation.

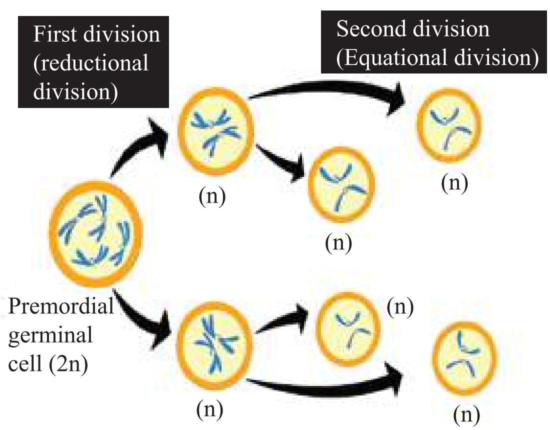


Figure: 3.09 concept of meiosis cell division

Meiosis mainly occurs in the primordial germinal cells during the development of gametes. Meiosis occurs in the anthers and ovules of flowering plants and in the testes and ovaries of animals. During the development of the haploid meiosis occurs in the zygotes of pollen from diploid pollen mother cells in haploid plants like fungus, algae and mosses.

Two consecutive divisions occur in a cell in the process of meiosis, called meiosis- I and meiosis-II respectively.

In the first division (meiosis-I), the number of chromosomes in a daughter cell becomes half that of its mother cell. The second division is simply mitosis.

Because of meiosis, the chromosome number in organisms remains constant. Genetic diversity is also found in species of organisms as the exchange of genes occurs during meiosis.

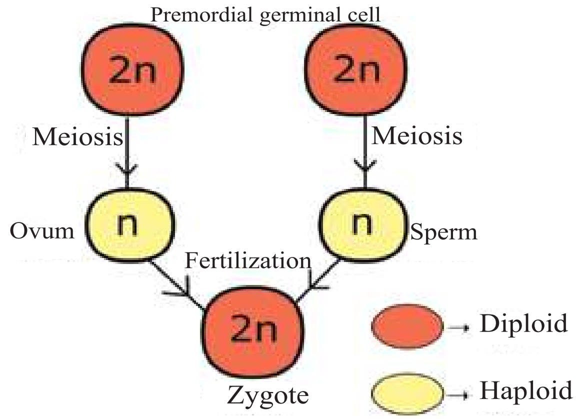


Figure: 3.10 Formation of zygote due to meiosis cell division

In reality, sometimes a new species may come into being if suddenly the number of chromosomes increases. For example, one species of frog *Xenopus laevis* was created when the chromosome set of another species *Xenopus tropicalis* was doubled. In somatic cells (not reproductive cells) of different members of the Plant kingdom (such as vegetables like potato), this is a normal process. Sometimes we select this species of plant intentionally, or even create them in a planned way because their size is comparatively bigger. Such species are helpful in meeting the increasing demand of food. Besides creating homologous chromosomes through genetic recombination, meiosis also contributes in maintaining genetic diversity or genetic variation. Through sexual reproduction, a population maintains its genetic diversity and creates unique individuals in each new generation.

Figure 3.11 : A. ***Xenopus tropicalis***
B. ***Xenopus laevis***

Genetic variation among the members of a species is what ensures that the species is able to survive in a changing environment. Ecosystems are not static, and species need genetic variation on which natural selection can operate so that they can adjust with a new or changed environment. If all of the individuals of a species are too genetically similar and have no genetic variation, then there is less possibility of surviving in a new situation. A single disease or change in the environment could drive the species to extinction. But if genetic variation exists in any species, there is the possibility of survival in a new environment. At least some members of the species will be able to escape danger that may be fall on them. Thus, meiosis increases the possibility of survival by creating genetic diversity.

Exercise

Short answer questions

1. What is cell division?
2. What is meant by equational cell division?

Essay type questions

1. Describe the different stages of mitosis with labeled diagrams.
2. Discuss the significance of mitosis.

Multiple choice questions

1. In which stage does a nucleus become larger?

   a. Prophase b. Metaphase

   c. Anaphase d. Telophase

2. Through meiosis-

   i. the number of chromosomes is changed.

   ii. haploid gametes are developed.

   iii. consistency of features in organisms is maintained.

Which one of the following is correct?

a. i &ii b. ii & iii

c. i & iii d. i, ii & iii

Answer the following questions 3 and 4 based on the figure given below.

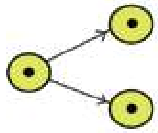


Figure-A

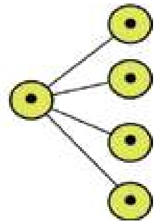


Figure-B

3. In the cell division of figure A-
   i. the mother cell and the daughter cells bear same features.
   ii. the number of chromosome becomes half in the newly developed cell.
   iii. chromosomes divide once.

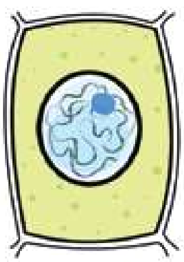
Which one of the following is correct?

a. i & ii b. ii & iii

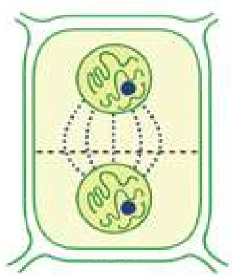
c. i & iii d. i, ii & iii

4. The division in the figure B is different from that of figure A and so-
   a. the number of chromosomes remains the same in the daughter cells.
   b. the number of chromosomes increases.
   c. abnormal cells are produced.
   d. the normal growth of the body occurs.

Creative questions



Stage-A



Stage-B

a. Where does mitosis occur?

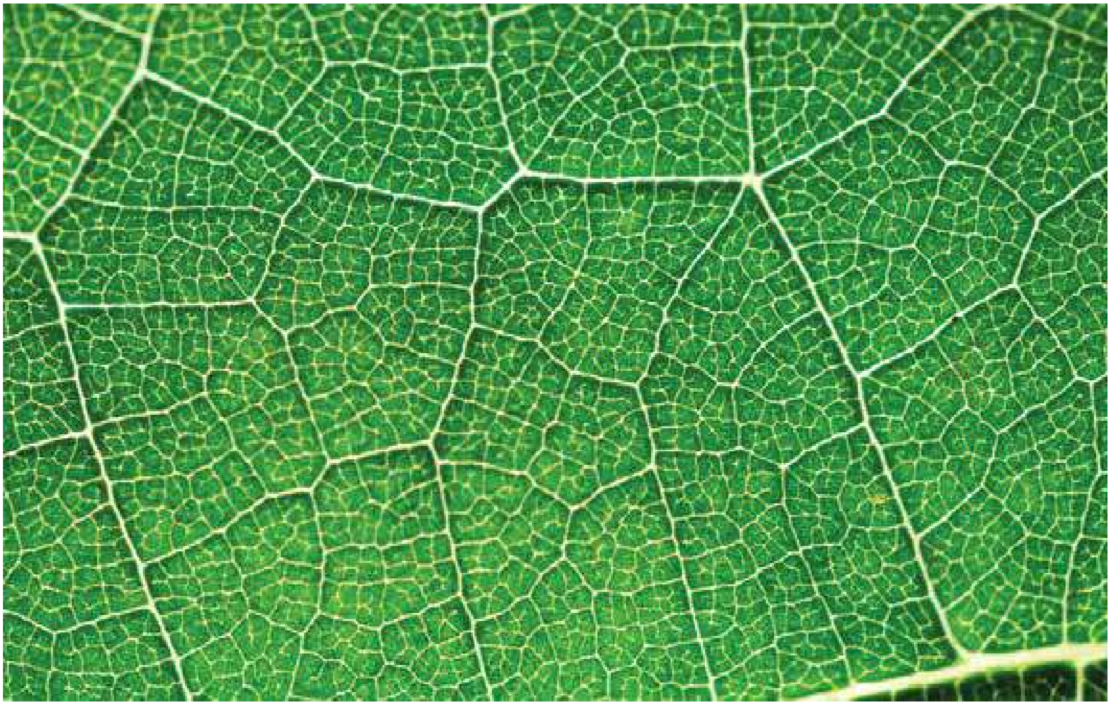
b. Write in detail why meiosis is called ‘reductional division’.

c. In stage B what changes occur? Explain.

d. Analyse what problems may emerge if the process expressed in the figures above is not accomplished properly.

Chapter Four

Bioenergetics



Thousands of biochemical reactions are being continuously carried out in the cells of organisms for the maintenance of life. For these reactions, energy is somewhat required. The sun is the main source of energy. The green plants transforming solar energy into chemical energy produce the food carbohydrates through the process of photosynthesis. Animals and non-green organisms cannot directly utilize solar energy. They have to depend somehow on green plants for the energy they require for the maintenance of their life. The main objective of bioenergetics is to discuss the energy flow through the living system. In this chapter, these cellular processes are discussed.

At the end of this chapter, we will be able to-

- explain the role of ATP as the main source of energy in a living cell;
- explain the production of carbohydrates through the process of photosynthesis;
- explain the role of chlorophyll and light in photosynthesis;
- describe the role of factors in photosynthesis;
- evaluate the dependence of organism on photosynthesis;
- explain respiration;
- explain the concept and significance of aerobic and anaerobic respiration;
- draw comparisons between photosynthesis and respiration;
- examine the necessity of chlorophyll and light in the process of photosynthesis;
- perform the experiment to demonstrate the release of energy in the form of heat during respiration;
- understand the contribution of plants in preparing food for organisms and learn conscious behaviors towards plants.

4.1 Bioenergetics and the role of ATP

The basic mechanism of production and utilisation of energy in the body of a living organism is its bio-energy. This is not very different from the definition of energy given in Physics. The energy we get from making and breaking of chemical bonds in the molecules found in biological organisms is called by this name. Living organisms continuously collect energy from the environment, transform them from one form into another, sometimes preserve them, and release them again in the environment.

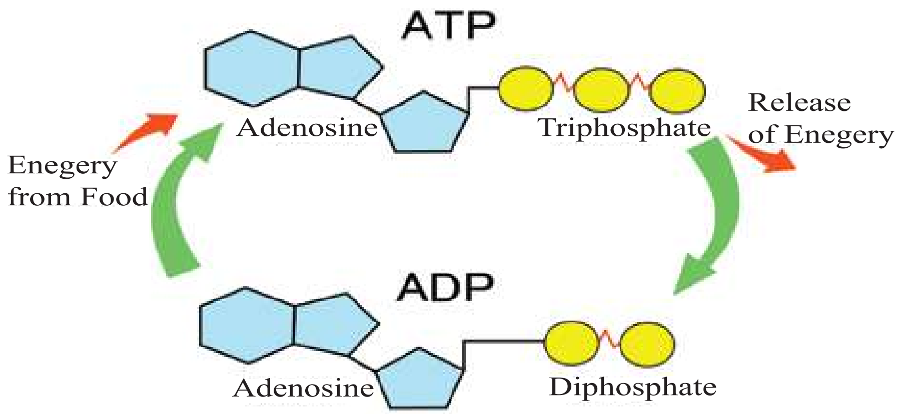


Figure : 4.01 The amount of energy needed to be supplied from outer source to produce Adenosine triphosphate(ATP) by combining Adenosine diphosphate (ADP) and phosphate, the same amount of energy is released when ATP is broken down into ADP and inorganic phosphate. These two chemical reactions continue in cyclic order in living cells.

Adenine is a fundamental component of DNA and RNA. It is a nitrogen base. Adenosine is composed of one molecule of adenine attached to a pentose (with five carbons) ribose sugar molecule. Adenosine can be linked to a chain of one, two, or three phosphate groups to form Adenosine Monophosphate (AMP), Adenosine Diphosphate (ADP), or Adenosine Triphosphate (ATP). Energy needs to be supplied from an outside source for the process of adding phosphate and this is called phosphorylation. In the reverse process, energy is released when a phosphate group is removed. This chemical reaction is known as dephosphorylation. Note here that 7.3 kilocalorie (approx. 30.55 kilojoules) is captured and remains stored in the phosphate group of each mole of ATP.

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Two organelles of a living cell collect energy from the environment and transform them into a form usable for the host cell. These two organelles are the mitochondria and the plastid. Both have a set of special complexes of molecules called Electron Transport System whose function is to store received energy from external source of energy as the energy of phosphate group in ATP. In case of mitochondria it may be the source of that energy is nutrients (such as: Glucose) or any transactional energy (such as: NADH2) and in case of plastid (specially chloroplast) it may be the source of that energy is sunlight or the photon come from another suitable source. All physiological functions, from muscle contraction to sensitivity, swallowing to digesting food, respiration to speaking, shouting to smiling and, physical growth to reproduction, controlling body temperature to maintain natural cell volume: everything is completed by energy released from the breaking down of the chemical bond of ATP. The food we eat is oxidized, and the energy released from this oxidization is used to create ATP through phosphorylation. It breaks down when energy is needed, and combines taking energy from food. This is like a rechargeable battery. ATP stores energy and supplies energy for other reactions when necessary. ATP is therefore called Biological coin or energy coin.

4.2 Photosynthesis

An important feature of green plants is that they produce carbohydrates from carbon dioxide and water in the presence of sunlight. In green plants, the process of the formation of carbohydrates is called photosynthesis. In this process, light energy is transformed into chemical energy. The food produced by the green plant is used to accomplish the metabolic processes required for its survival, and remaining food is stored in fruits, stems or leaves. The existence of mankind and other living creatures depends on the food produced and stored in plants. The essential components for photosynthesis are (1) chlorophyll (2) light (3) water and (4) carbon dioxide. Photosynthesis is a biochemical reaction shown below:

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

The mesophyll tissue of a leaf is the main site of photosynthesis. Terrestrial green plants absorb water from the soil through their roots and send it to the chloroplasts in the mesophyll tissue. CO_2 from atmosphere is absorbed through the stomata, and is sent to the same chloroplasts. Aquatic plants absorb the CO_2 which is dissolved in water. The presence of CO_2 in the atmosphere and water is 0.03% and 0.3% respectively. So, the rate of photosynthesis is higher in aquatic plants than that of land plants.

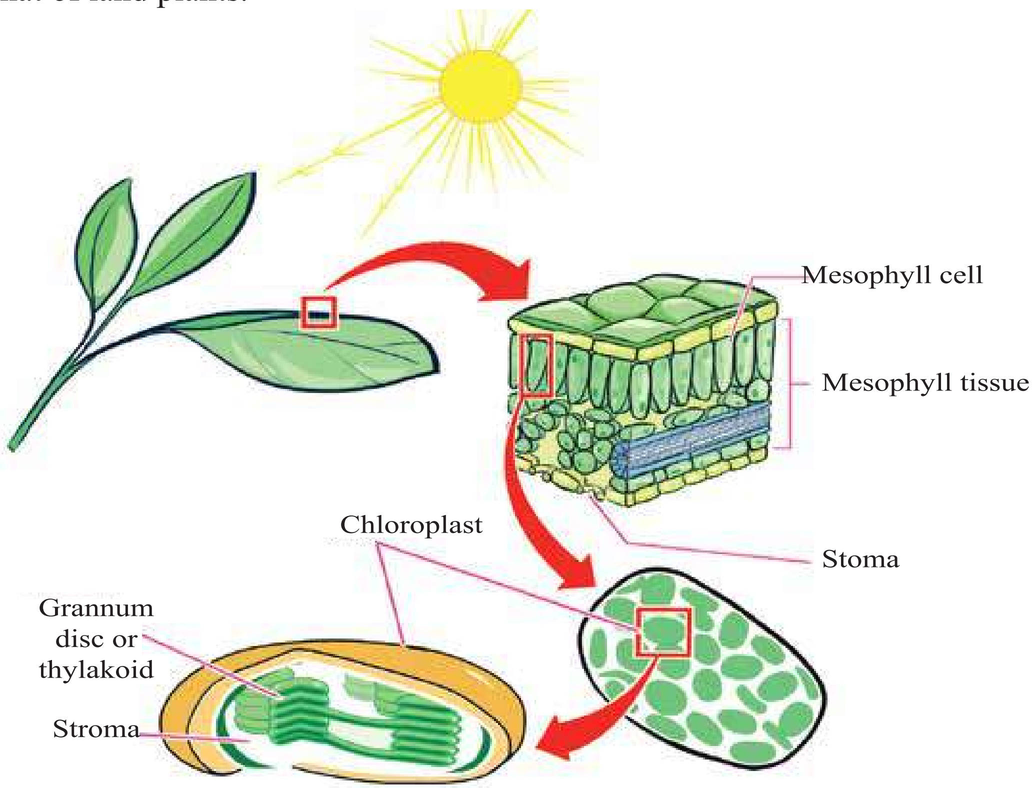

Figure: 4.02 Photosynthesis

Oxygen and water are by-products of photosynthesis. So, it is an oxidation-reduction process. In this process H_2O is oxidised and CO_2 is reduced.

4.2.1 The Process of Photosynthesis

Photosynthesis is a long and complex process. In 1905, British physiologist Blackman divided the process into two phases. They are the (1) light dependent phase and the (2) light independent phase.

(1) Light dependent phase: Light energy is essential in the light dependent phase of photosynthesis. In this phase, solar energy is transformed into chemical energy. Through this process ATP (Adenosine triphosphate) and NADPH (reduced nicotinamide adenine dinucleotide phosphate) and H+ (Hydrogen ion or proton) are produced. Energy converted from the photon is stored in the phosphate group of ATP as the chemical bonding energy. Chlorophyll plays a very important role

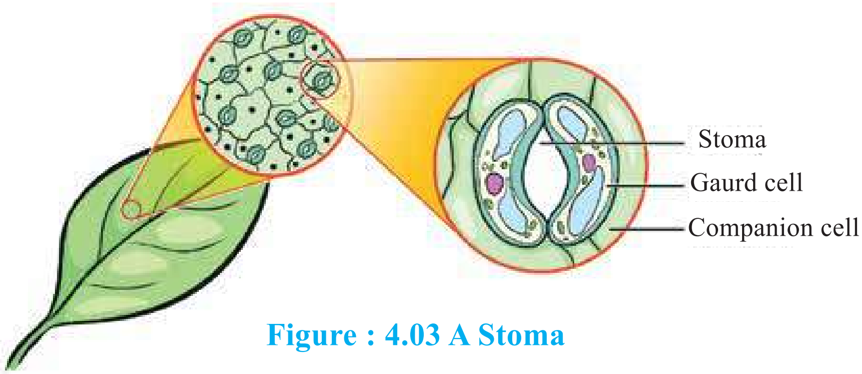

Figure : 4.03 A Stoma

in the production of ATP and NADPH+H+. Chlorophyll molecules absorb photons from light, and with the help of the energy obtained from the photon absorbed, ATP is formed through the addition of an inorganic phosphate with ADP. The process of the formation of ATP is called photophosphorylation.

$$\text{ADP} + \text{Pi} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{ATP}$$

Oxygen, proton/hydrogen ion and electrons are released through the hydrolysis of water with the help of sunlight and chlorophyll. The process is called the photolysis of water.

ATP is produced through the process of photophosphorylation. The electrons reduce NADP, and produce $NADPH+H^+$. This process of producing ATP and $NADPH+H^+$ is called assimilatory power.

(2) Light independent phase or dark phase: No light is directly required in the light independent phase, although the process can be carried out in presence of light. Atmospheric CO_2 enters the cells through the stomata of the leaves. In this phase, carbohydrates are produced by the reduction of CO_2 with the help of ATP and $NADPH+H^+$ that was produced in the light phase. In green plants, the pathways of CO_2 reduction have been identified, and they are briefly discussed here: (a) Calvin cycle (b) Hatch & Slack pathway and (c) Crassulacean acid metabolism (CAM). Of these, the first two cycles are briefly discussed below.

(a) Calvin cycle or C_3 cycle: The pathway of fixing CO_2 is named after its discoverers Calvin-Benson-Bassham (CBB) cycle or simply the Calvin cycle. Melvin Ellis Calvin was awarded the Nobel Prize in 1961 for this discovery. In most plants, carbohydrates are produced through this process. Because the first stable compound, formed by this process is the 3-carbon compound phosphoglyceric acid, so this pathway is called C_3 pathway and the plants where this cycle takes place is called C_3 plants.

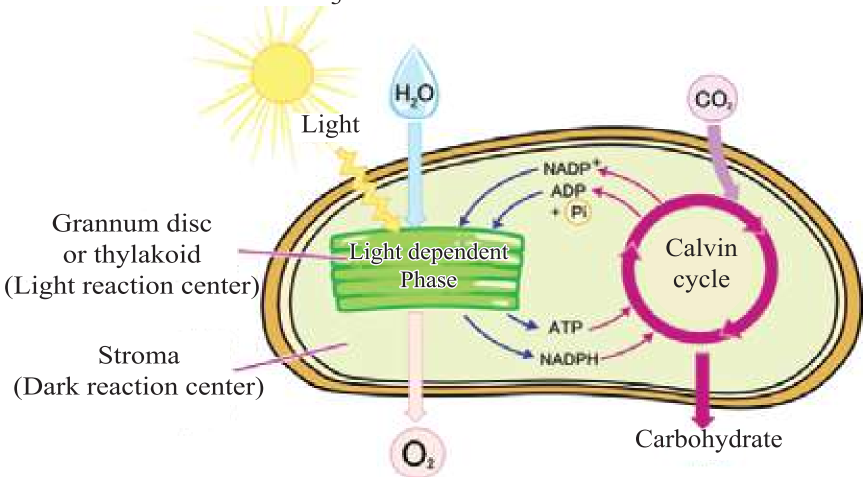

Figure : 4.04 Light dependent phase and Calvin Cycle

(b) C_4 cycle or Hatch and Slack pathway: In 1966, two Australian scientists, M.D. Hatch and C.R. Slack discovered the reduction pathway of CO_2. The first stable substance formed in this pathway is 4-carbon based Oxaloacetic acid. So this pathway is also called C4 pathway and the plants where this cycle takes place is called C_4 plants.

In C_4 plants, both the Hatch and Slack cycle and the Calvin cycle are carried out simultaneously. The rate of photosynthesis in C_4 plants is higher than that of in C_3 plants. Some examples of C_4 plants are maize, sugarcanes, other plants of grass type, motha grass and amaranthus.

4.2.2 Role of Chlorophyll in Photosynthesis

There is a direct relationship between the rate of photosynthesis and the amount of chlorophyll in the leaves, because only chlorophyll can capture solar energy. We know the old chloroplasts are disintegrated, and then new chloroplasts are synthesised. The rate of photosynthesis is dependent on the rate of regeneration of chloroplasts or the components of chloroplasts. For the maintenance of photosynthesis, different components of chlorophyll are required to be regenerated speedily in large amounts. But, too much chlorophyll in the cell results in the shortage of enzymes and the rate of photosynthesis slows down.

4.2.3 Role of Light in Photosynthesis

The importance of light in photosynthesis is immense. For the production of carbohydrates from H_2O and CO_2, the source of required energy is light. Sunlight also takes part in the development of chlorophyll. With sunlight and when stomata are open, CO_2 can enter the leaves, and take part in the production of food. But only a small proportion of the light falling on the leaf, is used in photosynthesis. Red, blue, orange and purple portions of the visible spectrum function better than that of green and yellow in the process of photosynthesis. The rate of photosynthesis increases with the increase of light up to a definite limit. If the amount of light increases too much, enzymes disintegrate and cause the production of chlorophyll to reduce. Consequently the rate of photosynthesis also decreases. Photosynthesis, generally, is carried out well with light of wave length between 400nm-480nm and 680nm.

4.2.4 Factors affecting photosynthesis

Besides light and chlorophyll, photosynthesis is also affected by other factors. Some of the factors are external and some are internal. These factors are mentioned below.

(a) External factors

Light: It has already been discussed.

Carbon dioxide: Photosynthesis cannot be carried out without carbon dioxide. Food produced by this process is formed from the reduction of carbon dioxide. The concentration of carbon dioxide in atmosphere is 0.03% but , plants can use carbon dioxide upto 1% concentration. So, the rate of photosynthesis increases with the increase of carbon dioxide upto 1% in atmosphere. If the amount of carbon dioxide is increased to a very high level, acidic condition in the cells of mesophyll tissue increases and stomata get closed, so the rate of photosynthesis, then decreases.

Temperature: Temperature as a factor plays a very important role in the process of photosynthesis. At a very low temperature (around 0°C) and a very high temperature (above 45°C), photosynthesis cannot be carried out. The optimum temperature for photosynthesis is from 22°C to 30°C. If temperature remains below 22°C or above 35°C, the rate of photosynthesis will decrease.

Water: In photosynthesis the H+ (Hydrogen ion) required for the reduction of CO_2, for the production of carbohydrates comes from water. In scarcity of water, the guard cells of stomata become flaccid, and so, the entry of CO_2 is disrupted. In the excessive scarcity of water, photosynthesis may be completely stopped as the enzymes become inactivated.

Oxygen: If the concentration of oxygen increases in the atmosphere, the rate of photosynthesis decreases. Conversely, the rate of photosynthesis increases with the decrease of oxygen in the atmosphere. However, photosynthesis stops completly in the absence of oxygen.

Mineral nutrient elements: Nitrogen and magnesium are two main components of chlorophyll. A leaf cannot synthesize chlorophyll in absence of iron, and consequently, the leaves become yellow. Thus, the rate of photosynthesis decreases if there are low levels of minerals in the soil.

Chemical substances: The process of photosynthesis is inhibited or completly stopped if the chloroform, hydrogen sulfide, methane or any poisonous gases are present in the air.

(b) Internal factors

Chlorophyll: It has already been discussed.

Age and number of leaves: Leaves that are too young or too old contain very little chlorophyll. This is why the rate of photosynthesis in them is very low. With the aging of leaves, the number of chloroplasts also increases. The rate of photosynthesis in the middle-aged leaves is the highest. With the increase of the number of leaves, the rate of photosynthesis is accelerated.

Amount of carbohydrates: During photosynthesis, if the conduction of carbohydrates is low, carbohydrates become clogged in the leaves. In the evening, the rate of photosynthesis is low because of the accumulation of carbohydrates that were produced earlier.

Potassium: The rate of photosynthesis is found to become slow if there is a shortage of potassium, since potassium likely plays a role as a catalyst in the process.

Enzymes: Several enzymes are required for the process of photosynthesis.

4.2.5 Importance of photosynthesis in living world

Photosynthesis is the most important biochemical process in the world. Through the process, a bridge is developed between living things and sunlight. The importance of photosynthesis can be understood from the discussion below.

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Observing the vast impact of this process on earth, some scientists have named it the Bio-Chemical factory.

The sun is the main source of all energy. Only green plants can transform solar energy into chemical energy and store as food through photosynthesis.

No animal can produce its food itself. The foods we eat such as rice, bread, fruits, vegetables, fish, meat, milk, egg etc., are directly or indirectly derived from green plants. So, all animals are completely dependent on green plants for their food, and the green plants produce food through the process of photosynthesis. It can be said that the food for all plants and animals on earth is produced through the physiological process of photosynthesis. Photosynthesis is very important for maintaining the balance of different components in the atmosphere, especially the ratio of CO_2 and O_2. The presence of O_2 and CO_2 gases in the atmosphere is 20.95% and 0.033% respectively.

For normal growth and survival of plants and animals on earth, these two gases must be present in atmosphere within a normal limit. If the amount of the gases is different than normal, the atmospheric environment becomes hostile to living world. We know that cellular respiration is taking place in all living organisms (both plants or animals) all the time. In respiration, organisms use O_2 and release CO_2. If only respiration would have occurred in nature, a shortage of O_2 and a surplus of CO_2 would definitely be found in the atmosphere. As green plants absorb CO_2 and release O_2 through the process of photosynthesis, the correct ratio of O_2 and CO_2 in the atmosphere is maintained. Nowadays a dangerous situation has occurred as the ratio between these two gases is changing due to the excessive cutting of trees. So we should plant trees in large numbers.

The progress of human civilization is dependent on photosynthesis directly and indirectly. Foods, clothes, industrial materials (such as nylon, rayon, paper, cellulose, timber, rubber), medicine (such as quinine, morphine), and fuel coal, petrol, gas are produced from plants. So, if photosynthesis does not occur, human civilization would be ruined, and the living world would be destroyed. This is why photosynthesis is the most important biochemical process in the living world.

Not only that there was no gaseous oxygen about 5 billon years ago when the earth was created. Through the process of photosynthesis, primitive plant produced oxygen which helped to make the earth habitable for us.

Individual Activity

Activity-1: Experiment to show the necessity of light in the process of photosynthesis.

Essentials: A potted plant with green leaves, black paper, 95% ethyl alcohol, 1% iodine solution, black paper, clips, water, petridish, test tube, beaker, bunsen burner or spirit lamp, dropper, forcep.

Procedure: The potted plant should be kept in a dark place for 48 hours so that the leaves become starchless. A part of a leaf on the potted plant kept in the dark needs to be covered with a piece of black paper and clipped in such a way that no sunlight can reach it. Then, the potted plant should be kept in sunlight for 6-7 hours. After 6-7 hours the leaf, plucked off and black paper removed, will be boiled in water for several minutes. Then, in order to make it chlorophyll free, the leaf should be again boiled in 95% ethyle alcohol until it becomes faded. Now the leaf is to be washed in water and drained with iodine solution. In order to avoid any accident while boiling in alcohol, the test tube containing alcohol and the leaf should be heated inside water in a beaker, instead of giving it any direct heat.

Figure: 4.05 Essentialily of light in Photosysthesis

Observation: When the leaf is picked up from iodine solution, we can see that except the covered part, the remaining part of the leaf becomes blue, deep purple or black.

Conclusion: Because of the chemical reaction between starch and iodine, starch will turn blue, deep purple or black. As the sunlight cannot reach the part of the leaf covered with the black paper, starch cannot be formed there through photosynthesis. As starch is not formed in that part of the leaf, it cannot turn blue, deep purple or black after reaction with the iodine solution. Since sunlight has fallen on the remaining parts of the leaf, starch was produced there. It proves that light is essential for the formation of starch during photosynthesis.

Precautions

(1) Before performing the experiment, the potted plant should be kept in dark for sometime (about 48 hours).

(2) Black paper should be of such quality that no light can pass through it.

(3) Before the test, the potted plant should be kept in sunlight at least for 6- 7 hours.

(4) While boiling the leaf into alcohol, it is better not to use direct heat.

Individual Activity

Activity-2: Experiment to show the necessity of chlorophyll in the process of photosynthesis.

Essentials: Manihot or variegated leaf, alcohol, iodine solution, water, petridish, test tube, bunsen burner, dropper, beaker.

Procedure: A manihot or variegated leaf is to be picked at noon and its green portion marked. After boiling the leaf for a few minutes in water, it is then be boiled in alcohol until its colour has faded. Now, after washing the leaf in water, dip it in iodine solution. In order to avoid accidents while boiling in alcohol, the test tube containing the alcohol and the leaf, should be heated in water in a beaker instead of applying direct heat.

Observation: Only the green portion of the leaf becomes blue, deep purple, or black after the leaf from iodine solution.

Conclusion: Only the green portion of the leaf produced carbohydrate through photosynthesis, because of the presence of chlorophyll. Since there is no chlorophyll in the non-green (orange or yellow) portion, carbohydrate was not produced. Because of the carbohydrate, the green portion becomes blue or deep purple or black in the iodine solution.

Precaution : While boiling the leaf in alcohol, it is better not to use direct heat.

4.3 Respiration

In previous classes you learned about respiration and how through respiration, organisms accomplish growth and derive energy. In this chapter, a more detailed discussion will be made on respiration. Energy is required to maintain the process of life of organisms for activities like locomotion, healing of injury, growth and reproduction. We have already known that the main source of energy is the sun. Through photosynthesis, plants store solar energy in carbohydrates as potential energy. The stored energy in the food cannot be directly used by the organisms for the maintenance of their life. During respiration, this potential energy is converted into kinetic energy (ATP) in the form of heat, which supplies the necessary energy for various physiological activities. Carbohydrates, fats, proteins and organic acids can be processed and consumed through this process. These complex compounds in the bodies of living organisms, are broken down into simple compounds and later transformed into ATP. At normal temperature, the process of respiration occurs in the living organisms around the clock. But, in the growing parts of a plant, such as in floral and lateral buds, germinating seeds, and the tip of stem and root, the rate of transpiration is very high. Respiration takes place in the cytoplasm and mitochondria of a living cell.

4.3.1 Types of respiration

Based on the availability of oxygen during respiration, the process is divided into two types: (1) Aerobic respiration (2) Anaerobic respiration.

(1) Aerobic respiration: The respiration process, which requires oxygen and produces CO_2, H_2O and a large amount of energy by oxidising the respiratory materials (carbohydrates, proteins, lipids, different kinds of organic acids) completely, is called aerobic respiration. Aerobic respiration is the typical respiratory process of plants and animals. It can be expressed with the following equation:

$$\underset{\text{glucose}}{C_6H_{12}O_6} + 6O_2 \xrightarrow{\text{different enzymes}} 6CO_2 + 6H_2O + \text{energy}\ (686\ \text{k Cal / Mole})$$

Through aerobic respiration, one molecule of glucose when completely oxidised produces 6 molecules of CO_2, 6 molecules of H_2O and 38 molecules of ATP.

(2) Anaerobic respiration: Respiration, which occurs in absence of oxygen, is called anaerobic respiration. That is, in anaerobic respiration, respiratory substances are partially oxidised with the help of enzymes to produce different types of organic compounds (ethyl alcohol, lactic acid etc.), CO_2 and a small amount of energy.

$$\underset{\text{glucose}}{C_6H_{12}O_6} \xrightarrow{\text{enzyme}} \underset{\text{ethyl alcohol}}{2C_2H_5OH} + 2CO_2 + \text{energy (56 k Cal / Mole)}$$

Anaerobic respiration only occurs in some microorganisms such as in bacteria, yeast etc.

Short description of aerobic respiration

Aerobic respiration is generally divided into four distinct stages:

Stage 1: Glycolysis

When oxidized through chemical reactions, one molecule of glucose ($C_6H_{12}O_6$) is broken down into two molecules of pyruvic acid ($C_3H_4O_3$). Four molecules of ATP (two ATP being used in the process) and two molecules of NADH+H^+ are produced in this stage. In this process, no oxygen is required. It is the initial stage for both aerobic and anaerobic respiration. It takes place in the cytoplasm of a cell.

Stage-2: Acetyl Co-A formation

This stage also takes place in the cytoplasm. Each molecule of pyruvic acid, produced in glycolysis, is transformed into a molecule of 2-carbon acetyl co-A, a molecule of CO_2 and a molecule of NADH+H^+ (i.e. from two molecules of pyruvic acid two molecules of acetyl Co-enzyme-A, two molecules of CO_2 and two molecules of NADH+H+ are produced). Previously it is assumed that this stage occurs in cytoplasm but the latest data show that the reaction occurs in the matrix of mitochondria.

Stage-3: Kreb's cycle

In Kreb's cycle, 2-carbon acetyl Co-A, are oxidized to produce two molecules of CO_2. This cycle is named after the British biochemist Sir Hans Kreb who discovered the cycle. In this stage, acetyl Co-A enters the mitochondria and participates in Kreb's cycle. All the reactions of this cycle occur in the mitochondria. In this cycle, from one molecule of acetyl Co-A, two molecules of carbon dioxide, three molecules of $NADH+H^+$, one molecule of FADH2 and one molecule of GTP (Guanosine triphosphate) are produced. So, from two molecules of acetyl Co-A, four molecules of CO_2, six molecules of $NADH+H^+$, two molecules of $FADH_2$ and two molecules of GTP are produced. It is notable that ATP can be produced directly instead of GTP in the Kreb's cycle of animal cell. But in almost all plants ATP is always produced instead of GTP. Since one molecule of ATP is produced in next stage (i,e Electron Transport System) which is equivalent of one molecule of GTP. That's why this difference does not occur any variation of total amount of energy derived from Kreb's cycle.

Stage-4: Electron transport system

In this stage, NADH+H+ (reduced NAD), and FADH2 (reduced FAD) produced in the above three stages are oxidized. Consequently ATP, water, electrons containing high-energy and protons are produced. The energy is released while electrons containing high-energy move through the electron transport system. This energy is used in the formation of ATP. The electron transport system takes place in the mitochondria.

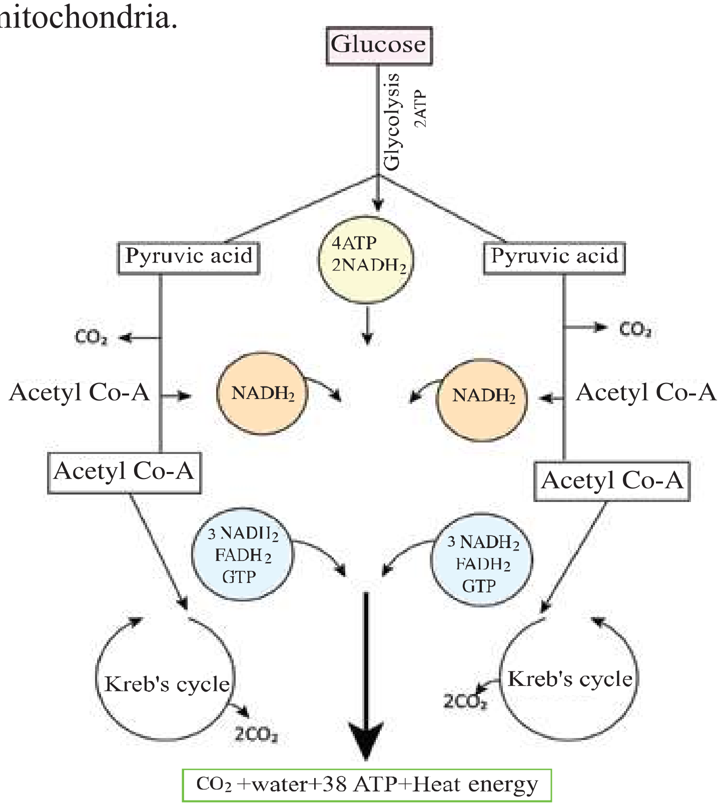

Figure 4.06 Aerobic respiration process

In aerobic respiration, one molecule of glucose is completely oxidized to produces six molecule of CO_2, six molecules of water and 38 ATP. This is shown in the chart below.

Stage of respiration	Substance produced	Used substance	Neat product
Glycolysis	2 molecules pyruvic acid 2 molecules $NADH+H^+$ 4 molecules ATP	2 molecules ATP	6 ATP 2 ATP
Acetyl Co-A	2 molecules acetyl Co-A 2 molecules CO_2 2 molecules $NADH+H^+$	2 molecules pyruvic acid	2 molecules CO_2 6 ATP
Kreb's Cycle	4 molecules CO_2 6 molecules $NADH+H^+$ 2 molecules $FADH_2$ 2 molecules GTP	2 molecules acetyl Co-A	4 molecules CO_2 18 ATP 4 ATP 2 ATP
		Total	38 ATP (net total ATP) +6 molecules CO_2

1 molecule $NADH+H^+$ or $NADH_2$ = 3 molecules ATP
1 molecule $FADH_2$ = 2 molecules ATP
1 molecule GTP = 1 molecule ATP

Stages of anaerobic respiration

Anaerobic respiration has two stages. The two stages are:

Stage -1: Incomplete oxidation of glucose

In this stage, from one molecule of glucose, two molecules of pyruvic acid, four molecules of ATP(two of them already being used) and two molecules of $NADH+H^+$ are produced. This process looks similar to glycolysis in aerobic respiration. However, it is considered that the oxidation of glucose here is incomplete because the pyruvic acid that is produced here is reduced in the next stage.

Stage-2: Incomplete reduction of Pyruvic Acid

With the help of enzymes in the cytoplasm, pyruvic acid is reduced to CO_2 and ethyl alcohol, or only lactic acid. In this case NAD (NADH+H+), which is reduced in glycolysis, releases electron, proton and energy after oxidization and these are used to produce lactic acid and in some cases ethanol from pyruvic acid. On the other hand, oxidative phosphorylation does not take place because of the absence of oxygen. So in anaerobic respiration, only two molecules of ATP are produced from the glycolysis of glucose.

4.3.2 Factors affecting respiration

The factors affecting respiration are both external and internal.

(a) External factors: External factors affecting respiration are mentioned below:

I)Temperature: The rate of respiration becomes low at temperatures below 20°Celsius and above 45° Celsius. The optimum temperature for respiration is from 20° Celsius to 45°Celsius.

II)Oxygen: In aerobic respiration, pyruvic acid is oxidised into CO_2 and H_2O. So, aerobic respiration cannot be carried out without oxygen.

III)Water: The supply of optimum amount of water keeps in respiration its normal state. If the supply of water is too little or too much, respiration is inhibited.

IV)Light: Though light is not required for respiration, the rate of respiration is higher in day light, because the exchange of CO_2 and O_2through stomata is easier since the stomata is opened.

V)Carbon dioxide: If the amount of CO_2 in the air is increased, the rate of respiration becomes slower.

b) Internal factors: The internal factors are mentioned below:

I)Food materials: In respiration energy, water and CO_2 are produced by breaking down food materials (respiratory substance), so the amount and types of food control the rate of respiration.

II)Enzymes: Many types of enzymes actively take part in the process of respiration. So, a deficiency of enzymes causes the rate of respiration to slow.

III)Age of cells: In young cells (especially, cells in the meristematic tissue) the greater amount of protoplasm causes respiration at a higher speed than in old cells.

IV)Inorganic salts: Though some salts inhibit the process of respiration, some salts in the cells are essential for the running of normal activities of the cell and to drive the process of respiration.

V)Intracellular water: Water is necessary to dissolve different respiratory substances and to increase the effect of enzymes.

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4.3.3 Significance of respiration

An organism performs all activities with the energy produced through respiration. CO_2 released during respiration is used in the process of photosynthesis to produce carbohydrate, the main food of living beings. This process helps plants to absorb mineral salts, which indirectly drive the growth and other physiological activities in a plant. The energy required for cell division is produced through respiration. So, this process also controls the growth of organisms. Different sub-alkaline or organic acids are also produced through respiration and they help other physiological activities of life. Some bacteria cannot live in the presence of oxygen. Their main source of energy is anaerobic respiration. Through the process, ethyl alcohol is produced. This process is also used in industry. Through this process, lactic acid, through fermentation, produces curd, cheese etc. It is also used in making bread. Yeast produces alcohol and CO_2 gas through the process fermentation. CO_2 makes the bread inflamed.

Individual Activity

Activity : Experiment to demonstrate the release of energy in the form of heat during respiration.

Essentials: Two thermoflasks, two thermometers, two rubber corks with holes, some germinated chick-peas, 10% mercuric chloride solution.

Procedure: Label one of the thermoflasks as A and the other as B. Some germinatd chickpeas along with some water are placed in thermoflask A. A thermometer should be inserted through the hole of a cork on the 'flask A' with its opening sealed well. The remaining chickpeas will be placed in flask B after soaking in 10% mercuric chloride solution for 10 minutes.

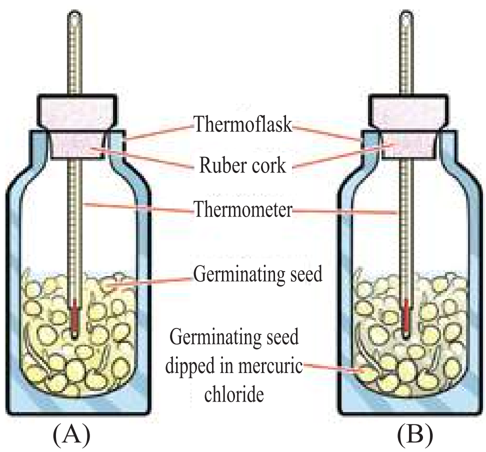


Figure 4.07: Thermoflask

A thermometer will also be inserted in thermoflask B. Now, after taking the initial temperature of each thermometer 'A' and B', they should be kept at rest.

Observation: After a few hours the temperature of the thermoflask, containing germinated seeds, marked 'A' rises. There is no temperature change in the other flask.

Conclusion: As the chick peas in the flask 'A' was fresh, it carried out respiration and released of energy in the form of heat, the temperature in the flask rises. But, in thermoflask 'B', as the seeds are dead and sterilized because they were soaked in mercuric chloride solution, the respiration process does not occur. So, the temperature remains unchanged.

Precautions

1. The seeds should be fresh and well germinated.
2. The tip of the thermometer should be positioned at the middle of the stacks of seeds.

Exercise

Short answer questions

1. What is photosynthesis? Represent it by a chemical equation.
2. What are the raw materials for photosynthesis?
3. What is respiration? Represent it by a chemical equation.
4. State the differences between photosynthesis and respiration.
5. State the differences between aerobic and anaerobic respiration.

Essay type questions

1. Explain the dependence of organisms on photosynthesis.
2. Discuss the significance of respiration.

Multiple choice questions

1. Which one is evolved as a by-product in the process of photosynthesis?

   a. Water b. Carbohydrates

   c. Oxygen d. Carbon dioxide

2. What number of ATP is produced in the glycolysis stage of respiration?

   a. 4 b. 6

   c. 8 d. 18

Look at the stem and answer the questions no. 3 and 4.

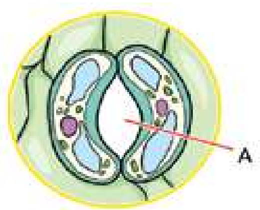


Figure X

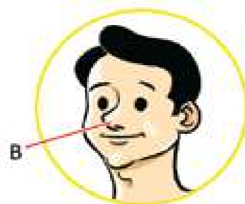


Figure Y

3. The functions of both A and B are –

   i. to intake O_2

   ii. to release H_2O

   iii. to remove CO_2

   Which one of the following is correct?

   a. i & ii b. i & iii

   c. ii & iii d. i, ii & iii

4. The process accomplished in the figure X-

   i. keeps the environment cold

   ii. helps the process of photosynthesis

   iii. inhibits the process of respiration

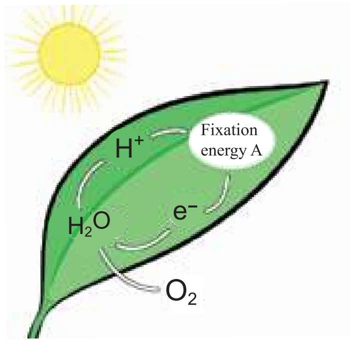
   Which one of the following is correct?

   a. i & ii b. i & iii

   c. ii & iii d. i, ii & iii

Creative questions

1.



a. What is the chemical formula of pyruvic acid?

b. What do you understand by anaerobic respiration?

c. Explain how the component A of above figure is being produced.

d. What are the effects on plants if the production of A shown in the figure is inhibited? Explain.

2. Bipasha, a student of class X, likes to eat carrots. As the carrots contain glucose, it provides her with energy. Her younger sister asks her how a plant derives energy for its growth. She replies that a plant also derives energy through the respiration.

a. What is photolysis of water?

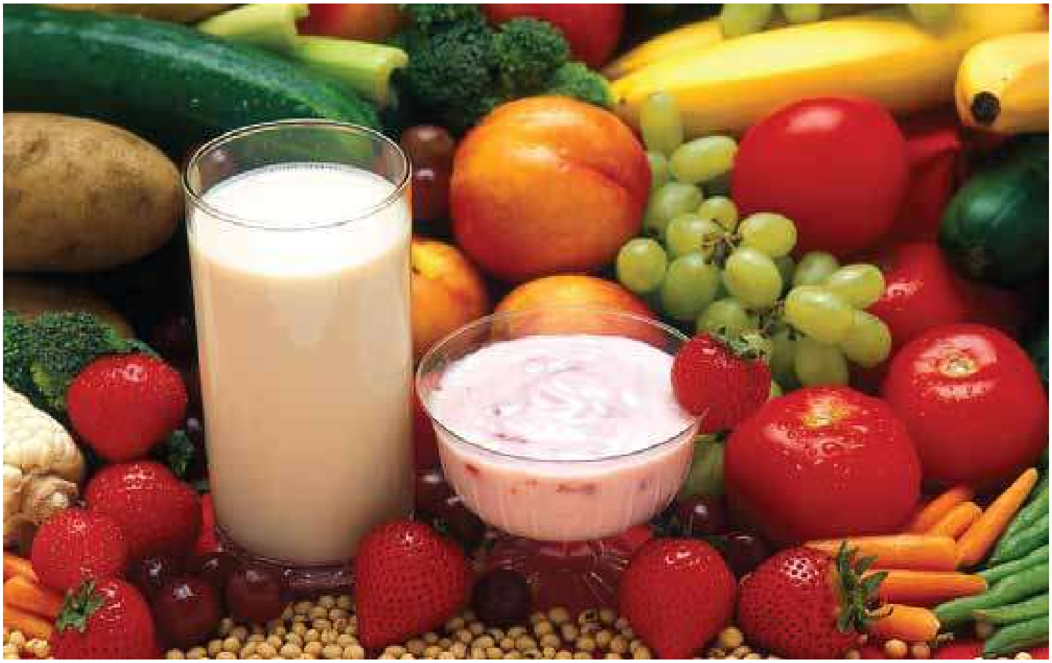
b. What is meant by C_4 plants?

c. Explain with a chart how much energy is produced in Kreb's cycle from two molecules of food eaten by Bipasha.

d. What are the effects on plants if the process mentioned above is inhibited?

Chapter Five

Food, Nutrition and Digestion



Living organisms live on food. Food is essential to survive. But the process of consuming food is different in plants and animals. Different elements are necessary for the nutrition of living organisms. In this chapter, food, nutrition and digestion in the human body and plant nutrition are discussed.

At the end of this chapter, we will be able to-

- explain the necessity of essential elements for plant nutrition;
- analyse nutrition deficiency symptoms in plants;
- describe the main components of animal foods and their sources;
- explain the ideal food pyramid;
- explain the principles of consuming foods;
- explain the symptoms, remedies and prevention of nutrition deficiency diseases;
- explain kilocalories and kilojoules;
- explain the amount of energy in nutrients and their conversion in calorie and joule;
- explain the importance of body mass index (BMI) and body mass ratio (BMR);
- determine BMI and BMR;
- determine the relation between BMR and energy spent;
- determine how BMI differs according to the age and sex;
- explain the importance of exercise and rest for good health;
- explain the necessity of using chemicals in preserving foods;
- analyse the effect of using excessive chemicals and colours in food on the human body;
- describe the structure and functions of the alimentary canal along with accessory glands;
- draw a labeled diagram of the main parts of alimentary canal;
- explain the functions of the liver;
- explain the functions of the pancreas;
- evaluate the role of enzymes in digestion;
- describe the different symptoms, remedies and prevention of different intestinal diseases;
- make yourself and other family members aware about intestinal diseases for healthy living;
- make a list of food consumed in last seven days and compare with the balanced food;
- draw a poster to raise awareness among people regarding the contribution of nutrition to healthy living;
- make yourself and others aware about the contribution of nutrition to healthy living.

5.1 Plant Mineral Nutrition

Plants absorb certain elements from the soil, air and water for growth and nutrition. Plants can not live without these elements. These elements are called nutrients. As most nutrients are taken from the soil, they are called mineral nutrition. About 60 inorganic nutritional elements have been identified in plants. Only 16 nutrients out of 60 are essential for the normal growth of plants. These 16 nutrients are collectively called essential elements because they are required for the normal growth, physiological activities and reproduction of all types of plants. Deficiency of any of these elements results in deficiency symptoms in plants, and causes diseases in them. One element cannot be substituted by another element.

Of these 16 nutrients, some are consumed in large amounts and others in low amounts by plants. Based on the amount of essential mineral nutrition consumed by plants, nutrients are divided into two groups: macro-nutrient (or macro-element) and micro-nutrient (or micro-element).

(a) Macronutrient or macro element: The nutrient elements, which are consumed by plants in large quantities for growth, are called macronutrients or macroelements. Plants use 9 macronutrients or macro elements: they are Nitrogen (N), Potassium (K), Phosphorus (P), Calcium (Ca), Magnesium (Mg), Carbon (C), Hydrogen (H), Oxygen (0) and Sulfur (S).

(b) Micronutrient or microelement: The elements which are consumed in very small quantities required for the normal growth of plants are called micronutrients or microelements. Plants use 7 micronutrients: they are Zinc (Zn), Manganese (Mn), Molybdenum (Mo), Boron (B), Copper (Cu) and Chlorine (Cl) and Iron (Fe).

5.1.1 Source and Role of Nutrients

Source of Nutrients: Plants absorb carbon and oxygen from the atmosphere and hydrogen and oxygen from water. Other elements are absorbed from the soil through roots. These elements are found in the soil in the form of different salts. Plants cannot absorb them as salts directly. They are absorbed in ionic form, such as Ca^{++}, Mg^{++}, NH_4^+, NO_3^-, K^+ etc.

The Role of different mineral elements in plant nutrition: Mineral nutrients play a very important role in the normal growth of plants.The role of some macronutrients are mentioned below.

Nitrogen : Nitrogen is an essential element of nucleic acid, proteins and chlorophyll. Nitrogen plays a very important role in general growth of plants and increases the amount of water in plant tissues. The formation of chlorophyll is hindered if there is a shortage of nitrogen. If the formation of chlorophyll is hindered, the production of food affected. And if the production of food is interrupted, the release of energy through respiration will be lessened.

Magnesium : Magnesium is an important component of chlorophyll and helps the process of respiration. If there is a shortage of magnesium in a plant, the formation of chlorophyll molecule and the production of food through photosynthesis will be hampered.

Potassium : Potassium helps in many biological reaction of plants. It also plays an important role in opening and closing stomata. Potassium helps a plant absorb water. In addition, it helps the development and growth of roots, flower and fruits. Potassium also controls the growth of plants through cell division.

Phosphorous : Phosphorous is essential for the development of roots. It is the structural component of DNA, RNA and ATP in living cells. So, without phosphorous, nutrition of plants is not possible. Phosphorous is also an essential element for the elongation of roots.

Iron : Iron is the structural component of cytochrome, and so it is required for aerobic respiration. Iron also plays an important role in the formation of chlorophyll.

Because of their role in nutrition, chemical fertilizers such as urea for nitrogen, muriate of potash for potassium chloride, and triple super phosphate for phosphorus are used in cultivating fields for high yields.

Micronutrients also plays an important role for the normal growth of plants. For instance :

Manganese : Manganese is needed to construct and maintain chloroplasts.

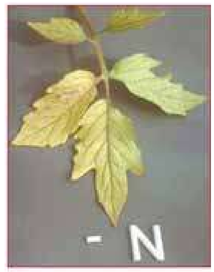
Copper : Copper plays an important role in the respiration process. It plays an important role in tomato and sunflower plant for their normal growth.

Boron : Boron is required for the active growing regions of plants, and it also plays a role in the transportation of sugar.

Molybdenum : Molybdenum is essential for the fixation of nitrogen by microorganisms.

Chlorine : Chlorine is necessary for the growth of root and stem of sugar beet.

5.1.2 Symptoms of Nutrient Deficiencies: In case of the deficiency of any nutrients, symptoms are visible in plants. These symptoms are called deficiency symptoms. By observing these symptoms we can understand which nutrient is deficient in which plant. Some deficiency symptoms associated with several nutrients are mentioned below.

Deficiency symptoms	Diseased Plant
Nitrogen (N): The formation of chlorophyll is inhibited if the deficiency of nitrogen occurs in a plant. Because of this, green leaves gradually turn yellow. Without chlorophyll, other pigments also appear yellow. The condition of leaves becoming yellow is called chlorosis. Deficiency of iron, manganese or copper may also cause chlorosis as they are also responsible for the production of chlorophyll in various ways. Due to chlorosis the growth and division of cells is decreased and ultimately the total growth of a plant is reduced. The figures show leaves with nitrogen deficiency and healthy leaves.	 
Phosphorus (P): Leaves turn purple if a deficiency of phosphorus occurs in them. Necrotic spots develop in the leaves. Shedding of leaves, flowers and fruits may occur. The growth of plant collapses and the plant becomes stunted. Plants usually display no obvious early symptoms of phosphorus deficiency. By the time a visual deficiency is recognized, it may be too late to take any action.	
Potassium (K): In deficiency of potassium, the tip and the blade of leaf turn yellow and necrotic spots are developed. Interveinal chlorosis occurs. Leaves may wilt and look scorched along the leaf margin. The growth of the plant is reduced, and apical and lateral buds die.	

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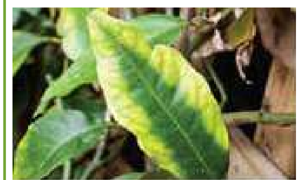
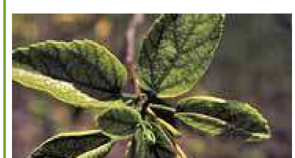
Calcium (Ca): The normal level of calcium in the cytosol of the cell is related to the functioning of mitochondria and endoplasmic reticulum. If the level decreases, oxidative phosphorylation in mitochondria, as well as the protein trafficking process in endoplasmic reticulum, is hampered. Young leaves face chlorosis due to deficiency of calcium, and the growing apical parts of a plant die. At the time of flowering in plants, stems dry up and the plants wilt.	
Magnesium (Mg): Chlorophyll is not synthesized if there is a deficiency of magnesium, so the green colour gets paler and the rate of photosynthesis is reduced. Chlorosis occurs deeply and rapidly in the middle places of the veins.	
Iron (Fe): If there is a deficiency of iron, young leaves first turn pale. It also causes yellowing of young leaves, starting between the leaf veins and resulting in chlorosis. Sometimes the whole leaf becomes pale. The stem gets weak and short.	
Sulpher (S): Sulpher not only serves as a structural component of protein, hormones and vitamins but also maintains the balance of water in cell. Leaves show general chlorosis, and reddish and purple spots appear on them. Chlorosis happens more with young leaves and less in old ones. The tissue of the leaves, stems and root die gradually from tips to the bottom due to deficiency of sulpher. This is called die back. Inter-nodes of stems become short, and consequently the plant becomes stunted.	
Boron (B): Boron gives strength to a cell by being inside the cell wall. It also regulates various reactions in the metabolism process. Necrosis of meristematic tissue in growing regions occurs when there is a deficiency of boron. The growth of young leaves is inhibited and the leaves lose their proper shape, the stem becomes brittle, rupturing their surface. The initiation of floral bud is obstructed.	

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Individual Activity

Activity: The teacher will ask the students to prepare a chart stating the different deficiency symptoms of different mineral nutrients.

5.2 Food and Nutrition of Animal

You have learned in Class six and eight that food is essential for life. In the same way, a balanced diet is necessary for good health. When oxidized, foods produce heat and energy in the body. In the previous chapter, you learned how heat and energy are produced by chemical reactions in the respiration process. From the beginning to the end of life, the influence of chemical reactions is endless. To move, play or do other activities energy is necessary. We get this energy from food. The substances which are digested and absorbed within the body and help in repairing itself, staying healthy, supplies nourishment for vital activities, protect from diseases and produce heat and energy, are called food.

5.2.1 Components of food and their sources: All the above mentioned tasks are essential for our living. Different types of food are necessary to perform these tasks properly. Foods are the chemical combination of many compounds. These chemical substances are the ingredients of food. Nutrition exists within these ingredients and are called nutrients. Most of the foods contain more than one nutrient, but they are classified into the category of the nutrient that is present in greater quantity compared to other nutrients in that food. Depending on the principle of ingredients, foods are divided into three classes:

a. Protein : Helps in growth and repair.

b. Carbohydrate: Helps in producing energy.

c. Fat and oils: Produces heat and energy.

Besides these, three other components are essential for the body :

d. Vitamins: Increases immunity power and enhances chemical reactions.

e. Minerals: Takes part in various biological functions.

f. Water: Keeps the balance of water and temperature. Regulates cell activity and contains organelles.

There is also another component. Although it is not a nutrient, it is nevertheless an important component of our diet.

g. Fiber or Roughage: Roughage absorbs water, increases the amount of stool, and helps in bowel function.

(a) Proteins: Proteins are composed of carbon, hydrogen, oxygen and nitrogen. There are 16% nitrogen in Protein. Sulpher, phosphorus and iron are also present in small quantities. Due to the presence of nitrogen, sulpher, phosphorus and iron, the importance of protein is different from carbohydrate and fat. Protein is the only source of nitrogen. That is why it is considered an important component.

Sources of Protein : We have learned earlier that we get protein from fish, meat, eggs, milk, pulse, dried fish, bean seed, nuts etc. Proteins are of two kinds:

1) Animal protein and 2) Plant protein.

Animal protein: Fish, meat, eggs, cheese, posset, liver are the sources of animal protein. Amino acids, which are essential for the body, can be found in these foods.

Plant protein: Pulses (dal), nuts, bean seeds etc. are the sources of plant proteins. Once it was thought that these are less nutritious, because plant protein does not contain all the essential amino acid. In fact, like animal proteins, plant proteins contain all amino acids in sufficient amounts. Sometimes two or more plant proteins are cooked together. But this does not have any significant effect on the proportion of amino acids.

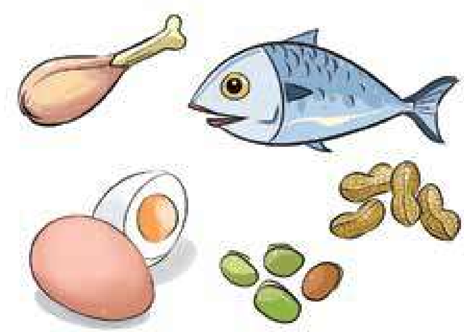

Figure - 5.01 : Proteins

(b) Carbohydrates: Carbohydrates are the main sources of energy. They are composed of carbon, hydrogen and oxygen. Carbohydrates are deposited in roots, stems, flowers and seeds in different forms. Glucose in fruit juice, lactose in milk, starch in wheat, potato, rice etc. are different forms of carbohydrates. According to composition, carbohydrates are of three types.The formation and composition of three types of carbohydrates are shown in the table below.

Table 10.2: Classification of carbohydrates.

Carbohydrates	Composition	Example	Sources
Mono-saccharide	One molecule of Carbohydrate	Glucose	Honey, fruit juice.
Di-saccharide	Two molecules of Carbohydrate	Sucrose, lactose.	Sugar and milk.
Poly-saccharide	Many molecules of Carbohydrate	Carbohydrate, glycogen.	Rice, ata, potato, green vegetables

We mostly get carbohydrates from rice, wheat, and potato. In raw form carbohydrates cannot be easily digested. That is why we eat foods like potato, rice, wheat etc. after cooking. Carbohydrates are then digested and turned into glucose. Di-saccharides and poly saccharides turn into simple carbohydrates (glucose) through digestion and become ready for absorption. For human nutrition, simple carbohydrates are very important. The human body can only absorb glucose.

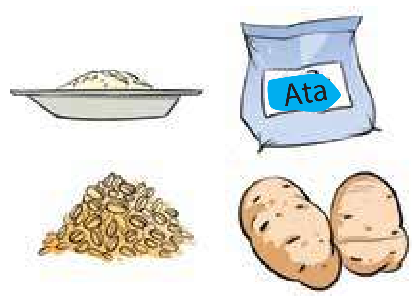

Figure: 5.02 Carbohydrates

(c) Fats: Fat is an essential component of food. It is composed of carbon, hydrogen and oxygen and its main function is to produce heat. It remains in the stomach for a long time, so we do not feel hungry. Fat is stored beneath the skin. It is also stored in various organs, such as, in the liver, brain and muscles. These stored fats are used when food is not available. It contains more than twice as many calories as carbohydrates and proteins.

The calorie is the measuring unit of energy in food. Food, cooked with oil or ghee, makes the food tasty. At the same time it also increases the nutritional value, such as, fried potato instead of boiled potato, luchi or porota instead of roti are not only tasty but also contain more calories. Some fats contain vitamin 'A', some contain vitamin 'E'.

According to the sources, fats are of two kinds, such as - 1) Vegetable fat and 2) Animal fat.

1) Vegetable fat : Soyabean, mustard, sesame, nuts, sunflower and corn oils are used as vegetables oils. Among them soyabean oil is the best one.

2) Animal fats : Fats, ghee, dalda etc. are animal fats. Egg yolk contains fat but the white part of the egg does not. Fats are insoluble in water. Fat floats on water because it is lighter than water. The daily requirement of a healthy adult person is 50-60 gm of fat.

Figure: 5.03 Fats

(d) Vitamins: Very small amount of vitamins is needed for health; even so, its importance is unlimited. To grow and to remain healthy vitamins are absolutely necessary. A balanced diet contains different types of nutrients, so sufficient vitamins can be obtained from a balanced diet. The absence of vitamins in regular diet causes vitamin-deficiency diseases. It can even cause severe harmful effects on the body, or even death. Vitamins are of two types, as : 1) Fat soluble vitamins and 2) Water soluble vitamins. Vitamin 'A', 'D', 'E' and 'K' are soluble in fat and vitamin B-complex and vitamin 'C' are soluble in water.

Fat soluble vitamins

Vitamin A: Vitamin A is obtained from milk, butter, fats, eggs, carrot, mango, jack fruit, coloured vegetables, mola fish etc.

Vitamin D: Milk, eggs, liver, dairy products, fish oil, edible oil etc. are the sources of vitamin D.

Vitamin E & K: Vitamin E and vitamin K can be obtained from all the above mentioned foods.

Water soluble vitamins

Vitamin B: Yeast, husking rice, red ata, sprout gram, peas, cauliflower, pea nut, beans, liver, heart, milk, eggs, meat, green vegetables etc. are the sources of vitamin B.

Vitamin C: Vitamin C can be obtained from guava, pomelo, star fruit, orange, cabbage, tomato, pineapple, green chili, fresh vegetables etc.

(e) Mineral salts or Minerals: Mineral salts are essential for body cells and body fluids. The human body contains mineral salts, such as: calcium, iron, sulphur, zinc, sodium, potassium, iodine etc. These ingredients do not exist as stand-alone elements. These elements are in food and the body as a compound with other elements, forming various organic and inorganic salts. Mineral salts regulate body building and internal functions.

Mineral salts are the most essential elements in the formation of teeth, muscles, bones, enzymes and hormones. They play a particular role in nerve impulses, muscle contraction, maintaining water balance in body cells, and keeping balance of acid and base.

Milk, curd, cheese, small fishes (mola-dhela), pulses, green vegetables, red leaves, arum leaves etc. are sources of calcium. Liver, green vegetables, meat, egg yolk, arum leaves contain iron. Phosphorous is obtained from milk, fish, meat, nuts, pulses. Table salt, chips, salty food, cheese, nuts, pickles etc. contain sodium. Fish, meat, nuts, pulses, banana, potatoes, carrots, apples etc. contain potassium. The sources of iodine are sea weeds, sea fish, meat and algae.

(f) Water: The other name of water is life. For the existence of life, Water is just as important as oxygen. Water is the most essential component for nutrition. Body building and internal functions are not possible without water. There are three functions of water: (1) Body formation (2) Control of internal functions and (3) Elimination of waste products.

(1) Body formation: Body formation and maintenance cannot be possible without water. At least 50-65% of body weight of the human body is water.

(2) Control of internal functions: No chemical reaction can occur inside the body without water. It acts as a solvent. Blood transport is possible only because of water. Nutrients from digested food in blood and oxygen are carried to the cells through water. Mineral salts remain dissolved in body fluid. Nutrients from digested food, dissolved into water, are absorbed into blood through the small intestine.

(3) Elimination of waste products: Water helps to remove waste products from the body. A large amount of water leaves the body with urine, stools, sweat etc.

The demand of water for the body depends on the person's age, labour, food habits and environmental conditions.

(g) Fiber or Roughage: Dietary fiber or roughage is found in the outer covering of cereals, vegetables, skin of fruits, endosperm, seeds, roots, leaves, stem of plants, etc. These are the cellulose and lignin of cell walls. The way bones make up the structure of the body, likewise cellulose and roughage make up the structure of plants. These are complex carbohydrates. While human beings cannot digest cellulose, cows, goats and buffalo can. Roughage absorbs water, increases the amount of feces and helps to eliminate stools. Roughage enriched food also absorbs harmful products from the intestine. It is assumed that roughage reduces the risk of cancer to some extent. Roughage plays a role in reducing obesity, the tendency of fat deposition, and hunger.

5.2.2 An Ideal Food Pyramid

A balanced diet includes carbohydrates, vitamins and minerals, protein, fats or oils. If we observe a balanced food chart of a teenage boy or girl, or an adult male or female, we may find that carbohydrates have the most highest presence in the list. Placing carbohydrates at the bottom and considering the quantities of vegetables, fruits, proteins, fats and oils successively, if we arrange these substances in successive tiers, it looks like a pyramid. This is called the ideal food pyramid. This diagram shows carbohydrates at the base and fats and oils at the apex.

The necessary foods that we eat daily, are shown in the form of pyramid (Fig: 5.04). You may notice the highest quantity is at the base and the lowest quantity is at the apex. We should eat carbohydrates in a large quantity as the largest level at the base indicates rice, potato, bread etc. Vegetables, fruits are placed in the next tier. These substances should be eaten in less than carbohydrates.

Fish, meat, eggs, milk, pulses, cheese, posset, curds should be eaten in lesser quantities than fruits and vegetables. Sweets, fat and oil should be eaten the least. We have to choose what we eat according to the food pyramid, and then we will be able to eat a balanced diet. Generally we eat tasty foods the most. This habit is not good for health. So we should make a habit of eating food in moderation.

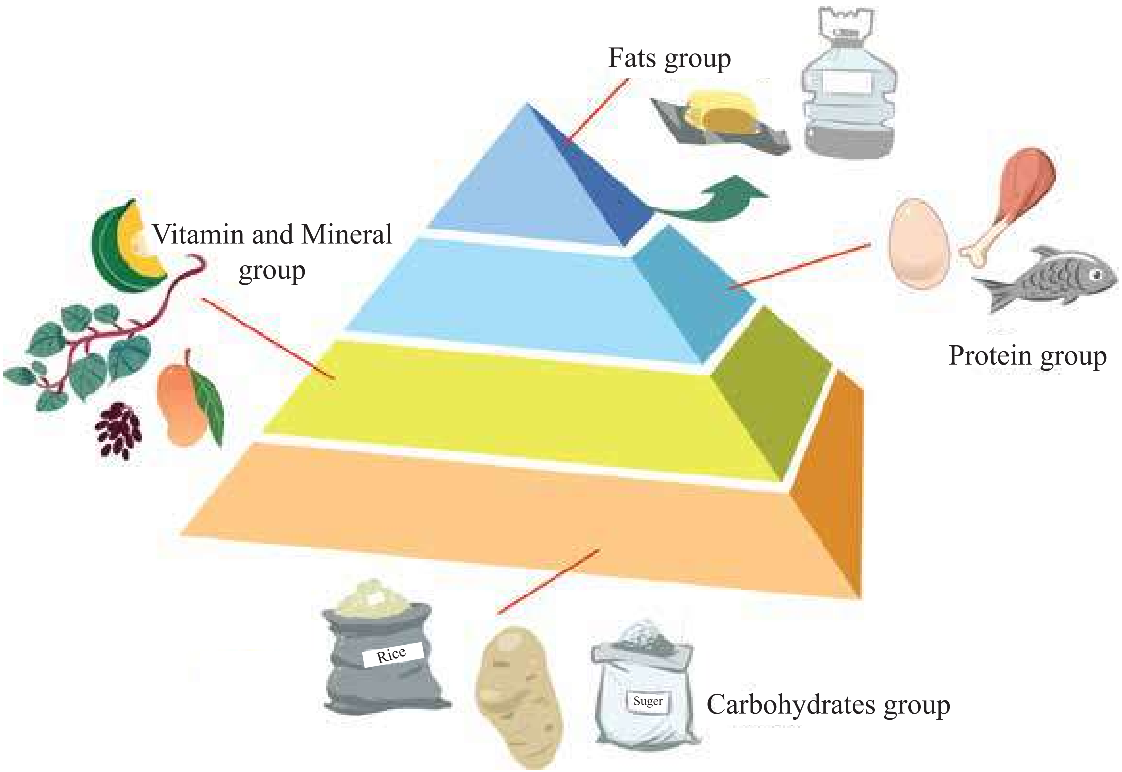

Figure-5.04: Ideal food pyramid

5.2.3 Principles of Food Habit

Selection of food or a balanced diet is a precondition for healthy living. Every body should know the rules of healthy eating because then it becomes simpler to fulfill the demands of family members taking into account food selection, food calories, family income etc.

Characteristics of balanced diet

1. People should have the ability to produce adequate energy through metabolism.
2. Protein, fats and carbohydrates should be eaten proportionately.
3. Include fresh fruits and vegetables in the diet for the supply of necessary vitamins, roughage or cellulose.
4. There must be sufficient water and minerals.
5. The diet must be easily digestible.

There is no alternative to a balanced diet for a healthy life. For a well developed body it is important to make a food chart or menu by including foods that contain six ingredients. A realistic menu can be prepared if the demands of the body, availability of food and family income are taken into consideration while selecting items or planning the menu. A menu can be made or chalked out by selecting the low cost food that contains the equal or same food value. Selecting low cost food, that contains equal food value (instead of costly food) is a good practice.

Preparing a balanced food chart

In order to prepare a balanced food chart, some issues should be taken into consideration. For instance-

1. Person's sex, age, occupation and health condition.
2. Knowledge about food value.
3. Presence of adequate protein supply for repairing and body building.
4. Presence of adequate amount of vitamins, minerals and water.
5. Knowledge regarding climate, weather and food habit.
6. Economic condition of the family and number of family members.

Observe the table mentioned below. You will learn about the amount of food needed for male and female persons of different age.

Table (A) Food chart for adult male and female

In order to get the required amount of calories per day, adult males or females should consume food mentioned in the following chart. Pregnant and nursing mothers need extra food. Young children may eat less food according to their age.

Adult male				Adult female		
Name of food grains	Without work (gm)	Moderate working (gm)	Hard working (gm)	Without work (gm)	Moderate working (gm)	Hard working (gm)
Bean/kidney bean	20	25	30	20	22.5	25
Egg/fish/meat	One/30gm	One/30gm	One/30gm	One/30gm	One/30gm	One/30gm
Leafy vegetables	40	40	40	100	100	150
Other vegetables	60	70	80	40	40	100
potato	50	60	80	50	50	60
Milk	150	200	250	100	150	200
Fat/oils	45	50	70	25	30	45
Sugar/molasses	30	35	55	20	20	40

Table B: General food value/nutritional value of some food in Bangladesh

This table has been prepared on the basis of food value or nutritional value of food grains in Bangladesh. This is published and accepted by the Institute of Nutrition and Food Science (INFS, 1975). Calories have been determined for every 100 gms edible part of food. How to determine calorie value is discussed in this chapter.

Name of food grains	Energy kilocalorie
Rice	346
Wheat (ata)	341
Gram	360
Lentil (dal)	343
Carrot	48
Patato	97
Water Spinach (Kalmi shak)	28
Basella	26
Pumpkin (small)	60

Name of food grains	Energy kilocalorie
Brinjal	24
Cauliflower	30
Cabbage	27
Kidney bean	26
Bean	96
Hilsha fish	273
Catla fish	111
Prawn	89
Beef meat	114
Egg	173
Chicken	109
Mutton	194
Milk (Cow's milk)	67
Milk (Mother's milk)	65
Ghee (from Cow's milk)	900
Cooking oil	900

Individual Activity

Activity: Prepare a food list of carbohydrates, proteins and fats from the list above.

Additional matters that should be of special consideration-

- Maintain cleanliness while preparing food, serving, and eating food.
- Drink sufficient water daily. Water must be boiled before drinking.
- Make a habit of eating seasonal fruits, fresh vegetables. These must be included in daily food chart. Avoid canned and frozen vegetables.

Individual Activity

Activity: Students will make a food chart which he/she has been taken for the last 7 days and compare it with the balanced diet and place it in the class room.

5.3 Vitamin deficiency diseases

(a) Goiter: In the conventional scenes goiter indicates any kind of swelling of the thyroid gland, but according to medical science all swellings of the thyroid gland are not goiters. The thyroid can be enlarged abnormally due to tumours, cancer or other inflammation but these are not goiters. Again, goiter does not indicate any particular disease of the thyroid; rather it is a general symptom for different diseases related to thyroid. Goiter can be caused for various reasons. A deficiency of iodine in food is one of the main reasons of goiter.

Figure: 5.05 Goiter patient

There is less iodine in the soil of the regions that are away from the sea, such as North Bengal and hilly areas. So people of these regions tend to suffer more from this disease.

(b) Night blindness: The disease Xerophthalmia occurs due to the deficiency of vitamin A. If the deficiency is not treated, the level and intensity of the disease increases. There are seven to eight levels of xerophthalmia and night blindness is the lowest level. Generally, 2-5 year old children suffer from this disease. The sensory rod cells of the eyes get damaged. The patient can not see in dim light. Everything seems to be hazy. If the disease worsens, the cornea turns cloudy. These are the symptoms of night blindness. Starting from night blindness, the fourth to fifth level of xerophthalmia can be cured by applying vitamin A supplements and medicines. If the disease becomes acute, there is no other alternative but surgical intervention or corneal transplant. Vitamin 'A' enriched food, such as, fish liver oil, liver, green vegetables, yellow and orange fruits and vegetables (ripe mango, banana, sweet pumpkin, carrot etc.) mola and dhela fish, or if necessary vitamin A capsule should be taken to prevent the disease.

(c) Rickets: This is not a viral or bacterial disease. Deficiency of vitamin 'D' is the cause of this disease. This vitamin is essential for the absorption of calcium and phosphorous in the intestine, formation of teeth and bones. Milk, butter, eggs, cod liver oil are the sources of vitamin 'D'. Cholesterol stored in human skin can also produce vitamin D with the help of ultra violet ray of the sun, but in that case, the last stage of producing vitamin D occurs in the kidneys. The symptoms of this disease are weakening of the bones, swelling of the joints, and bending of the bones, especially the leg bones. This structure of the body can not be maintained, as bones become brittle and the thorax turns narrow. It is necessary to feed children vitamin 'D' enriched food. It is wise to keep new born babies in sunlight, keeping the eyes and reproductive organs covered. A deficiency of vitamin D may occur if the whole body remains covered with dark or black clothes regularly or if one stay indoors for a long period of time.

(d) Anemia: Anemia is a general disease often occurring in children and females in our country. Anemia occurs when the density of haemoglobin is less than normal with respect to age and gender. This disease occurs due to the deficiency of the essential elements of food like iron, folic acid, or vitamin B-12. There are many causes of anemia and it may occur even without the deficiency of any nutrients. The deficiency of iron based protein is the general cause of anemia in Bangladesh. Children, women of reproductive age group (15 –45 years) and pregnant mothers often suffer from this disease. There may be various causes of having iron deficiency anemia, such as - excessive blood loss, worms, shortage of iron in food for growing children and pregnant mothers, obstruction in absorption of iron based food, or infection in intestine. Symptoms of this disease are: feeling weak, headache, depression, insomnia, loss of appetite, palpitation, vision suddenly goes dark.

To prevent this disease, eating iron enriched food, such as : kidney bean, liver, meat, eggs, peanut, lentile, vegetables, molasses etc. is necessary. If anemia is due to the infection of worms in the intestine, the patient needs to take worm destroying drugs. If necessary, this disease can be prevented by taking iron supplements under doctors' advice. Giving treatment of anemia without doctors' advice may be dangerous because there are some cases of anemia (like thalassemia) where taking a normal dose of iron supplements or food may worsen the condition of the patient. So it is necessary to diagnose the disease properly before treating the anemia.

Individual Activity

Activity: Draw a poster regarding the contribution of nutrition to healthy living.

5.4 Energy in food ingredients

We know that food gives us nutrition and energy. But do we know what amount of food gives us what amount of energy? Is the energy yielded by different nutrients the same? Among the six nutrients, only proteins, carbohydrates and fats can produce energy. The other three ingredients can not.

Muscles of our body help in movement and locomotion. We can do any work because of our muscles, such as : moving, walking, running, sitting etc. How much energy is spent to do these activities? Energy consumption depends on muscle contraction and relaxation. The more the muscles will contract or expand, the more energy will be spent.

The consumption of energy depends on work. So, is energy required if we do not walk or move? If we do not perform any work, only pass our time idly, we still need food. We feel hungry. Energy is also spent when resting. How does it happen? When taking rest our external organs, like-hand, legs do not work. But during respiration, our heart continues to work. So all the muscles, involved in these functions, contract and relax to perform work as a whole, so consumption of energy still goes on. This energy is called basic metabolic energy. How much energy is required for a person depends on three factors. (1) Basic metabolic rate (2) Type of daily physical labour and (3) Influence of food. The demand for calories also depends on body growth, physical condition and climate.

5.4.1 Standard unit to Calculate Food Energy

You know that there are various forms of energy. The energy released from food is heat energy. The unit to measure heat energy is the calorie. According to Physics, 1000 calorie or 1 kilocalorie is required to increase the temperature of 1 kilogram (1000 gram) by 1 degree centigrade. Nutritionists also use the word calorie to indicate food energy, but food calorie, in fact, is kilocalorie. To avoid any confusion, the word food calorie or kilocalorie has been used in this book.

According to international standards 'kilojoule' should be used instead of kilocalorie. In this case 1 food calorie=1 kilocalorie = 4.2 kilojoule (approx).

5.4.2 Determining food energy in food nutrients

Every day we consume different types of nutrients. We eat everything starting from rice, khichuri, polao, from meat to fruits, vegetables, drinks etc. So, to measure the amount of energy of the nutrients we have to know about the nature of the foods.

Nature of the nutrients in mixed food and pure foods

Nature of food means whether it is mixed or single food. Mixed food like milk, egg, khichuri, and guava contains more than one nutrient. On the other hand, single food like sugar, glucose contains only one nutrient (only carbohydrate).

Nutrients and determining of its amount

After knowing the nature of the food, we should know which food contains what nutrients in what amounts. The nutritional constituents, their amounts and food value can be known from food value chart.

Determining calorie

After knowing about the ingredients of the food and their amounts, we have to calculate the calories of carbohydrates, proteins, and fats. In this case we calculate it considering the calorie value of vitamins, mineral salts and water as zero. The following table shows the amount of calories per gram of element.

Ingredients/ gm	Calorie
Carbohydrate	4
Protein	4
Fat	9

Example:

Question: If 20 gm chira contains 15.4 gm carbohydrate (77%), 1.32 gm protein (6.6%) and 0.24 gm fat, what is the calorie of 1 kg chira?

Answer: Let us determine the calorie of 20 gms of chira. According to the table the same amount of chira contains-

15.4 gm carbon (77%)
1.32 gm protein (6.6%)
0.24 gm fats (1.2%)

Then, according to formula :

From 15.4 gm carbon $15.4 \times 4 = 61.60$ food calorie.
From 1.32 gm protein $1.32 \times 4 = 5.28$ food calorie.
From 0.24 gm fat $0.24 \times 9 = 2.16$ food calorie.

Therefore, the net calorie $= 69.04$ food calorie or 69.04 kilocalorie

So, calorie value of 1kg of chira $= \dfrac{69.04 \times 1000}{20}$

$= 3452$ calorie.

Since 1 kilocalorie = 4.2 kilojoule.
Therefore, 3452 kilocalorie = 14,490 kilojoule (approx).

An adult person usually needs 2000 to 2500 food calorie but this can be more or less depending on gender or nature of activities. If kilocalorie intake is more than necessary, it is stored in the body as fat.

Individual Activity

Activity: Suppose your daily need is 2000 kilocalories. Considering balanced diet, prepare a menu for a day for yourself with the food of your liking.

5.5 Basal Metabolic Rate(BMR) and Body Mass Index(BMI):

The Basal Metabolic Rate indicates the energy used by human beings at resting stage. The Body Mass Index indicates the structure of the body and the presence of fats. So, Body mass index indicates the relation between the height and deposition of fat of a person of particular age for healthy living and maintaining good health. To determine a person's sound health and obesity, these two scales are very important.

5.5.1 Determining BMR value

To calculate BMR value is a bit difficult, its equations are with respect to sex and age. To get an idea about BMR, Harris Benedict's popular formula is used.

BMR (female) = 655 + (9.6 x weight. kg) + (1.8 x height. cm) - (4.7 x age. year)

BMR (male) = 66 + (13.7 x weight. Kg) + (5 x height. cm) - (6.8 x age. year)

Suppose a woman is 33 years old, height 165 cm and weight is 94 kg.

So, her BMR = 655 + (9.6 x 94) + (1.8 x 165) - (4.7 x 33)
= 655 + 902.4 + 297 - 155.1
= 1699.3 calorie.

Calorie demand per day can be measured by using the table below.

Physical condition	Calorie
Not working	BMR value × 1.2
Light working, playing 2-3 days in a week.	BMR value × 1.375
Working, sufficient playing 2-3 days in a week.	BMR value × 1.55
Working, sufficient playing everyday in a week.	BMR value × 1.725
Hard working, sufficient jumping, running and playing.	BMR value × 1.9

Example: If the above mentioned woman is hard working, sufficient playing every day, and if her BMR is 1699.3, then her calorie demand will be (1699.3 × 1.725) = 2931.29. That means if the woman consumes around 3000 kilocalorie, she can maintain her weight.

Relation between BMR and energy spent

The value of BMR depends on sex, age, body structure and food habit. It is observed that the BMR value is balanced with the daily demand of food of our body. BMR has controls the production of 60-75 percent energy in our body. Our body gets 10%-12% of energy from taking in food and gets 20%-30% of energy through physical activities. The BMR value declines with increasing age. Some people diet to keep the body slim, so the BMR value declines more. As a result there is no more scope of getting slim by dieting. BMR can be raised or increased by adequate physical work. Health can be kept sound by following certain rules.

5.5.2 Determining BMI value

BMI = Body weight (kg)/ height of the body. $(\text{meter})^2$

As for example: A man, having 125 cm (1.25 meter) height and 50 kg weight, has 32 BMI.

BMI scales:

BMI Value	To Do
Below18.5	Underweight; weight to be increased by taking adequate food.
18.5-24.9	Ideal scale for good health.
25-29.9	Over weight. Necessary to decrease body weight by physical exercise.
30-34.9	First stage of obesity. Taking selective food and exercise is necessary.
35-39.9	Second stage of obesity. Taking moderate amount of food and exercise is necessary.
Above 40	Extreme obesity. Possibility of death risk, doctor's advice necessary.

According to BMI scale, body weight of the above person should be 38 kg. Body weight can be controlled by consuming accurate nutrition and exercise.

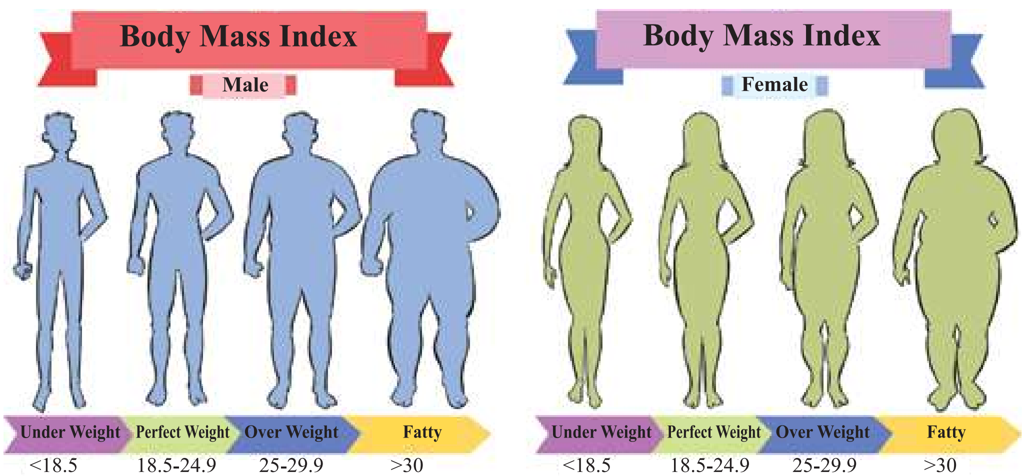

Figure : 5.06 Body Mass Index

Individual Activity

Activity: Calculate your BMR and how many kilocalories you need every day.

Individual Activity

Activity: Calculate your BMI and see if your intake of food and life style is correct.

Group activity

Activity: Find out average BMR and BMI of your class and write a report on it.

5.6 Exercise and Rest

Everybody should do adequate physical activity to keep the body healthy. Nowadays obesity is increasing as our physical movement has become restricted due to the scarcity of playground, excessive internet addiction, nature of work, academic pressure, and less physical activity. We are becoming uninterested in physical activity. So, the body doesn't remain strong and healthy. By doing adequate physical activity, we can maintain work efficiency of our body. A long and healthy living is possible by practicing an hour moderate work daily and taking in adequate food. Excessive body weight can be decreased by physical exercise. We can prevent diabetes, heart diseases and some kinds of cancer through physical exercise. There are different types of physical exercise, such as, athletics, or exercises that make bones and muscles strong. Walking fast, jogging, running, swimming, playing, cycling etc. are examples of physical exercise.

Rest is very important for health. Rest is essential after physical and mental work. Lying down and sleeping is a part of rest. After rest different parts of the body regains energy and stores it. You will be astonished to know that almost all animals in the living world take rest. This rest is related to the day and night cycle. Many animals are active in sunlight. Other animals take rest by day and remain active during the night, when they come out in search of food. These are called nocturnal animals.

5.7 Use of Chemicals in Food Preservation

Food preservation is a process by which rotting of food can be resisted. As a result, the properties, acceptability, food value remain intact. Food preservation prevents the rotting of food by bacteria, fungal infection, or the oxidation of fats. Fish drying, salted Hilsha, pickle, cooling by ice, fish sidol, prawn nappi etc. are customary means of food preservation. Modern methods of canning and smoking processes are also used for preserving food. Healthy, approved chemical substances are used to preserve food so that decomposing bacteria and fungal infection do not happen. Generally sodium nitrate, sodium chloride or table salt, calcium apernate, sulphur di-oxide, sodium-bisulphate, sodium benzoit, sorbet (Na, K, Ca) are used. These are approved chemicals. Harmful formalin and various kinds of coloured substances should not be used, because it can be dangerous.

Adulterant in food and use of colours

Just as a clean environment is necessary to live in this beautiful world, similarly, eating safe food is essential. Nowadays various harmful and unhealthy chemical substances and colours are used as adulterants. As a result, public health is now threatened. If this health risk continues, Bangladeshis will face a great disaster in course of time just like the Romans. Once upon a time the Romans used water containers made of lead. As a result, people who drank that water got affected by poisonous lead and gave birth to a crippled generation. In Bangladesh, various kinds of adulterants are mixed with the food. Commercial colours, antibiotics, chemical substances, insecticides, pesticides, formalin, heavy metals are mentionable. The cattle, fishes, poultry animals etc. which are fed the unapproved adulterant food, are threatening to human life and health.

Some harmful effects of health risk : Commercial colours used in textile or for colouring are sometimes used in ice-cream, blended ice cream, candies, beguni, chop etc.These types of foods gradually affect liver function and cause various diseases. Bacteria that help in decomposition cannot grow in fish, fruits and other food stuffs submerged in formalin. So, it looks fresh. Research has found that formalin forms a compound within cell of the fishes. Even after frequent washing it remains within the fish body. It enters the human body with the cooked food. These poisonous compounds are the cause of complex disease symptoms and may even cause some types of cancer.

Insecticides are used in the storage of food and vegetables. If these are sold before the effect of the insecticides expires, the poisonous effect on food creates great health risk. Infants are more affected. Poisonous insecticides have an adverse effect on their growing cells. So, infants suffer from various types of illnesses and their mental development is hampered. The list of chemical substances and adulterants, used in food, are shown in the chart below-

Adulterant/poisonous chemical substances	Probable source	Remedy
1. Antibiotics	Used in fish and cattle food, stores in animals body.	Only drugs approved by registered physicians should be used.
2. Heavy metals	Inedible components used in fish and cattle food (such as-waste of tanneries) stores in animal body.	Avoid using inedible components, such as : waste products of tannery, coal, soil, faeces of animals.
3. Commercial colours	Unapproved colours used in industries, manufacturing ice-cream, blended ice-cream, artificial juice, coloured drinks, producing sweet, meat chop etc.	Avoid using inedible components, such as : waste products of tannery, coal, soil, faeces of animals.
4. Formalin	Mainly used to preserve dead bodies in the morgue,unapproved use for the preservation of fish, fruits, milk etc.	Avoid using formalin.
5. Insecticides	Used as pesticide in vegetables production, but its poisonous effect exists in many cases, unapproved use of D.D.T in dry fish.	After expiry of the effects of poisonous chemials, vegetables should be sold. Not to use D.D.T. in dry fish.

6. Chemical substances	Excessive and unapproved use of chemical substances to ripen fruits and tomato. Exessive use of sorbet in soft drinks and energy drinks.	Allow the fruit to ripe naturally. Discourage the use of carbide. Use of suitable amount of sorbet.
7. Microbes	At the time of production and preparation of food, microbes can get mixed with the food.	Be ensured of bio-security.

Group Work

Activity: Teacher will make several groups of students and tell them to make a list of harmful effects of eating adulterated food for presentation in the classroom.

5.8 Digestion

The human body is composed of innumerable cells. To keep it alive and functioning, it requires food. But most of the time foods are eaten as complex and organic compounds. The body cells are unable to absorb these directly. So, to make it absorptionable food is broken down into simple, easy and soluble form.

Food substances turn absorptionable in two ways, such as–

(1) Mechanical process and (2) Chemical process.

(1) Mechanical process: Teeth help in chewing or masticating food. First the food substances break into small pieces. Within the stomach and intestine these particles turn into pulp.

(2) Chemical process: Chemical process is the second step of digestion. Secretion of digestive enzymes helps to enhance chemical reaction. So the compounds break into simple soluble components. Intra cellular reaction also depends on enzymes.

Digestive system: There is a particular system for the digestion of food called the digestive system. This is the system, by which food substances are broken down into absorptionable substance for the body and absorbed. The digestive system consists of the alimentary canal and the digestive glands. Alimentary canal starts from the mouth to anus.

5.8.1 Alimentary System or Alimentary Canal: This is a canal running from the mouth to the anus. Some parts of this canal are broad, while some are narrow. The main parts of the canal are:

1. **Mouth :** The mouth is the starting point of the alimentary canal. It is a transverse opening below the nostrils and bounded by the lips.

2. **Buccal cavity:** The buccal cavity contains teeth, tongue and salivary glands. They helps to digest food directly and indirectly. Teeth helps to cut, grind and chew food into small pieces. The functions of the tongue are to move food around the mouth for mastication and to taste. Salivary gland secrets enzyme. These glands are located below the ear, at side of the jaws and below the tongue. Salivary juice secreted from the salivary glands contains mucin, which makes the food slippery helps in swallowing. The secretion containing the enzymes named ptyalin and moltes takes part in digestion.

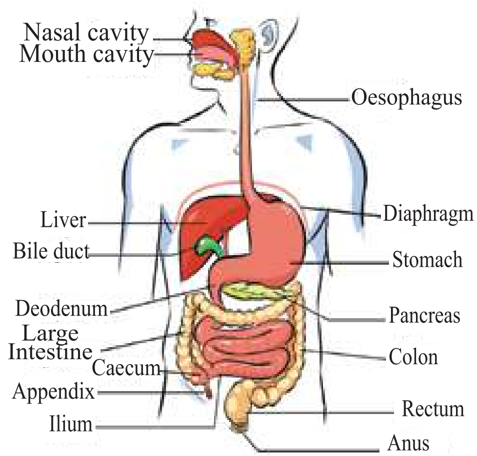

Figure: 5.07: Digestive system of human

Tooth: Fish, reptiles and almost all vertebrates (except mammals) shed and grow teeth numerous times during their lifetime, but mammals (such as humans) grow teeth only twice in their lifetime. Human children have 20 temporary teeth, or baby teeth, which fall out, followed by eruption of 14-16 teeth in each of the upper and lower jaw by age 18, for a total of 28-32 permanent teeth.

Permanent teeth are of four types, such as :

(a) Incisor : Incisors are used in cutting and biting food.
(b) Canine : Canines are used for tearing and grasping.
(c) Premolar : These teeth are specialized for crushing and grinding.
(d) Molar : These teeth are used in crushing, and grinding. The last two teeth of the gums are called wisdom teeth.

Every adult preson has 8 incisor, 4 canine, 8 premolar and 4 wisdom teeth.

Structure of a tooth: The tooth typically consists of three parts, such as–

(1) Crown: The part above the gum.

(2) Root: The inner part below the gum.

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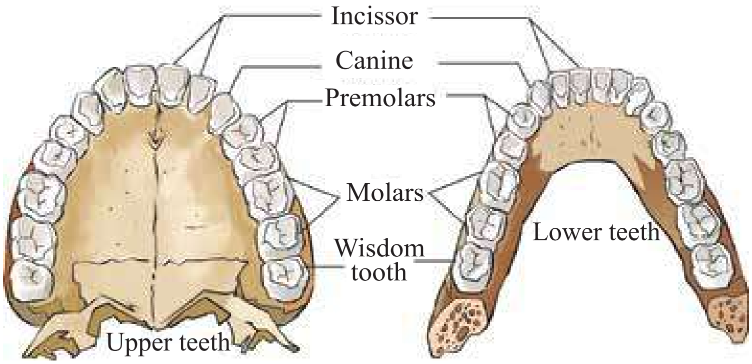

Figure: 5.08 Various types of teeth

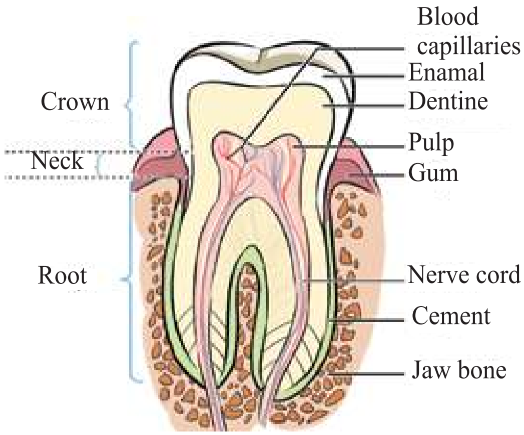

Figure: 5.09 Longitudinal section of teeth

(3) Neck: The tooth between the crown and the root.

Each tooth is composed of the following components:

(a) Dentine: The main part of the tooth consists of hard substances.

(b) Enamel: The crown is covered with enamel. Enamel is the hardest component of a tooth. Both Dentine and Enamel are composed of calcium phosphate, calcium carbonate and fluoride.

(c) Pulp: Dentine surrounds a pulp cavity with blood vessels (artery and vein), soft cells and nerves running through it. The blood supply nourishes dentine with nutrients and oxygen.

(d) Cement: The main part of the tooth dentine is covered with a thin covering, the cement. The tooth remains attached with the gums by means of this cement.

3. Pharynx : The next part of the buccal cavity is the pharynx. Food passes to oesophagus through the pharynx.

4. Oesophagus : The tube, stretching from the pharynx to the stomach, is the oesophagus. Food passes to the stomach through the oesophagus.

5. Stomach: The stomach is a bag like organ located in between the oesophagus and the small intestine. Its wall is thick and muscular. The inner surface of the stomach has numerous gastric glands. Continuous contraction and relaxation of the muscular wall of the stomach turns food material into pulp or semi fluid mass, called chyme. The juice, secreted from the gastric glands, helps in food digestion.

6. Intestine: The coiled duct, extended from behind the stomach, is the intestine. Intestine is divided into two parts :

(a) Small intestine: The coiled, long duct which extends from the stomach up to the large intestine, is called the small intestine. It is divided into three parts: duodenum, jejunum and ileum. Bile duct from the gall bladder and pancreatic duct of the pancreas joins just before it, and opens into the duodenum. Bile from the liver and pancreatic juice from the pancreas and enters the first part of duodenum. The inner wall of the intestine bears finger like projections called villi. There are intestinal glands in the inside of the small intestine. The villi absorb the vast majority of small soluble food molecules produced by digestion.

(b) Large intestine: The region from the end of the ileum to the anus is the large intestine. It is the wider part of the alimentary canal. The large intestine is divided into three parts: caecum, colon, and rectum. A small finger-like projection is connected to the caecum. This is the appendix. Here the undigested part of the food becomes feces. An important step in the formation of feces is the fermentation and decomposition of undigested food with the help of bacteria, the process of which emits gases that cause the foul smell of feces.

7. Anus : There is an aperture at the end of the alimentary canal. This aperture is the anus.

5.8.2 Digestive Glands: The glands, whose secretion takes part in the digestion of food, are called digestive glands. The digestive glands in humans are as follows :

(a) Salivary glands : There are three pairs of salivary glands. A pair of parotid glands, located in front of and below each ear, a pair of sub maxillary glands below the jaw and a pair of sub lingual glands below the tongue open into the buccal cavity through various ducts. Secretion from the

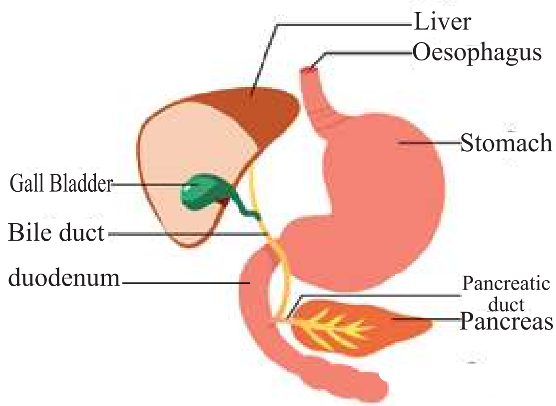

Figure: 5.10 Digestive gland

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salivary glands is known as saliva. Salivary juice contains water and an enzyme named ptyalin.

(b) Liver: The liver is situated just below the diaphragm on the right side of the stomach. It is the largest gland of the body and is deep brown in colour. The right lobe of the liver is larger than the left lobe. The liver consists of four incomplete lobes. Each lobe consists of lobules. Each lobule contains numerous cells. These cells produce bile. Bile is alkaline in nature. Different types of biochemical reactions take place in the liver. So, it is also called the organic laboratory. Beneath the liver the gall bladder is attached. It stores bile. Bile is deep green in colour and of bitter taste. The gall bladder is connected with the bile duct, pancreas are connected with the pancreatic duct. These two ducts together form a common duct that opens into the duodenum. It enters into the duodenum through the pancreatic duct.

Individual Activity:

Activity: Draw a labelled diagram of the alimentary canal and present it to the class.

Functions of liver: The liver produces bile. The ingredients of bile are mainly water, bile salt, bile, cholesterol, and mineral salts. It is stored in the gall bladder. When necessary, the bile passes to the duodenum and takes part indirectly in digestion. There are no enzymes in the bile. The liver stores excessive glucose as glycogen. The bile neutralizes the acidic chyme and creates an alkaline medium. This is favourable digestion because food is not digested in acidic medium. The bile breaks fat or oil into minute droplets. So, it becomes easier for lipase to digest the fats easily. Excessive amino acids are taken to the liver. After various chemical reactions urea, uric acid, ammonia, nitrogen products are produced, and these help in the absorption of fats. When blood sugar falls below the normal level, the glycogen stored in the liver is reconverted into glucose and transmits to the blood stream. Thus the level of blood glucose remains under control.

(c) Pancreas: The pancreas is an important mixed gland located obliquely at the back of the stomach. The pancreas secretes digestive juices as well as hormones that control the level of glucose. So, the pancreas acts as both an exocrine and an endocrine gland. The pancreatic juice passes into the duodenum through the pancreatic duct which joins the common bile duct (hepato pancreatic duct).

The pancreas secretes pancreatic juice. It contains the enzymes trypsin, lipase and amylase. These enzymes helps in the digestion of carbohydrates, proteins and fats. It maintains an acid-base balance, water balance and controls body temperature. The pancreas also acts as an endocrine gland and secretes essential hormones, such as, insulin and glucagon. These two hormones have an important role in keeping glucose under control and in other physiological processes.

(d) Gastric glands: The glands in the stomach wall are called gastric glands. The juice secreted from these glands (trypsin, lipase, amylase) is known as gastric juice.

(e) Intestinal glands: Villi, located in the wall of small intestine, contain intestinal glands. The secretion of these glands is known as intestinal juice.

5.8.3 Digestion of food

The bio-chemical process, by which larger complex, insoluble, unabsorbable food substances break into absorbable and soluble simple elements in the presence of enzymes and hormones is called digestion. First, food substances break into a simple soluble form, and then it diffuses through the cell membrane and enters the cell easily. Lastly, blood transports the digested simple ingredients to different parts of the body.

(a) Digestion in Mouth: In the buccal cavity the tongue and teeth work together to move, cut, grind and chew food into smaller pieces inside the mouth. Saliva from the salivary glands mixes with the food. This helps in the digestion and swallowing of the food. The saliva contains the salivary enzymes ptyalin or salivary amylase. The salivary amylase begins to break carbohydrate into maltose. Proteins and fats have no change in the buccal cavity. The food from buccal cavity enters the stomach through the oesophagus by peristalsis. The muscular wall of the alimentary canal contracts and relaxes simultaneously, causing forward movement of the food. No digestion of food occurs in the oesophagus.

(b) Digestion in stomach: When the food reaches the stomach, gastric juice is secreted from the inner wall.This juice contains the following main components

Hydrochloric acid: Hydrochloric acid destroys the germs coming with the food substances, converts inactive pepsinogen into active pepsin and creates an acidic medium to help its proper functioning.

$$\text{Inactive Pepsinogen} \xrightarrow{\text{HCL}} \text{Active Pepsin}$$

Pepsin: Pepsin is an enzyme which breaks protein into a compound named polypeptide which consists two or more amino acids.

$$\text{Protein} \xrightarrow{\text{Pepsine}} \text{Polypeptide}$$

Digestion of carbohydrates and fats do not occur in the stomach, because gastric juice does not contain any particular enzyme for the digestion of carbohydrates and fats. As soon as the food enters the stomach, the above mentioned juices are released. The muscles of the stomach contract and relax continuously. The chemical reactions that occur convert food into a semi liquid. This is chyme. It is more or less like a soup and enters the small intestine through valves.

(c) Digestion in the small intestine: When the chyme enters the duodenum, two secretions, pancreatic juice from the pancreas and bile from the liver, are released through the bile duct. Both of these secretions are alkaline in nature. Pancreatic juice neutralizes the acidity of the chyme. The enzymes of the pancreatic juice continue the digestion process of proteins and carbohydrate (maltose) and start fat digestion. Bile neutralizes the acidity of the food and creates an alkaline medium. Bile salt, one of the constituents of bile, emulsifies fats, meaning it helps fat droplets to mix with water. It then becomes easier for the enzyme lipase to digest fats. The lipase converts the fat droplets into fatty acid and glycerol.

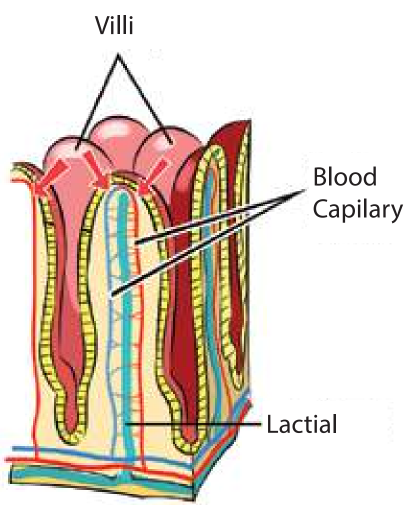


Figure: 5.11 Absorption of soluble food and fats in ileum

$$\text{Fats} \xrightarrow{\text{Lipase}} \text{Fatty acid + glycerol}$$

Pancreatic juice contains trypsin, lipase and amylase. On the other hand, intestinal juice contains the enzymes, maltase, lactase, and sucrase. Trypsin, converts partly digested protein into amino acid and simple peptide.

$$\text{Polypeptide} \xrightarrow{\text{Trypsin}} \text{Amino acid + simple peptide}$$

Amylase converts starch into simple glucose.

$$\text{starch} \xrightarrow{\text{amylase}} \text{glucose}$$

Absorption of digested food: Most of the foods are fully digested in the small intestine in the presence of enzymes and are converted into simple absorbable ingredients. The inner surface of the intestine (ileum) is covered with finger-like projections called villi, which contain capillary networks. Each villus (singular of villi) also contains a lymphatic vessel in the middle which is called the lacteal. The lacteal is surrounded by blood capillaries. As villi are folded, they increase the surface area of the ileum. Here absorption of the food ingredients takes place.

These blood vessels (capillaries) join together to form a large blood vessel called the hepatic portal vein which carries blood to the liver. Fat droplets are absorbed into the lacteal of the villi. First it is carried by lymph, then mixes with the blood stream. After reaching into the cell, bile salt becomes separate from fatty acid.

At the time of flowing blood, a kind of watery substance comes out of the capillaries. This watery fluid is lymph. Lymph supplies nutrients to the cell and collects the waste products and returns to the blood stream. After absorption the rest of the chyme reaches the colon.

(d) Digestion in large intestine: No chemical reaction or digestion takes place in the large intestine. But the water that remains within undigested products is absorbed here. There also remains a small portion of protein, lipid, salt and excess enzymes. Water and salt are reabsorbed from these products and are transferred to the blood. Then undigested products concentrate here and turn into faeces or stool. Faeces are stored in the rectum and pass out through the anus.

Assimilation: The process of converting digested food substances into the constituents of protoplasm is called assimilation. It is an anabolic process. Through the action of enzymes secreted from protoplasm, simple nutrients are converted into complex ingredients, such as: amino acid, glucose, fatty acid and glycerol. These ingredients spread all over the body through blood. Digested food substances are converted into protein, carbohydrates and lipids due to the action of enzymes secreted from protoplasm. This results in repair of worn out tissues and helps in growth.

5.9 Diseases caused by Intestinal Disorder

Sometimes physical problem or diseases caused by intestinal disorder. They are:

(a) Dyspepsia: Indigestion is dyspepsia. There are many causes of indigestion or disturbance in digestion, such as- infection in stomach, depression, disease of pancreas, thyroid problems, enzyme deficiency, diabetes etc. Pain in the upper abdomen, abdominal flatulence, feeling a full stomach, burning sensation in the chest, nausea or vomiting, chest pain, sour belch etc. are the symptoms of dyspepsia. Digestion problem may also occur because of stomach or intestinal ulcers. Generally people called it gastric. Actually its correct name is peptic ulcer.

To prevent dyspepsia, we need to avoid over eating, chew food slowly and properly, avoid smoking and if necessary, consult a physician to find out the cause and take medicine. It should be kept in mind that sometimes the symptoms of heart attack are similar to the symptoms of indigestion and peptic ulcer. That's why if the man above 40 years suddenly feel disturbance in digestion and do not get relief by conventional medicine then the patient should be hospitalized quickly. Because in that case, it may be heart attack not indigestion.

(b) Dysentery : Dysentery is caused by infection of a protozoa named *Entamoeba histolytica* or by a bacteria named *shigella.*

Frequent bowel elimination, abdominal pain, mucous and blood in the stool, and inability to digest dairy products are the symptoms of dysentery. If necessary, one needs to follow treatment of dysentery prescribed by physicians; otherwise it may turn out to be fatal.

The things we need to do to prevent dysentery are as follows– to drink pure water, wash fruits and vegetables carefully, wash hands with soap or ash after passing stool, use sanitary latrines, and wash hands and utensils carefully.

(c) Constipation: It is not a special disease. When stools become hard, or stool does not pass for two or more days, this condition is called constipation. There are various causes of constipation, such as: withholding bowel pressure, excessive water absorption from the undigested part of food in the colon, slow movement of the undigested part of the food through the alimentary canal, leading a lazy life, intestinal disorder, slowing down of the contraction of colonic muscles, and not eating food containing roughage increase the probability of constipation.

Due to constipation the passing stool becomes difficult. This results in an uneasy feeling in the abdomen, abdominal pain and various accompanying disorders. Long term constipation may cause hernias or other complexities. Constipation may also occur due to tumours of alimentary canal or other diseases. So it is wise to consult a doctor if constipation occurs.

To prevent this disease the things to do are– eat fibrous food, drink enough water, regularly eat vegetables, fruits, apples, bananas, coconut, dates, oranges, papaya, pine apple, tea etc. One should make a habit of regular walking and passing of stool.

(d) Gastric and Peptic Ulcer : An ulcer is the inflammation and sores of the stomach or the intestine. A peptic ulcer indicates open sores or ulcers of the digestive tract. If it occurs in the stomach, it is called a gastric ulcer. If it occurs in the duodenum, it is called Duodenal Ulcer. Irregularities in eating, cause the over secretion of acid. If this continues for a long time, sores in stomach and intestine occur.

Research of physician Robin Warren (1951–till today) and Barry Marshall (1937–till today) has shown that though irregularities in taking food, taking spicy food or stress may cause peptic ulcers, the main reason is a bacteria named *Helicobacter pylori* (in short *H pylori*). For this discovery, in the year of 2005 they received the Nobel Prize in Medicine. Previously, it was thought that no bacteria could ever survive in the strong hydrochloric acid (pH 1.5–3.5) inside the stomach. In order to prove his discovery, *Barry Marshall* drank a cocktail consisting of a beaker full of *H pylori* bacteria and became seriously ill from a peptic ulcer (It is important to note that this bacterium not only causes ulcer but can also cause stomach cancer. *Marshall* took a great risk to his life which should not be followed). Feeling continuous dull pain in the mid part of the abdomen is caused by this disease. Pain increases in an empty stomach or after taking excessive fatty foods. It may cause vomiting. Sometimes blood may come out with stool and vomit. The disease can be ascertained by endoscope or barium x-rays.

Things that should be followed to prevent this disease are: eat easily digestible food regularly, avoid spicy and oily food. Drinking boiled milk, cheese, or eating bananas gives some relief. Eating regularly, avoiding stimulating substances, such as- coffee, cigarette etc, following treatment and consulting the physician may help in preventing this disease. However, we have learnt from the discovery of Marshall and Warren that if anybody gets infected by *H pylori*, then his disease may not be cured even after following the above mentioned health rules. For his full recovery, antibiotics should be taken as prescribed by a physician along with eating on time.

(e) Appendicitis : In the right side of the lower part of the abdomen a finger like pouch that joins with the caecum of the large intestine is the appendix. Infection in the appendix is the cause of appendicitis. Pain starts around the navel, after sometime that moves downward on the right side. Loss of appetite, vomiting, and constipation are the symptoms of appendicitis. In this situation, a physician should be consulted. If the situation demands, patient should be taken to the hospital and the appendix should be removed by surgery. If the infection of appendix is severe, it can burst and may be fatal.

(f) Worm related diseases: Worms live in the body as parasites. The human body is a host for different kinds of worms. Round worms, thread worms, and tape worms live in the human intestine as parasites. Abdominal pain, weakness, indigestion, feeling of uneasiness in the abdomen, nausea, insomnia, loss of appetite, pale face, anemia, swelling of hand and legs, and enlarged abdomen, are the symptoms of worm related diseases. When an infant suffers from fever, worms may come out not only with the stool but also from the nose or mouth. Through pathological examination of stool, the presence of worms can be ascertained. After being ensured about the presence of eggs of the worms, treatment should be followed according to the advice of the physician.

Food substances become infected by flies which can lead to people being affected by worm. Worms spread out from infected food. Preventive measures are as follows - eating raw fruits only after proper washing, washing hands properly before eating, using sanitary latrines, not walking bare footed, not eating semi-cooked food.

(g) Diarrhoea : If anyone suffer from loose motion at least three times a day, this is the symptom of diarrhoea. Though people of all ages suffer from diarrhoea, the condition of infants deteriorates more quickly. Water and salt leave the patient's body. As water decreases, the patient becomes weak. So, shortage of salt and water is noticed. At that time if proper treatment is not ensured, the patient may even die.

Frequent loose motion and vomiting, feeling of thirst, dried up mouth and tongue, shrinking of skin, sunken eyes etc. are the symptoms of diarrhoea. In this situation the patient may not want any food or drink. When the child cries, the crown of the skull goes down. The child slowly becomes weak.

This disease spreads more quickly in cases such as: drinking impure water, eating of stale and dirty foods, using unclean utensils, intake of food with dirty hands.

If the symptoms of diarrhoea are noticed, then patient should be given oral saline as early as possible. Nowadays, oral saline, prepared by Institute of Diarrhoea Research Centre, is available in the market. The instruction of making oral saline is written on the packet. Oral saline can also be prepared in the house. You have already learnt how to prepare oral saline at home. Rice saline is one of the recent inventions. Rice saline is prepared by mixing 50 gm of rice powder and one pinch of salt with 1 litre of water. Remember the following instructions at the time of using oral saline, such as : continue to drink oral saline till diarrhoea stops, do not stop taking saline even if the patient vomits, allow breast feeding for infants. Patients should be given normal food regularly. After recovery the patient should be supplied extra diet for at least a week.

Diarrhoea may be caused by germs like virus, bacteria or protozoa. Rota virus is one of the main causes of diarrhoea. 82% of death due to rota virus occurs in deprived poor countries. The percentage of death is high in poor countries. The severity of this disease has also been found in developed countries, but death rate is comparatively less.

Group Activity:

Activity: Prepare oral saline in a group. Prepare a poster on writing the necessity of taking oral saline and present it before the class.

Exercise

Short answer questions

1. What are the mineral nutrients of plants?
2. How many essential mineral nutrients do plants use?
3. What is a food pyramid?
4. Why does anemia occur?
5. Why does night blindness occur?

Essay type questions

1. Describe the structure of a tooth with diagram.
2. Write down the characteristics of a balanced diet?

Multiple choice questions

1. Which of the following nutrients serve in a plant as a macronutrient?

   a. Zinc b. Chlorine

   c. Boron d. Potassium

2. Chlorosis is caused by –

   i. nitrogen deficiency

   ii. sulfur deficiency

   iii. iron deficiency

Which one of the following is correct?

a. i & ii b. i & iii

c. ii & iii d. i, ii & iii

Read the stem and answer the questions number 3 and 4.

Five years old Sanjana can see all the writings in her book. But at night she can not see the writing clearly.

3. Which vitamin deficiency does Sanjana have?

   a) vitamin 'A' b) vitamin 'B'

   c) vitamin 'C' d) vitamin 'D'

4. To prevent this disease which food should Sanjana eat ?
   i) liver
   ii) carrot
   iii) Mola fish

Which one is correct?

a) i & ii
b) i & iii
c) ii & iii
b) i, ii & iii

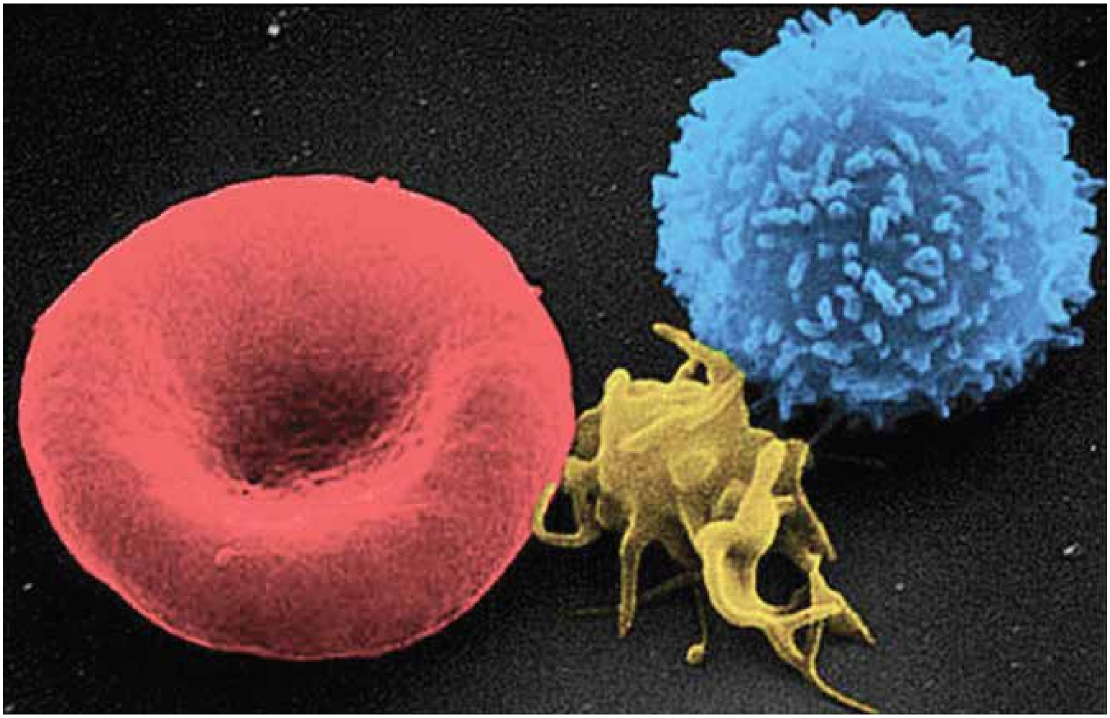
Creative questions

1. Dr. Raihan spends most of the time in the laboratory. So, his body weight is increasing. On the other hand, his younger brother Jahir is a regular player of the National Football Team. For that he has to play and take exercise daily.
   a) What type of food is the source of nitrogen?
   b) What do you mean by high protein? Explain it.
   c) Which food should be in much quantity in Jahir's food chart? Explain the reason.
   d) Which type of food is not applicable for Dr. Raihan that is included in Jahir's food chart? With analysis give your opinion.

2. Irfan Ali observed that the leaves of the grass in his garden were becoming yellow, and the leaves, flowers and buds of flowering plants were falling off plants. To solve these problems, he asked for help from a horticulturist, and the horticulturist suggested that Irfan Ali apply some essential nutrient elements in his garden.
   a. What is micronutrient?
   b. What are the essential elements for plants? Explain.
   c. Explain the causes of the problems found with the grass in Irfan's garden.
   d. Evaluate the suggestions given by the horticulturist.

Chapter Six

Transport in Organisms



Transport is an essential system, functioning all the time in all the living organisms. In plants, the conduction of water and minerals is as important as the translocation of food in them. Translocation of water and minerals absorbed from the soil and taken to the leaves is as essential as the translocation of food produced in the leaves to the different parts of the plant body. Transportation of substances in a human body is not the same as in a plant body, but both follow the same rules of Physics. Transport systems in both plant and human bodies are discussed in this chapter.

At the end of the chapter, we will be able to-

- explain the concepts and necessity of transport in plants;
- explain the plant and water relationship;
- explain the absorbing system of water and mineral substances and their necessity in plants;
- describe the translocation of substances produced through the process of photosynthesis;
- explain the conduction system of water and mineral substances and their necessity in plants;
- explain the concept and significance of the process transpiration;
- analyse the role of factors in controlling the rate of transpiration;
- evaluate that transpiration is a necessary evil;
- perform an experiment to demonstrate transpiration in the plants;
- explain the concept of transportation in the human body;
- explain the function of the components of blood;
- explain the characteristics of different blood groups;
- choose blood depending upon the blood group characteristics;
- describe the rules of blood donation and social commitment;
- describe the process of blood transportation in the human body;
- describe the structure and the function of heart;
- analyse the adaptation of the heart's structure with its activity;
- analysis the role of blood pressure in blood circulation;
- explain the ideal blood pressure;
- describe types of cholesterol, its range, usefulness and its risks for health;
- analyse the role of cholesterol in blood circulation;
- describe the causes and effects of irregularities in blood;
- analyse the symptoms, causes, remedy and prevention of diseases relating to the heart;
- analyse how to keep the heart healthy;
- measure the pulse rate and blood pressure at rest and after exercise and analyse them in these two situations;
- measure blood pressure and pulse rate accurately;
- one has to be aware of keeping the heart sound and will be able to make others aware.

6.1 Plant and Water Relationship

Another name of water is life. Life cannot subsist without water. We know that protoplasm is the physical basis of life. 90% of this protoplasm is water. This is why water is called the fluid of life. If protoplasm is devoid of water, it become constricted and may die. Not only that all the metabolic reactions that usual occur in a plant will be ceased in deficiency of water. The important uses of water in a plant body are:

1. There is no substitute for water in maintaining the living nature of protoplasm. In order to keep a cell with constricted protoplasm, water supply must be ensured.

2. It is necessary to ascertain the supply of water in necessary amount for keeping transpiration and photosynthesis running. This is why irrigation is to be maintained for large plants in the dry season.

3. Water is an important solvent. The significance of water in many metabolic reactions is immense.

4. Water plays important roles in the cellular growth of plant and in their movement.

Now, the question arises, from where and how the plants do obtain water for the maintenance of life? Plants mainly absorb water through their roots from the soil. Absorption is accomplished with the coordination of three processes, imbibition, diffusion and osmosis.

1) Imbibition: If a piece of dry wood is placed in water, it will absorb some water in it. We know that dry or half-dry colloidal substances absorb liquid. This is why the piece of wood has absorbed the water. This process is called imbibition. The substances such as cellulose, starch, gelatin etc. are hydrophilic. When they come in contact with water, they absorb it, and conversely, they become constricted when they face deficiency of the liquid. As the cell wall and protoplasm are colloidal in nature, absorbing water they become swelled up. This is a unique process for absorbing water.

2) Diffusion: If some incense is poured in a corner of a room, its fragrance is immediately spread throughout the whole room. The small particles of the incense are spread in the air. If some sugar is added to a glass of water, the molecule of sugar immediately spread in the water and the water of the glass tastes sweet. This process is called diffusion. It is a physical process. The process through which the molecules of any substance are spread from a region of higher concentration to a region of lower concentration is called diffusion. At a constant temperature and atmospheric pressure, the potential energy of a substance to diffuse from a solution of higher concentration to a solution of lower concentration is called its diffusion pressure. Under the same atmospheric pressure, the difference between the diffusion pressure of a solution and that of a solvent is called the diffusion pressure deficit. Because of the diffusion pressure deficit in the mesophyll tissue of a leaf, a cell in deficiency of water absorbs it from its adjacent cell. The significance of diffusion in the absorption of water in plants is immense.

Individual Activity

Activity: Experiment on the demonstration of diffusion.
Essentials: a small bowl, attar or any incense.
Procedure: To prove the diffusion process by pouring incense into a bowl, describe the following situation.

3) Osmosis: Do you know what osmosis is? Have you ever observed when your mother places some raisins in water, the constricted raisins swell up, being turgid. Have you ever thought of how this happens? If you then place the turgid raisins in concentrated sugar solution, they again turn constricted. How does this happen? This is an essential phenomenon. Through the phenomenon, plants absorb water from the soil. This process can be accomplished in the laboratory without the involvement of any living cell. If the two solutions of different concentrations having the same solvent and solute are separated by a selectively permeable membrane, the concentration of both the solutions will soon be equal. When two solutions of different concentrations with the same solute and solvent are separated with a selectively permeable membrane, the solvent flows from its solution of lower concentration to the solution of higher concentration. Movement of the solvent through a selectively permeable membrane from a solution of lower concentration to a solution of higher concentration is called osmosis. Osmosis is usually the diffusion of solvents because in this case where the amount of solvent is proportionally higher (i,e less density of solution) flows in the direction where the amount of solvent is proportionally less (i, e more density of solution). In other words, osmosis is the flow of solvent from high density of solvent to low density of solvent. Since it is not possible for solute to cross the selectively permeable membrane.

Individual Activity

Activity: Experiment to demonstrate osmosis from cell to cell.

Essentials: A piece of potato, blade, petridish, water, and sugar.

Procedure: Prepare a potato osmoscope, and by pouring in the sugar beverage, demonstrate osmosis.

6.2 Absorption of water and mineral salts

In plants, the absorption of water and mineral salts occur through different processes. For the convenience of our discussion, we will learn about water absorption first.

(a) Absorption of water: Plants generally, absorb capillary water from the soil through their roots. The diffusion pressure deficit in a cell of a leaf is developed because of transpiration, and then water from the adjacent cell moves towards the cell. In the same way diffusion pressure deficit is developed in the second cell and water moves to it from the adjacent cell. This way, a continuous diffusion pressure deficit is extended up to root hair and a suction force is developed. Because of this suction force, capillary water continues to enter the cell root hair. Water enters the root hair cell through the process of osmosis and diffusion. This way, water is taken up into the root hairs and moves through the cortex tissue.

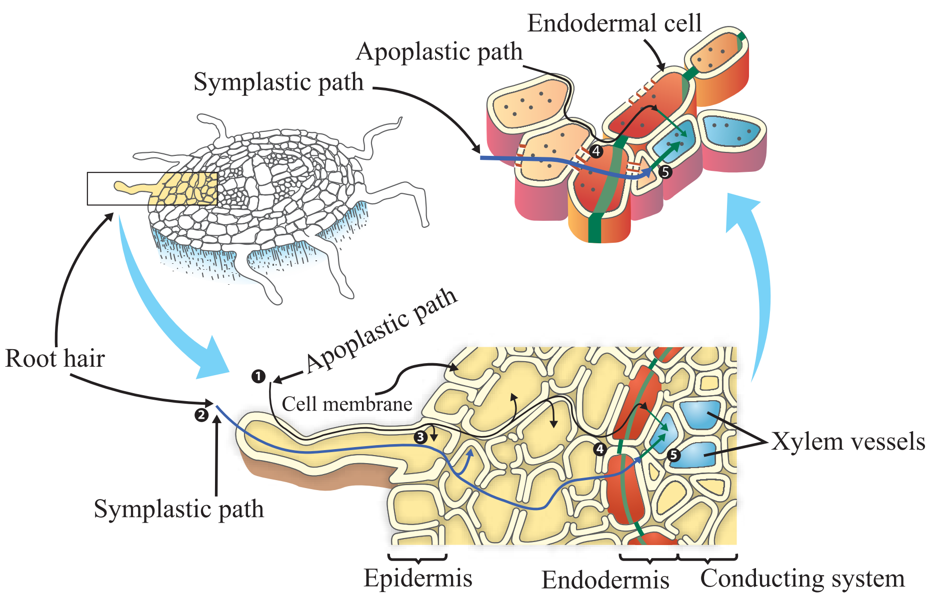


Figure : 6.01 Absorption and conduction of water

This water movement is called cell to cell osmosis. Then, water moves from the cortex tissue to the endodermis, the pericycle, and finally into the vascular bundles. Water, having entered into the vascular bundles, is taken up and flow laterally through the xylem tissue. The water flowing through different branches and branchlets of the plant, ultimately, reaches the leaves and this is accomplished by the active involvement of osmosis and transpiration.

(b) Absorption of mineral salts: Most plants absorb some mineral salts with water along. Though some salts are absorbed through the root hair, the meristematic region of the tip of root functions as the main region of absorbing mineral salts. Mineral salts are absorbed in the form of ions. Absorption of salts is done in two ways, passive absorption and active absorption.

1) Passive absorption: Salt absorption in this way is accomplished through the root hairs of plants with the process of imbibition and osmosis, and no metabolic energy is required for it.

2) Active absorption: Active absorption is the absorption of ions with the help of metabolic energy produced in the cells.

6.2.1 Translocation in plants: Translocation in plants represents the movement or flow of water and mineral salts and of the food produced in the leaves. We know that water and mineral salts are taken up the stem through the vessels of the xylem tissue. Scientists think that the force produced by transpiration, capillary action and root pressure causes the cell sap to reach the leaves of plants. In this way water reaches the leaves, and food is produced there. Then the phloem tissue takes active part in the translocation of food produced by photosynthesis. The food is translocated through the sieve tubes of the phloem tissue. Different organic compounds in plants move through phloem tissue at the same time in opposite directions. The compounds in the lower region flow downwards and compounds synthesized in the upper region flow upwards and the substances synthesized in the middle region flow in both directions.

Necessity of translocation in plants

Movement or transportation of water and mineral salts in plants is called translocation in plants. All scientists agree with the necessity of translocation of water and mineral substances in plants. Now, the matter of consideration is that the water and mineral substances, that are to be used, must be taken to the places where the reactions will occur. This is why translocation of water and mineral salts is very important. Water and mineral salts being absorbed through the root hair go through the vessels of the xylem tissue, cross the cortex region, by osmosis and gradually reach the leaves with the flow of transpiration. Food is produced in the leaves. The food produced in the leaf reaches the different regions of a plant through sieve tubes of the phloem tissue. If the flow in the xylem vessels or phloem sieve tubes is blocked, for any reason, the plant would die. So it is to be said that translocation is very important for plant life.

Translocation of water and minerals: We have already acquired some ideas about osmosis and diffusion. Plants absorb water from the soil through process osmosis. This is accomplished mainly through the root hairs. Plants also absorb mineral nutrients from the soil, though the process of absorbing water and the process of absorbing mineral salts are quite different. You will learn more about it at a higher level of education. Water and mineral salts inside the cell are collectively known as cell sap. Now, we will learn how the cell sap from the root reaches the top most branches and leaves of a plant.

Ascent of sap: Roots absorb water and mineral salts. The cell sap ascends slowly upwards. Simultaneously, the lateral translocation of cell sap also occurs. Translocation of cell sap is categorized into two steps: 1) the arrival of soil water and mineral salts from root hairs to the vascular tissue of the root and 2) translocation from vascular bundle of the root to leaves. At first osmosis, diffusion and suction from transpiration play an important role in the absorption and translocation of water and mineral salts. The water and the mineral substances absorbed by root hairs move to the adjacent cells by the process of osmosis. From there they move again to the next cell. In this way, water and mineral substances reach the vascular bundle of the root, and ultimately, reach the mesophyll tissue of leaves through the vascular bundle of the stem.

Individual Activity

Activity: Experiment to demonstrate the ascent of sap in a plant.

Essentials: *Peporomia* plant, bottle of glass, water and safranin or red ink.

Procedure: Take some water in a glass bottle. Add some drops of safranin or red ink to it. Place a living *Peporomia* plant in the bottle in such a way that its roots are submerged into water. Now place the bottle somewhere for a few hours and observe the result.

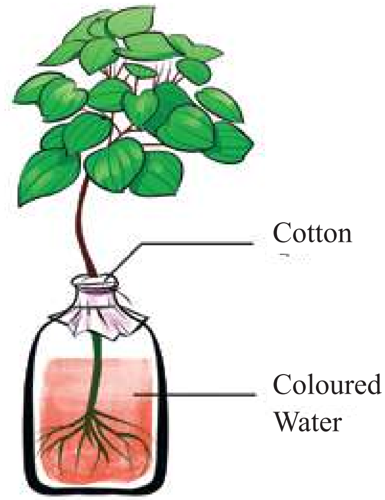


Figure: 6.02 Ascent of Sap in a plant

6.2.3 Translocation of the substances produced in photosynthesis: You have learned earlier that plants absorb water through osmosis. The water is conducted to the leaves even to the top most regions of a very tall plant. These leaves utilize water for photosynthesis. In the presence of light and chlorophyll, water taken from the soil reacts with CO_2 taken from the air and produces carbohydrate. The food produced in this way is conducted to different parts of a plant. Every cell of a plant derives its energy to perform metabolic activities by using food through respiration. After the completion of deriving energy through respiration, the remaining food is stored in the plant.The food is usually stored in stem (potatoes), root (sweet potatoes), leaf (aloes) and in different fruits and seeds. Now, we will study how the food produced in photosynthesis is conducted to different regions of a plant body.

Phloem translocation: As the leaves and the roots grow away from each other, there must be a rapid and effective transport system in between them for the conduction of food. This is done by sieve tubes of phloem. Phloem is an important bundles of vascular bundle. We know that there are xylem bundles and phloem bundles in a vascular bundle. In the phloem bundle, there are sieve tubes, companion cells, phloem parenchyma and bast fibers. A sieve tube is a kind of thin walled living cell without a nucleus. Being positioned longitudinally side by side, they form a net-like structure. The septa in between them, missing in some places, develop sieve shaped forms. This is why food substances can easily move from cell to cell. In winter, these openings are blocked because of the deposition of the chemical substance callose, and thus the movement of food is inhibited. At the advent of summer, the callose is degraded and the movement of food resumes.

6.2.4 Transpiration

Life cannot be imagined without water. Plants mostly absorb water they require through their roots. They use a very little part of the absorbed water for their metabolic activities. The remaining part of the water is released to the atmosphere in the form of vapour. The physiological process by which water is carried through plants and then released to the atmosphere in the form of vapour through aerial parts, is called transpiration. On the basis of aerial parts through which this process occurs, transpiration is categorized into three divisions: stomatal transpiration, cuticular transpiration and lenticular transpiration.

1) Stomatal transpiration: There are special types of openings with two guard cells in the leaves, young stems, sepals, and petals of flowers. These openings are called stomata (singular no. stoma). 95% of the total transpiration in a plant occurs through the stomata.

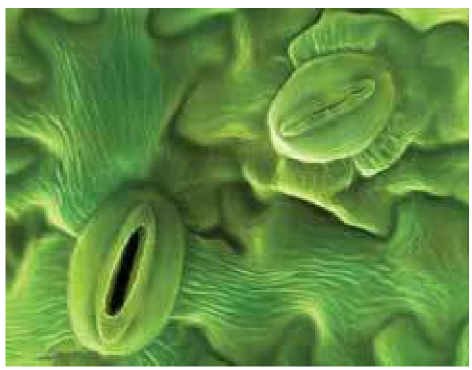


Figure : 6.03 An open and a close stomata

2) Cuticular transpiration: There is a layer of cutin on the epidermal layers of a plant, especially on the upper and lower surface of every leaf. This layer is called the cutıcle. Some water, when evaporated, is released through the cuticle. The process is called cuticular transpiration.

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3) Lenticular transpiration: After the occurrence of secondary growth in plants, the airy aggregation of cells that functions as a pore (called lenticel) develop on the rapture bark of some plants. The cells aggregated around a lenticel are loosely fitted and water from the inside can be released through it. This is called lenticular transpiration.

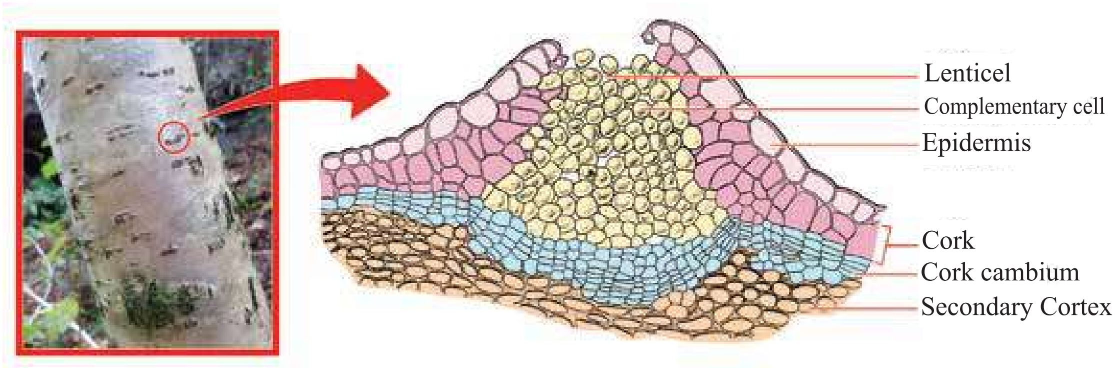

Figure: 6.04 A Lenticel

Through transpiration, as excess water escapes through evaporation, a suction force develops causing the root to absorb water. This process depends on many factors. They are roughly grouped into two: a) external factors and b) internal factors.

(a) External factors: The factors which affect transpiration from outside of the plant body are called external factors. They include:

(1) Temperature: The rate of transpiration fluctuates with the changes of temperature. Water can easily be vapourized at high temperature and thus transpiration is accelerated. The water-holding capacity of air increases if the temperature goes up. As a result, transpiration proceeds faster. If the temperature goes down, the rate of transpiration declines.

(2) Relative humidity: The ratio of the amount of water vapour in the air of the atmosphere and the amount of water vapour that the air can hold at a given temperature is its relative humidity. For instance, the air may be dry in spite of having high water vapour because the air may have a high water vapour holding capacity. Conversely, in spite of the presence of low amount of water vapour in atmosphere, the atmosphere may be humid if there is low water vapour holding capacity in the air. When relative humidity is low, the air remains unsaturated, and can retain more water vapour. If the relative humidity is high, the air loses its water vapour holding capacity. When the relative humidity is low, the rate of transpiration increases and when high, the rate of transpiration declines.

3) Light: In presence of light, stomata open, and so, the rate of transpiration increases. In the dark, the process is ceased because the stomata are closed. The increase or decrease of stomata size occur due to the fluctuation of light. As a result the rate of transpiration also fluctuate. Light also affects transpiration by increasing the temperature of the plant.

4) Wind: Because of transpiration, the air around the plant becomes moist, and causes the rate of transpiration to slow. When wind removes the saturated air, the rate of transpiration increases. With the wind, the leaves are swung and a kind of pressure is exerted on the stomata and so, water vapour comes out through them at a high rate. This is why with the change of wind velocity, the rate of transpiration also changes. If the atmospheric pressure rises, evaporation declines and the rate of transpiration also decreases. Again, at low atmospheric pressure, evaporation increases, and so, the rate of transpiration increases.

b) Internal factors

1) Stomata: The rate of transpiration varies with the number, volume, structure and arrangement of the stomata.

2) Number of leaf: The rate of transpiration varies with the number, volume, structure and arrangement of the leaves.

3) Surface area of mesophyll: If the volume of leaves is high, the rate of transpiration will also be high. The same way, if the volume of leaf is low, rate of transpiration will be low.

4) Volume of the aerial parts of the plant: If the total volume with all the aerial parts (including the leaves) and stem of a plant is increased, the rate of transpiration will be higher.

The presence of cuticle, area of spongy parenchyma etc. also change the rate of transpiration.

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Individual Activity

Activity: Prove with an experiment that water is released as water vapour from a plant through transpiration.

Essentials: A fresh potted plant, a glass bell jar or a cellophane bag, thread or clip and water.

Procedure: First, the plant with the pot should be placed on a table and required amount of water should be poured in the pot. Now, a branch of the plant (with some leaves covered with a cellophane bag) should be clipped or tied with thread or covered with a bell jar. The precaution should be taken that vapour cannot come out, or air cannot get in. The pot in this stage should be kept for an hour.

Figure: 6.05 Test of transpiration

Observation: After an hour, it will be found that there are water drops on the inner surface of the cellophane bag and the whole bag would become damp. How has that happened?

Conclusion: As there is no scope for water to get into the cellophane bag, it is clear that the water drops are escaping from the leaves. So, we see that a plant releases water in vapour form through its aerial parts.

Precautions:

1)The plant on the pot should be fresh and living.

2)The opening of the cellophane bag should be tightly tied so that no air can get in or come out.

Transpiration is a necessary evil

Scientists have agreed on the significance of transpiration. The metabolic activities of a living plant cell are dependent on this process. Because of transpiration a suction force is developed in the xylem vessel. With this suction force, the absorbed water and mineral salts by root hair of a plant are conducted to the leaves. If the force decreases, the absorption of water will be decreased and the metabolic activities along with the production of food will be slow. In the mesophyll of the leaf, a diffusion pressure deficit is developed because of transpiration and helps the absorption of water. A plant keeps the temperature in the cells of leaves within a certain range by continuously reducing the thermal energy absorbed by the mesophyll.

On the contrary, though transpiration contributes many uses to a plant, it also plays some harmful roles. For instance, if the rate of loss of water is greater than the rate of its absorption, this will cause deficiency of water and minerals in the plant. As a result, the plant may die. If water is deficient in the soil, absorption will be very little, though transpiration will continue as before. To deal with this, nature causes many plants to shed leaves in winter. Because of the lacking of transpiration, the required diffusion pressure deficit will not develop and as a result the rate of osmosis will be slow.

So, it can be said that transpiration is an essential activity for a plant though it causes some harms to it. For the contrary characteristic, the scientist Curtis designated the process transpiration as a 'necessary evil'. But as a whole, transpiration has continued in spite of its having some negative effects, because it enables plants to survive.

6.3 Blood circulation in Human Body

Blood is the source of vitality. Blood circulates throughout the whole body through blood vessels and distributes oxygen and nutrients. So, the cells remain active and alive. The system, through which the blood transports to organs and the different parts of the body, is called the blood circulatory system. The distribution of nutrients and oxygen throughout the body and the removal of body wastes is performed by this system.

The flow of blood in human is limited to the inside of the blood vessels and heart, it never comes outside. This type of circulatory system is called a closed circulatory system. Transporting blood throughout the whole body requires only one minute or less. The advantages of this circulatory system are (1) Blood reaches different organs directly, (2) can control the flow of blood to a particular organ by changing its diameter, and the distribution can be adjusted depending on demand, (3) blood goes around the whole body and returns to the heart quickly. Blood circulatory system is very much special than other system but structurally it is normal.

There are two types of circulatory systems, such as, (1) Blood circulatory system. It consists of the heart, arteries, veins and capillaries. (2) Lymphatic system. It consists of lymph, lymphatic ducts or lacteals.

6.3.1 Blood : Blood is a viscous, slightly alkaline and salty fluid. Blood circulates through the heart, arteries, arterioles, veins, venioles and capillaries. Due to the presence of haemoglobin in red blood cells, blood appears red. Blood originates from bone marrow.

Components of Blood : Blood is a type of liquid connective tissue. It has mainly two components, Plasma and Blood cells.

(a) Plasma : The colourless fluid part of plasma constitutes about 55% volume of the whole blood. The main component of plasma is water. A small amount of protein, organic substances and a small portion of inorganic salts are dissolved in it. The substances which are present are as follows-

(1) Protein, such as, albumin, globulin, fibrinogen (2) glucose (3) small droplets of fats (4) mineral salts (5) vitamins (6) hormones (7) antibodies (8) waste products such as carbon dioxide, urea, uric acid etc. It also contains a small amount of sodium chloride, sodium bicarbonate and amino acids. The food substances which we eat are digested and absorbed by the intestinal wall and mixed with blood, then transported all over the body. The cells absorb the nutrients, repair the worn out tissues and help in growth.

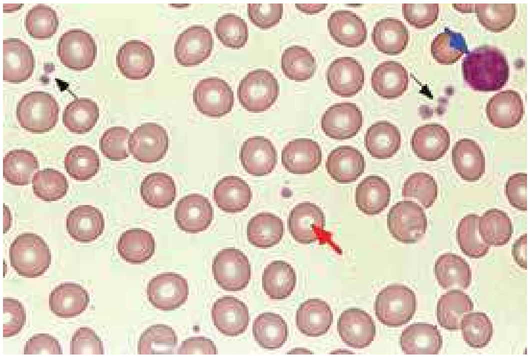

Figure : 6.06 Blood component (microscopic view). Red blood cells, White blood cells and platelets are indicated by red, blue and black coloured arrows.

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(b) Blood cells : Blood is made of three types of cells (a) Red blood cells or erythrocytes (b) White blood cells or leucocytes and (c) Platelets or thrombocytes. Though all of these are cell, in comparison with the floated particles in blood plasma these were called blood corpuscles. Then the microscope was not well developed like now. This name is still now accepted.

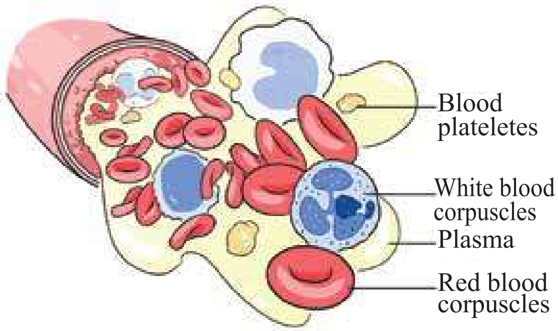

Figure : 6.07 : Various types of blood cells

(i) Red blood cells or erythrocytes: Among the three blood cells the red blood cells are huge in number and play an important role for the transportation of oxygen required for respiration. Red blood cells are formed in bone marrow. The average viability of a red blood cell is 120 days. The red blood cell is non-nucleated, and appears mostly like circles and biconcave discs. There are approximately 5 million red blood cell present per cubic milliliter of an adult male. This is 500 times more than that of white blood cells.

The amount of red blood cells is comparatively less in females. Red blood cells in infants are comparatively high in number. Red blood cells are destroyed at every moment and equal amount of cells are produced again. Haemoglobin in red blood cells transports oxygen as oxyheamoglobin and also carbon dioxide.

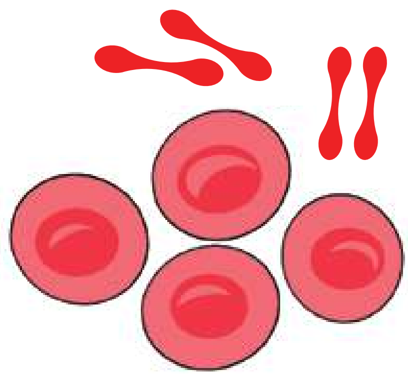

Figure : 6.08 : Red blood cells

Haemoglobin : Haemoglobin is a type of coloured pigment. Blood appears red because of its presence in red blood cells. If the number of red blood cells is not adequate, then the symptoms of anemia are noticed. In Bangladesh almost two thirds of the population suffer from this disease. To get rid of this disease it is necessary to take balanced diet.

(ii) White blood cells : White blood cells are big and irregular in shape, contain a nucleus and fewer in number than red blood corpuscles. There are 4-10 thousand white blood cells per cubic milliliter of human blood. White blood cells are produced in red bone marrow and lymphatic glands. Their average viability is 1-15 days.

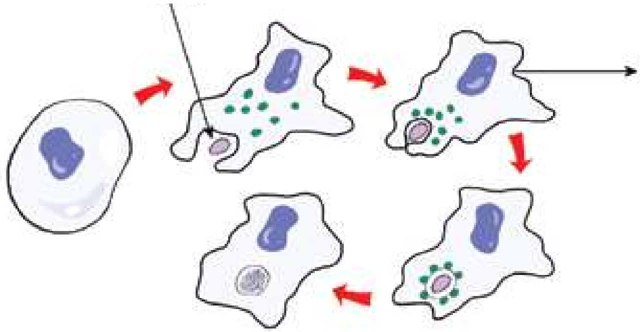

Figure 6.09 : Destruction of germ by white blood cells in the process of fagocytosis

They are colourless (without haemoglobin). That's why it is called White Blood Cell or WBC. White blood cells can change their shape like amoeba and can move from one place to another. It can enter into the tissue via the wall of blood capillery. If the body attacked by germ from outerside then the number of white cell increases rapidly. It kill germs by the phagocytosis process. In mammals among the blood cell, only white blood cell contain DNA.

Types: according to structure and presence of granules in the cytoplasm, white blood cells can be divided into two types: agranulocyte and granulocyte.

1. Agranulocyte: The cytoplasm of white blood cells are without granules and transparent. Again agranulocyte white blood cells are of two types– Lymphocyte and Monocytes. They are produced in the lymphnodes, tonsil, spleen etc. Lymphocytes are small cells with large nuclei. Monocytes are large cells with small oval or kidney-shaped nuclei. Lymphocytes kill the germs that enter the body by creating antibodies and thus increasing immunity power. On the other hand, monocytes kill germs in the phagocytosis process.

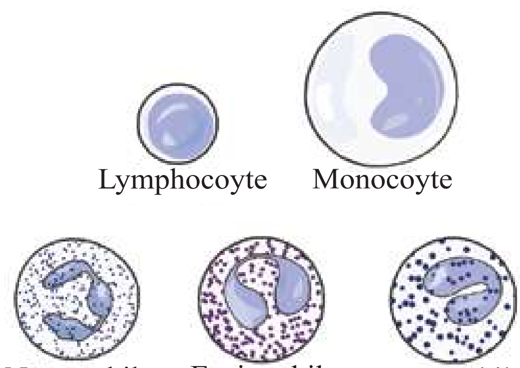

Figure 6.10 Various types of white blood cells

2. Granulocyte: Granulocytes have cytoplasm with slightly stained granules. According to the size of the nucleus, granulocyte white blood cells are categorized into three types: Neutrophils, Eosinophils and Basophils. Neutrophils kill germs in the phagocytosis process. Eosinophils and basophils prevent allergy in the body by secreting a chemical named histamine. Basophil secretes heparin and inhibits blood clot formation inside blood vessels.

White blood cells engulf the germs by spreading pseudopodia. This process is named phagocytosis. The dead white blood cells turn into pus. If white blood cells in the blood increases excessively, leukemia or blood cancer occurs. White blood cells act as a guard, destroying germs by the process of phagocytosis and produceing antibodies.

(iii) Platelets or Thrombocytes: Platelets are small in size, colourless and round, oval or rod shaped. Platelets have stained granular non-nucleated cytoplasm that contains cell organelles like golgi body, and mitochondria. Somebody opines that these are not a full cell they are the fragmented portion of the large cells of bone marrow. There are approximately 2.5 million platelets per cubic milliliter of blood. The number of platelet comparatively high in ill body. They originate in the bone marrow. Their average viability is 5-10 days. They help in coagulation or blood clotting. When the endothelial surface of a blood vessel is injured, the platelets there take irregular shapes and release a chemical substance called thromboplastine. This transforms prothrombine, the protein in blood, into thrombin. Thrombin then acts to transform fibrinogen, also present in plasma, into fibrin which helps to clot blood. Fibrin is a kind of insoluble protein that can create thread like strands very quickly. It coagulates blood in the injured place and stops bleeding. However, coagulation is a complex process where various chemical substances as well as vitamin K and calcium ions remain involved.

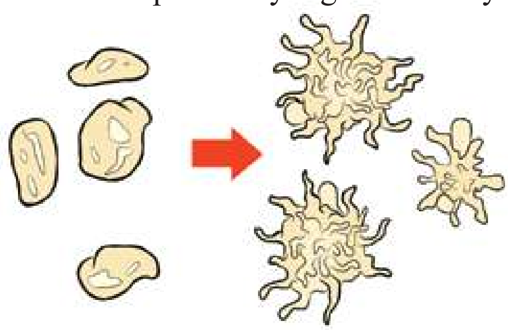

Figure 6.11: Platelet and changes of its shape

If blood does not contain the right amount of platelets, blood does not clot easily. This may lead the patient to a life threatening situation.

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Individual Activity

Activity: Draw this table in your notebook and fill it in groups. Note the differences between Red blood cells and White blood cells.

Characteristics	Red Blood cells	White Blood cells
(a) Nucleus		
(b) Shape		
(c) Haemoglobin		
(d) Number		
(e) Functions		

Functions of blood

Blood is an important component of body. Blood performs many different functions:

(1) Oxygen transport: Red blood cells transports oxygen as oxyhaemoglobin to the cells.

(2)Removal of carbon dioxide: Due to the chemical reaction in the tissue, carbon dioxide is produced. Carbon dioxide is transported in the form of sodium bicarbonate dissolved in the plasma. It carries carbon dioxide from the tissue to the lungs which is then expelled during expiration.

(3) Transportation of digested food: It provides plasma, glucose, amino acid, and fat granules to the cell.

(4) Balancing of temperature condition: Combustion done constantly in body. Heat is produced in the body tissues, especially in the muscles and liver. As a result, the temperature varies in different organs but blood helps maintaining uniform body temperature by distributing it throughout the body.

(5) Elimination of waste products: Blood carries all the waste products and eliminates as urea, uric acid and carbon dioxide through different organ.

(6) Hormone transport: Hormone is a bio-chemical substance which is produced in ductless glands. It mixes with the blood directly and is circulated to the different organs of the body. It helps in different important biological processes.

(7) Prevention of Diseases: Some types of white blood cells attack and engulf germs by the process of phagocytosis, thus preventing the body from the attack of germs. It increases the resistance power against diseases by producing antibodies and antigens.

(8) Blood clotting: If there is a wound at any part of the body, the clotting of blood heals the wound, preventing excess loss of blood.

6.3.2 Blood group

You hear that blood is necessary for a critical or dying patient. His or her blood group is B. You frequently see this type of advertisement on television. But what is a blood group? Why is it necessary to know about the blood group? Through many research and observation it is found that red blood cells contain A and B antigens and plasma has a and b antibodies. Blood can be classified into different groups depending upon the presence of these antigens and antibodies. This is called the blood group. Scientist Karl Landsteiner, in 1901, first classified and named human blood and placed it into four groups: A, B, AB and O. Normally the blood group of a person remains the same and unchanged throughout the whole life. The different kinds of antigens and antibodies in different blood groups is shown in the table below-

Blood group	Antigen (in red blood cells)	Antibodies (in plasma)
A	A	b
B	B	a
AB	A, B	No antibodies
O	Neither	a, b

We have observed the presence of different antigens and antibodies within the blood. On this basis we can explain blood group in this way. For Example -

1. Group A : Blood possesses antigen A and anti-B antibody (in short b antibody).
2. Group B : Blood possesses antigen B and anti-A antibody (in short a antibody).
3. Group AB : Blood possesses antigen A, B and both antibodies are absent.
4. Group O : Both antigens are absent and possesses antibody a, b.

If the antigen present in the surface of the red blood cell of a donor comes in contact with an antibody present in the plasma of the receiver, that can react with the antigen, causing a potentially fatal situation for the receiver or patient.

So every individual receiver should be given blood that is compatible. For example, if your blood group is A (i.e. surface of the red blood cell contains antigen A) and your friend's blood group is B (i.e. plasma contains antibody a), you cannot donate blood to your friend. If you did give him, antigen A in your blood will react with antibody a in your friend's blood and this can be life-threatening for him. So compatible blood group should be ensured so that the antibody in the receiver's blood does not react with the antigen of the donor's blood. Based on this principle, a table can be made showing the compatible blood groups.

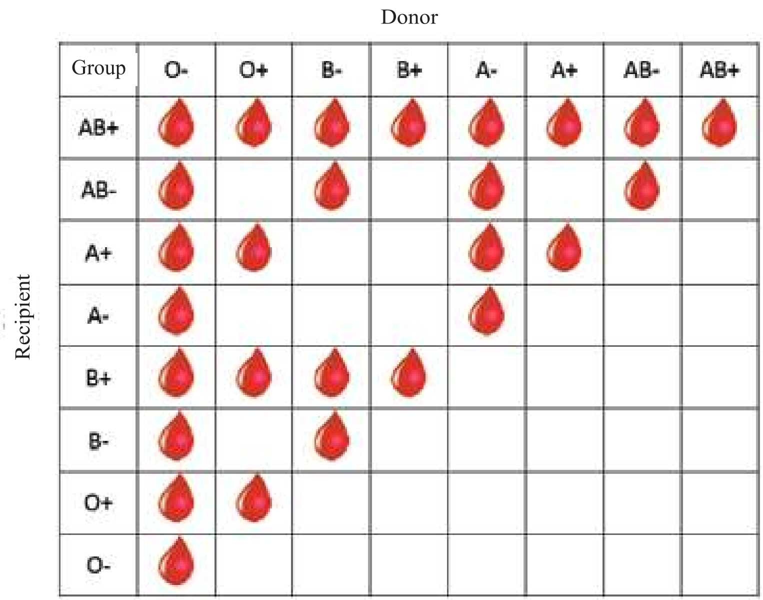

Figure 6.12: Blood group compatibility table

Table : On the basis of the blood group the donor's and recipient's list.

Blood Group	Groups to which blood can be donated	Groups from which blood can be received
A	A, AB	A, O
B	B, AB	B, O
AB	AB	A, B, AB, O
O	A, B, AB, O	O

From this table you can see that people with O are universal donors. People with blood group AB can receive the blood from all groups. So, people with blood group AB are called universal recipients.

The concepts of universal donor or universal recipients is not very acceptable in modern medical science. It is because although the ABO blood group system is considered to be the most important factor for the classification of blood group based on antigens, there may be numerous other antigens which can cause problems in many cases. For example. Rhesus factor is one kind of antigen. A person is said to be rh positive if this factor is present in his blood and if not, is called rh negative. In case of blood transfusion, if the rh factor does not match, the recipient or the patient's condition may deteriorate. So the rhesus factor must be checked along with ABO blood group compatibility. Thus if the rhesus factor is taken into consideration, the blood groups are A+, A-, B+ , B- , AB+, AB-, O+ and O-. As the negative blood group does not contain rhesus factor antigen, it can be given to people with positive blood group but positive blood group cannot be given to the negative ones. Besides there are also many more antigen based minor group in the blood. For avoiding complications of this minor blood group ABO grouping and Rh typing as well as cross-matching test is mandatory before blood transfusion. In addition, screening of donor blood is important to ensure that the recipient is not infected with a serious germ infected disease (such as AIDS, Hepatitis B, Hepatitis C etc.).

Donation of blood and social responsibilities: Excessive bleeding due to serious injury, accident, surgery, natural calamities or for any other reasons may lead to the amount of blood decreasing abruptly. Emergency transfusion of blood is the only way to recover from this. At present blood donation is a common practice. Emergency can be met by blood transfusion from one person to another directly, or by using a blood bank. The procedure, in which blood is given to a person through an intravenous line from an outer source to replace lost blood, is called blood transfusion. It is an effective measure and can save the life of a patient. Without examining the blood group and its nature, blood should not be transfused under any circumstances. Violations may cause different complexities in a patient and increase the possibility of death. For example - coagulation of red blood corpuscles, decomposition, jaundice and elimination of red blood corpuscles (haemoglobin) with urine.

On emergency basis blood is required for people wounded in accidents. Blood has no substitute and in this situation a lot of blood may be necessary. By collecting blood from others, this emergency crisis can be met. For this the cooperation of the general public is necessary. We must keep in mind that it is our social responsibility. To donate blood to others is a noble task. It causes no harm to the donor. A healthy person can donate 450 milliliter of blood.

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20 million of red blood corpuscles are produced in every second in his body. A healthy person can donate blood every 4 months. This amount of blood loss will not create any harm to the donor.

Nowadays, to inspire blood donation, different programmes are arranged. For example, blood donation on a particular day or occasion. Fear and false conception regarding blood donation is decreasing day by day. Now people are more conscious and eager to donate blood or to receive blood in emergencies.

6.4 Structure and function of Heart

6.4.1 Structure of Heart

The heart is a triangular shaped, hollow, muscular pumping organ. It is situated in the left side between the two lungs. The heart consists of special involuntary muscles. It is surrounded by a thin membrane named the pericardium. The heart wall consists of three layers: (1) Epicardium (2) Myocardium and (3) Endocardium.

(1) Epicardium: Mainly it consists of connective tissue. This layer is covered with epithelial tissue. Fat bodies are scattered on it.

(2) Myocardium: This layer is in between the epicardium and endocardium. It consists of strong involuntary muscles.

(3) Endocardium : This is the inner most layer. The chambers of the heart are surrounded by the endocardium. This layer also covers the valves. The inner part of the heart is hollow and four-chambered. The upper chambers are the right and left auricle or atrium and the lower chambers are the right and left ventricles. The atria are comparatively thin walled and the venticle walls are muscular and thick. The two atria and ventricles are separated by inter auricular and the inter ventricular septum respectively.

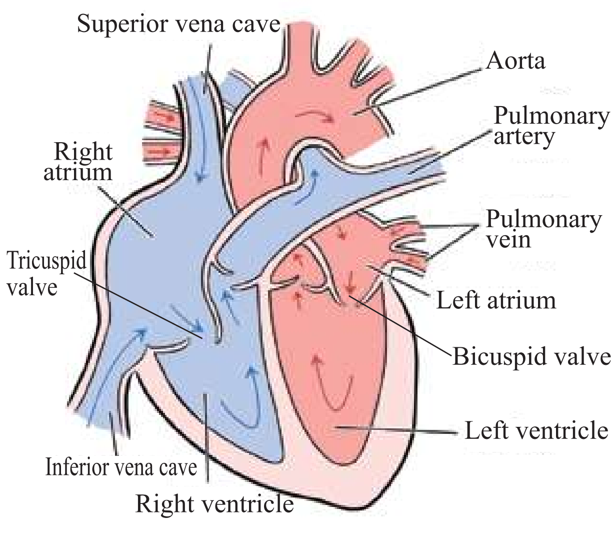


Figure : 6.13 Human Heart

The aperture between the two atria (singular-atrium) and ventricles are guarded by valves. The right auriculo ventricular aperture guarded by a tricuspid valve is made up of three flaps. Similarly, the left atrium and ventricle is guarded by a bicuspid valve made up of two flaps. The opening of the aorta and the pulmonary artery is guarded by valves called semilunar valves, which allow the transport of blood in one direction and prevents the back flow of blood.

6.4.2 Circulation of blood through the heart

We have learned earlier that the heart acts like a pump. The heart works by contraction and relaxation. The continuous contraction and relaxation transports blood throughout the whole body.

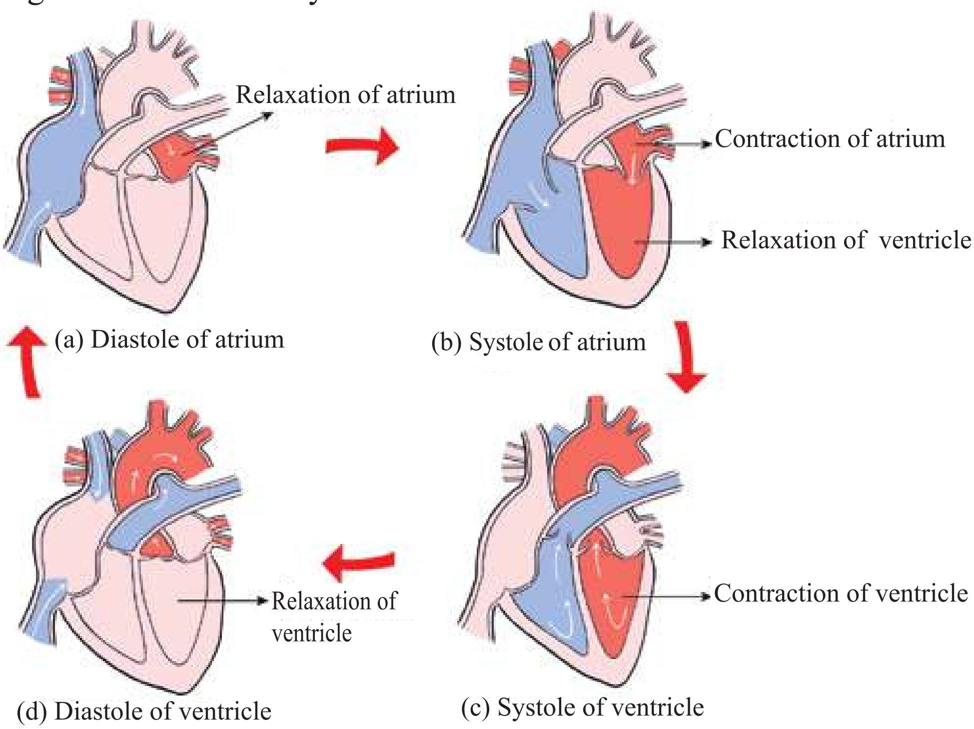


Figure : 6.14 Internal structure of heart and blood circulation

The contraction of heart is called the systole, and the relaxation of heart is called the diastole. A complete contraction (systole) and relaxation (diastole) of the heart constitutes a heart beat.

Due to the relaxation of atria (auricles) the blood enters the heart from different parts of the body, such as– deoxygenated blood from the superior vena cava enters the right atrium. At the same time, the oxygenated blood enters to the left atrium through the pulmonary veins from the lungs.

The walls of the two atrium contract and then the muscles of the ventricle relax. As a result the tricuspid valve situated between the right sino auricular ventricular apertures opens. So, the deoxygenated blood from the right auricle enters into the right ventricle. At the same time, the left sino auricular ventricular aperture, guarded by the bicuspid valve, opens. Then oxygenated blood enters the left ventricle from the left auricle. During this period the left and right auriculo ventricular apertures are closed by their tricuspid and bicuspid valves. So, blood of the ventricle cannot return to the atrium.

When the two ventricles relax, deoxygenated blood from the right ventricle passes through the pulmonary artery towards the lungs. Here the blood becomes purified. At the same time the oxygenated blood leaves the left ventricle through the aorta towards the body and the opening of both the arteries (aorta and pulmonary artery) are closed by the semi lunar valves which prevent blood from returning into the ventricle. Thus successive contraction and relaxation of atrium and ventricle help in continuous transportation of blood.

Functions of Heart: The heart is the principal organ of the circulatory system. It helps blood to keep moving. The human heart is divided into four chambers. In higher animals, the chambers are completely separated. So, oxygenated and deoxygenated blood do not mix.

6.4.3 Blood vessels

The channels, through which mass flow of the blood occurs, are called blood vessels. Through these vessels, blood is carried away from the heart to different parts of the body and back again. According to the size, shape and function blood vessels are of three types: artery, vein and capillary.

1. Artery: The blood vessels, which usually carry oxygen rich (oxygenated) blood away from the heart to different organs of the body, are called arteries. The pulmonary artery is the exception. this exceptional artery carries mostly deoxygenated or oxygen poor blood (containing high levels of carbon dioxide) from heart to the lungs. Each artery is made of three layers : (1) Tunica externa - which is made of connective tissues. (2) Tunica media- the middle layer made of round involuntary muscles (3) Tunica interna- the innermost layer made of simple endothelial tissue. The walls of the arteries are elastic and thick. The arteries do not have any

valves and have a narrow passage or lumen. When the heart contracts, the blood transports through the arteries and arteriole (small arteries) like a wave.
The expansion and contraction of the artery is known as the pulse. The flow of blood within the artery, and elasticity and contraction and relaxation of the artery walls are the main causes of pulse. You can feel the pulse by pressing the finger tips of one hand on the wrist of the other.

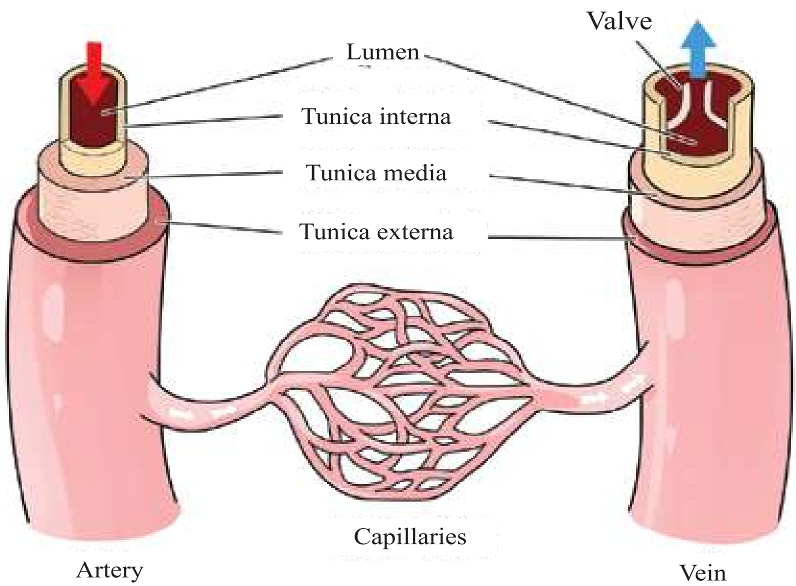


Figure: 6.15 various types of blood vessel

2. Vein: The vessels which carry blood from the various organs of the body towards the heart are called veins. They are spread all over the body just like arteries. Veins originate from the capillaries. Numerous capillaries together form small veniule. Veins and the vena cave open directly into the heart. Veins are also made of three layers, are thin walled, less elastic and have less muscles. The veins have valves and wider passage or lumen. Veins carry deoxygenated or carbon dioxide enriched blood. Pulmonary vein is its exception. This vein transports oxygenated blood from lungs to heart.

Note that both arterial and venous blood contain both oxygen and carbon dioxide, but their levels are different.

3. Capillaries: The hair like small delicate blood vessels visible in the muscle fiber, are called blood capillaries. These connect with the smallest artery in one side and the vein on the other side. All arteries are divided into secondary and lateral branches and form a fine network of capillaries. Each cell is surrounded by blood capillaries. The walls of the capillaries are thin. Through this thin layer, substances dissolved into the blood diffuse into the cells.

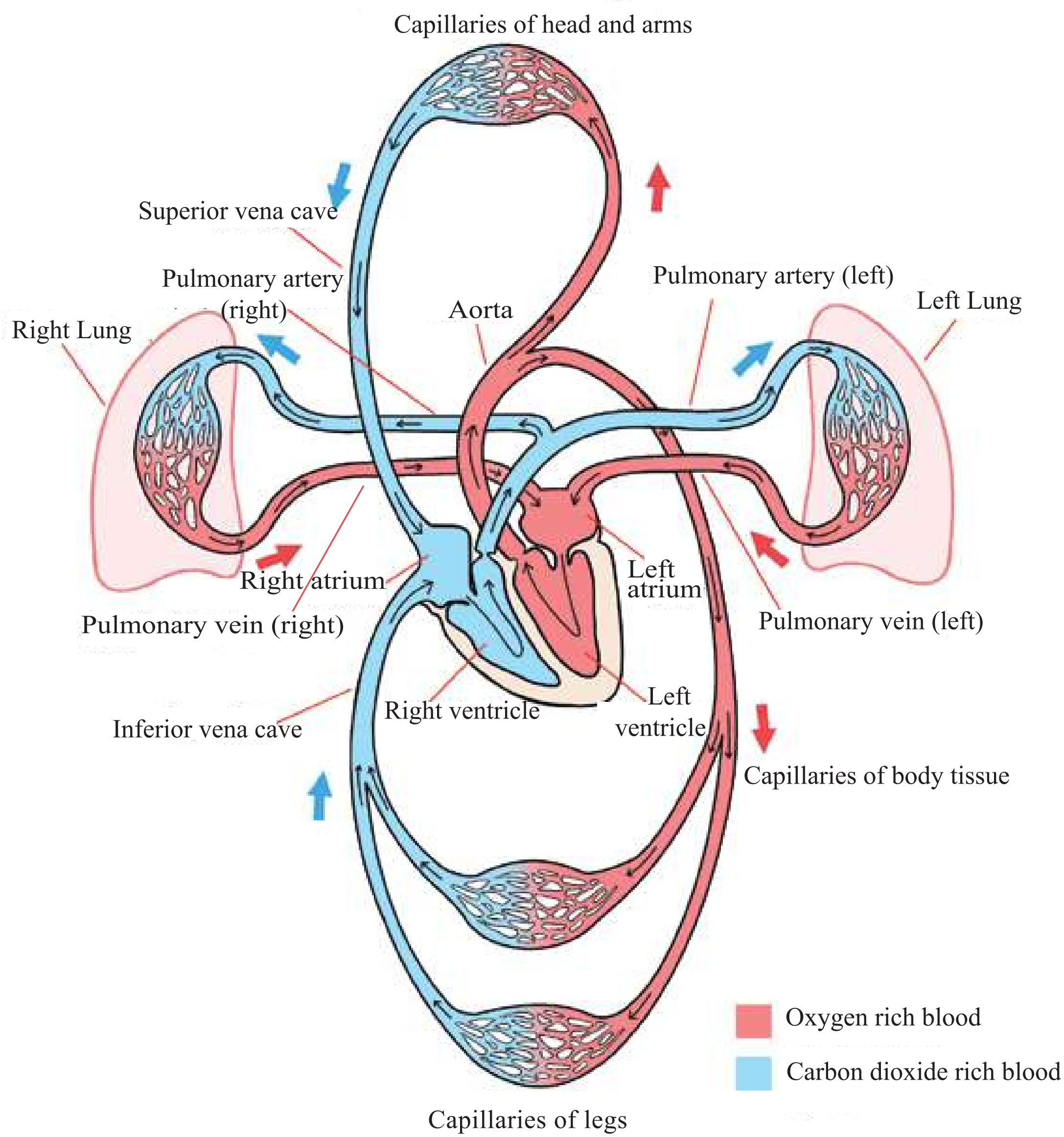


Figure: 6.16 Human blood circulation

Individual Activity

Activity : Determine differences between an artery and vein.

Characteristics	Artery	Vein
(a) Origin and ending		
(b) Direction of blood flow		
(c) Nature of blood		
(d) Wall		
(e) Lumen or passage		
(f) Valve		
(g) Location		

6.4.4 Blood Pressure

Blood pressure is the pressure of the blood against the wall of the arteries. The contraction of the heart is called systole. The pressure in the artery during systolic condition is called the systolic blood pressure. The pressure in the artery during systolic condition is the highest. Relaxation of the heart is called diastole. The pressure during the diastole condition is called the diastolic pressure. The pressure during the expansion of heart or ventricle i.e. in the diastole condition is the least.

Ideal blood pressure: A normal adult's blood pressure is generally near about 120/80ml. Blood pressure is expressed in two numbers, first one is for higher whereas the second one for the lower. The blood pressure in the arteries is the highest during systolic blood pressure and the ideal range should be 120 or slightly lower.

Figure: 6.17 Observation of pulse

The blood pressure in the arteries decreases during diastole. This is diastolic blood pressure and the ideal diastolic pressure should be less than 80. In between the time of two heart beats, this pressure is created. The difference between the two pressures in the arteries is called pulse pressure. The normal rate of the pulse, (the heart beat rate) is about 60-100 per minute in an adult at rest. Normally pulse rate is measured in the radial artery at the wrist. It can also be measured by the blood pressure machine on sphygmomanometer. By observing the systolic and diastolic pressure with the help of this machine blood pressure is determined.

Individual Activity

Activity: Count the pulse rate of your friend, brother or sister. Count it again after a short-run. Do you find any change? Explain why this happens.

High blood pressure or Hypertension: High blood pressure is considered to be a silent killer. According to World Health Organization report, by 2020, stroke and coronary artery diseases will be the number one life threatening disease. In the south Asian countries it will break out as an epidemic disease. One of the main causes of heart disease and stroke is high blood pressure.

What is hypertension?

When the heart pumps blood into the arteries, the blood pressure against the wall of the blood vessels is called the blood pressure. When blood pressure rises above the normal pressure, then it is considered as high blood pressure. In a healthy adult the expected systolic pressure is below 120 mm and the diastolic pressure is below 80 mm. When a person's blood pressure is consistently high (systolic > 140 mm or diastolic > 90 mm), we call it high blood pressure or hypertension.

Causes of Hypertension and its risk

If the father or mother suffers from blood pressure then the children may be affected. Those, who suffer from tension or have habit of smoking, have the probability of hypertension. Increase in body weight, intake of excessive salt and fatty diet, and history of diabetes and cholesterol of family members are main causes of this disease. Eclampsia at the time of child birth can also be a cause of hypertension in mothers.

Symptoms and signs of Hypertension: Headache, especially at the back of the head, is the primary symptom of hypertension. Vertigo, neck pain, palpitation and weakness are also some of the symptoms. Sometimes bleeding from the nose, sleeplessness or insomnia, and fatigue can also indicate symptoms of hypertension. It is alarming that almost 50% case, no symptom of blood pressure is seen.

Diagnosis: Blood pressure can be examined with a sphygmomanometer. Before measuring blood pressure the patient should take rest. Blood pressure should be measured after a gap of at least 15 to 20 minutes.

Individual Activity

Activity: Learn the skill of measuring blood pressure and write your friend's blood pressure in the table given below.

Name of the student	Blood pressure (systole/diastole)	Remarks

Prevention of high blood pressure: To prevent high blood pressure, a habit of eating fresh vegetables and fruits is necessary. Body weight should be controlled and physical work and exercise should be done regularly. High-fat foods and salt should be avoided in meals. Smoking must be avoided. If the blood pressure is out of control then hemorrhage occurs in the brain.

Blood pressure may vary more or less due to health, age, activities and disease. If the blood pressure is very high, consult a doctor and take medicine regularly.

6.4.5 Cholesterol

Cholesterol is a compound produced from the hydrocarbon cholestane. It is an important component in animal cells. Cholesterol circulates in the blood as lipoprotein.

There are three types of lipoprotein in blood :

1. LDL (Low Density Lipoprotein) : This is called bad cholesterol because it increases the risk of heart disease. Generally our blood contains 70% LDL. This varies from person to person.
2. HDL (High Density Lipoprotein) : This is generally called good cholesterol because it decreases the risk of heart disease.
3. Triglyceride : This cholesterol is in the plasma as fat triglyceride and is created from animal fat and carbohydrate.

The ideal range of cholesterol in blood is shown in the table below.

Types of cholesterol	**Mmol/Litre**
LDL	< 1.8
HDL	> 1.5
Triglyceride	< 1.7

Foods such as butter, prawn, oyster, liver of cattle, egg (especially egg yolk). contain a high amount of cholesterol.

Demerits of high cholesterol: A supply of oxygen and nutrients is essential in the heart as in all the other organs of our body. Blood circulation is interrupted if there is an accumulation of fat in the coronary artery of the heart. Consequently, cardiac muscle is damaged because of a deficiency of oxygen and nutrient. Due to less circulation of blood pain feels in the chest. This condition is called angina. Moreover, the possibility of heart disease increases to a great extent when the blood circulation is disturbed because of accumulation of too much fat on the artery wall.

Functions of cholesterol- Usefulness and its risk: Cholesterol is involved in constructing the cell membrane and its protection. It determines permeability, allowing certain substances to enter the cell. It helps in producing hormones such as, androgen and estrogen. Cholesterol plays an important role in producing the hormones of the adrenal glands and in the production of bile. In presence of sunlight, the cholesterol in the skin prepares vitamin D, which is carried by blood to the kidneys to be converted into the active form of vitamin D and again return to blood. Cholesterol is essential for the metabolism of fat soluble vitamins, such as- vitamin A, D, E and K and for the activities of neurons. Cholesterol is closely related to the prevention of diseases. However, the presence of high cholesterol is also related to irregularities of the heart and blood transportation. Though it is an important component of bile, it is also a waste product and it is eliminated through the liver. Increased amount of cholesterol deposit in the gall bladder as sediments. The sediment of cholesterol forms stones, known as gall bladder stone or gall stone. In addition to cholesterol, phosphate, and calcium may also form gall stones.

6.4.6 Irregularities in Blood and Bone Marrow-Leukemia

Red blood cells are produced in the liver and the pancreas in the embryonic stage. It starts developing from bone marrow after the birth of a child. These mainly supply O_2. If the production of RBC is interrupted for any reason, and an abnormal increase of WBC happens, the symptoms of leukemia is detected.

The cancer of blood cells is named leukemia. It occurs because of the abnormal formation and multiplication of white blood cells from bone marrow, which indirectly causes less production of red blood cells and platelets. Though leukemia is called blood cancer, it is in fact a disease related to the malfunctioning of blood production. A bone marrow is the worst affected. Low red blood cell count causes a deficiency of oxygen. As a result, patients become weak, pale and have shortness of breath. Due to the deficiency of platelets blood can not coagulate and bleeding may occur abnormally without any injury from gums, nose and the other portion of the body. For the same reason, small red spots on the skin and swelling and inflammation of leg joints may be seen. According to the World Health Organization (WHO), there are more than fifty types of leukemia, most of which have high white blood cell count. Though white blood cells increase in number, in fact, these are cancer cells and are unable to prevent diseases as these are supposed to. So, a person suffering from leukemia is easily vulnerable to various diseases. Swollen lymph nodes and a persistent fever may also occur due to immuno deficiency disorder. Thus the symptom of this disease shows the inability of almost all the blood cells to function properly. However, symptoms may vary based on types of leukemia.

Treatment

Now-a-days this disease can be cured if it is diagnosed at an early stage and proper treatment is ensured. Generally, bone marrow transplantation and chemotherapy are the major forms of treatment, though treatment may vary based on types of leukemia. In the past, there was no other alternative but going abroad for better treatment of this disease. Now there is arrangement of bone marrow transplantation in Dhaka Medical College Hospital, and chemotherapy is being provided in many public or private hospitals of the country.

6.5 Circulatory diseases and their Remedies

(a) Heart Attack: When blood clots in any part of the heart, it stops blood circulation. This causes the damage of cardiac cells. It results in myocardial infarction or coronary thrombosis which are commonly known as heart attack. The number of patients of heart disease (especially coronary heart disease) is increasing in Bangladesh. Oxygen and nutrients are carried by the blood to all cells of the body from heart. There are three main blood vessels of the heart that carry out its activities. These are called coronary arteries. Sometimes there is a deposition of lipids that forms a blockage in the wall of these arteries, which creates obstacle in blood flow. This causes life threatening heart disease. Nowadays, not only people aged between 40 to 60, but also many young men have heart attacks.

The main causes of this disease are being over weight, uncontrolled proportion of glucose in blood, eating unhealthy diet, such as·, oily food (Biriani, Tehari etc.), fast food (Burger, Beef or chicken patties etc.), idle life leading, lack of physical exercise, depression, emotional strain, anxiety, and sadness increase the risk of this disease at any age.

Symptoms of the diseases : Symptoms of a heart attack are feeling severe chest pain, particularly pain in mid chest, that does not decrease by taking antacid. The pain spreads from the left side to all over chest. Pain also spreads towards the neck and left hand. The patient complains that he or she feels pressure on the chest and starts sweating severely. Diabetic patients may have a heart attack without any chest pain. When it is diagnosed, it may be too late. Therefore, a diabetic patient needs to have regular medical checkup even if they do not face any problem.

Remedy: Do not ignore the situation. Do an E.C.G as early as possible, consult a doctor and render treatment. Coronary heart disease is a dangerous heart disease. To keep free from this disease some rules should be followed, so that blood pressure can be controlled.

- Avoid smoking, do regular exercise like walking.
- Eat sufficient amount of fruits and vegetables.
- Avoid fatty, fried, spicy and fast food.
- Changing of food habit.

(b) Rheumatic fever: Rheumatic fever is a disease brought on by streptococcal infections such as strep throat, scarlet fever, tonsillitis or middle ear infection. The initial attack of the disease usually occurs in childhood and may affect many parts of the body, especially the heart. If rheumatic heart disease develops, it sometimes injures the heart muscle and its valves. So, the heart can not pump adequate blood and the flow of blood within the body decreases.

Sometimes it is difficult for a doctor to diagnose rheumatic fever. If not diagnosed or treated properly, weight loss, anemia, exhaustion, loss of appetite, pallor etc. indicate the severity of the disease. Later red, swollen and painful joints are seen. If the disease is detected or identified at an early stage, penicillin may be used to cure it. Many physicians recommend penicillin be given regularly to children who have rheumatic fever until they reach adulthood.

Measures to keep the heart sound: The heart starts functioning even before a baby is born and continues till the last breath. The heart plays an important role both in life and death. In order to keep the heart healthy, it is necessary to maintain a proper life style and select the right kind of food. Oily or high-fat foods obstruct the proper functioning of heart. Cholesterol in the blood harms the heart by blocking blood vessels.

Drug and alcohol addiction increases heart beat and heart functioning. So, the addicted person gets mental pleasure and peace for a while, but it causes serious long-term harm to the heart. Poisoning due to smoking and taking nicotine of tobacco (Jordha) damages the heart. Avoiding a fatty diet, such as- oils, fats, excess carbohydrate and taking balance food, regular exercise and walking can make a person healthy.

Exercise

Short answer questions

1. What is meant by transpiration?
2. What is diffusion?
3. How many kinds of blood cells are there and what are they ?
4. What are the functions of an artery?
5. What is meant by blood pressure?

Essay type questions

1. Describe the measures of keeping the heart sound.
2. Describe the process of absorbing water with a diagram.

Multiple choice questions

1. What is the name of the membrane covering the heart?

   a) Epicardium b) Miocardium

   c) Pericardium d) Endocardium

2. Arafat saw some swelled raisins in a food (payesh) made of rice, milk and sugar. In this case, what is the cause of the swelling of these raisins?

   a. diffusion b. absorption

   c. osmosis d. imbibition

Observe the table and answer questions 3 and 4.

Name	Blood group
Rafin	A
Tamim	B
Tasmia	AB
Ratul	O

3. If blood input is necessary for Rafin, from whom he can receive blood?

   a) Tamim b) Tasmia

   c) Ratul d) Tamim and Ratul

4. Tasmia–

   i) carries A, B antigen in blood

   ii) can donate blood to Rafin

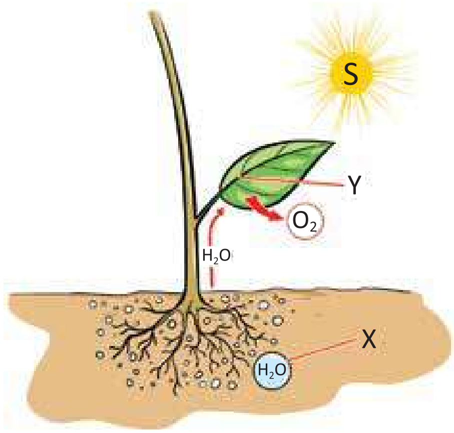
   iii) can receive blood from Tamim.

Which one is correct?

   a) i & ii b) i & iii

   c) ii & iii d) i, ii & iii

Creative questions



a. What is adhesion?
b. What do you mean by imbibition?
c. Explain what the effects will be on the process for the absence of the constituent S shown in the above figure.
d. Analyze the problems that may develop in the plant if the element X does not reach the region Y shown in the picture.

2. Mr. Hasan is 50 years old. He serves in a socio-economic institution. He is feeling headache, palpitation, restless. His 7 year old daughter Moon feels joint pain, and her skin turned swollen and reddish. They consulted a doctor. After some tests the doctor advised necessary measures.

a) What is blood?
b) Explain how white blood cells protect body.
c) Explain the causes of Mr. Hasan's disease.
d) Which disease is incurable from the problems mentioned in the stem? Explain.

Chapter Seven

Exchange of Gases

Gaseous exchange occurs in all organisms discovered till today. Gaseous exchange is a physiological phenomenon of organism. Gaseous exchange in plants and animals are of different types. Gaseous exchange in plants and animals is the matter of discussion in this chapter.

At the end of this chapter, we will be able to-

- explain the conception of plant's gaseous exchange;
- explain the function of main organs of respiratory system;
- describe the structure and function of lungs;
- describe the respiration process and the gaseous exchange in human;
- explain the symptoms, causes, remedy and the preventive measures of the diseases of respiratory system;
- determine the nature of exhaled air;
- draw the labelled diagram of lung;
- create awareness to prevent respiratory diseases.

7.1 Gas exchange in plants

We know that photosynthesis and respiration are the two very important processes in the life of a plant. A plant exchanges gases mainly through these two physiological processes. These two processes are accomplished through many chemical reactions. Plants take CO_2 from air and leave O_2 by Photosynthesis. On the other hand, plants take O_2 from the air and leave CO_2 by respiration. There is no special organ in the plant to breathe. The exchange of oxygen and carbon dioxide and other gases occurs through the stomata of leaves and lenticels on the bark of the mature stem. In plants, the frequent exchange of oxygen and carbon dioxide does not occur as it happens to an animal. In daylight or in presence of sufficient light, the rate of photosynthesis becomes high. An amount of oxygen gas, produced in photosynthesis, is spent in respiration. Reversibly, an amount of carbon dioxide gas, produced in respiration, is used in photosynthesis and so the amount of gases, exchanged, are approximately the same.

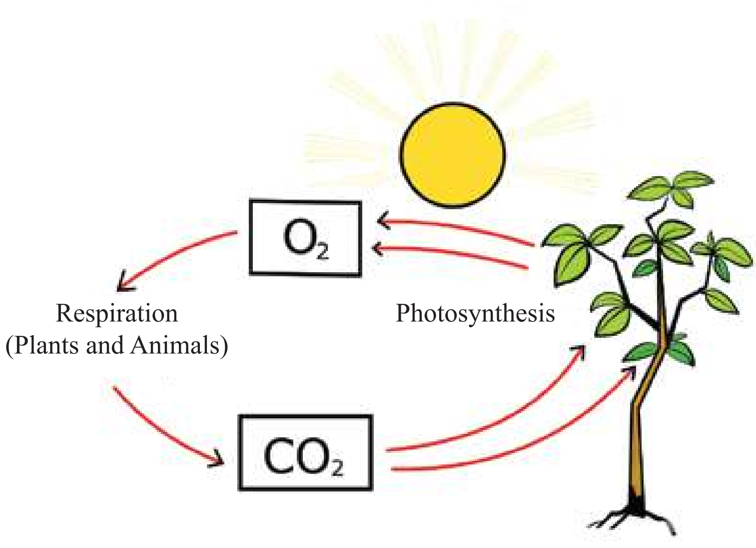


Figure: 7.01 Gaseous exchange in plants

At night the light phase of photosynthesis process ceases, and so oxygen gas is not produced. But the respiration process occurs round the clock, day and night, and the production of CO_2 continues. The carbon dioxide gas is released in the environment through stomata. These gases are also exchanged through the lenticels developed in the bark of the mature stem. This is why breathing problem may develop if someone sleeps under a big tree at night. A plant obtains its required gases from its environment. Just as the leaf absorbs oxygen and carbon dioxide from the air, root also absorbs required water from the soil. O_2 gas is produced as a result of the reaction between CO_2 and water which plants absorb from the soil by the root. Then O_2 gas returns in the atmosphere. In this way exchange of gases goes on in a plant.

7.2 Human Respiratory System

To sustain life, oxygen is indispensable for a living being. Not a single animal can survive without oxygen . Oxygen enters the body with air and is pushed into the lungs, and is then carried to all of the organs through the blood. Within the somatic or body cells food substance uses oxygen to break down the digested food substances sugar (glucose) to produce heat and energy. This heat keeps the body warm and supplies necessary energy.

Oxygen reacts with digested food substances (glucose) to produce carbon dioxide and water. Blood carries these substances to the lungs. Here oxygen is absorbed and carbon dioxide is expelled. The process of inhaling oxygen with which digested food substances in the body cell are oxidized, convert the potential energy into useable energy (kinetic energy) and eliminate carbon dioxide, is called respiration. The exchange of oxygen and carbon dioxide occurs within the lungs and cells simultaneously. The simple equation of respiration is given below:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy (ATP)}$$

$$\text{Glucose + oxygen} \longrightarrow \text{carbon dioxide + water + energy (ATP)}$$

You have learnt in class seven that inhaling of oxygen is inspiration and breathing out of carbon dioxide is expiration. If the supply of oxygen stops for 3 - 4 minutes death is inevitable. In both conscious and unconscious states inhaling of oxygen and expelling of carbon dioxide occurs continuously. Along with this process other processes also continue.

7.2.1 Respiratory System

The organs, which take part in respiration are called the respiratory system. The organs related with the respiratory system are :

(1) Nasal cavity and nasal passage, (2) pharynx, (3) larynx, (4) trachea, (5) bronchus, (6) lung and (7) diaphragm.

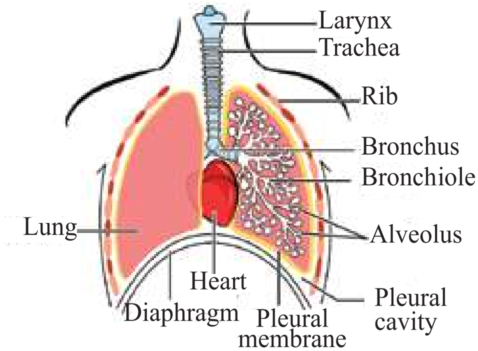


Fig: 7.02 Human respiratory system

(1) Nasal cavity and nasal passage : The nose is the beginner of respiratory system. It is a triangular hollow organ situated above the buccal cavity. It helps to sense the smell of a substance. A specific type of nerve in the nose stimulates the organ, to give us the sense of smell. Its structure is such that it makes the inhaled air suitable to be received by the lungs.

The nasal passage extends from an aperture in front of the nose and up to the pharynx behind. A thin partition divides it. Its front side is covered with cilia and the rear part is lined by mucous producing membrane.

The cilia together with mucous serve to trap foreign substances, such as germs and dust. Before entering the lungs this makes the air relatively free from dirt. The inhaled air when passed through the nasal passage becomes warm and moist so that sudden cold air does not harm the lungs.

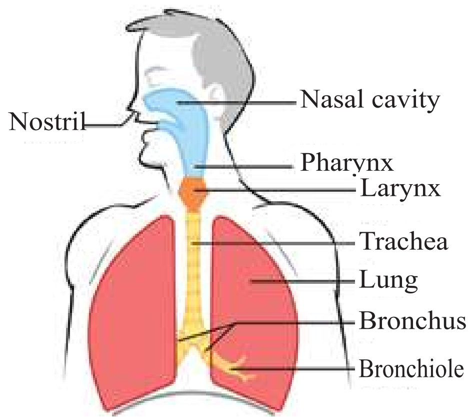


Figure: 7.03 Nasal passage and pharynx

(2) Pharynx - If we open our mouth, the pharynx can be seen at the back of the mouth. It extends behind the nasal passage to the upper part of larynx. At the back of the roof of the mouth, there is a small tongue like part called the soft palate. When swallowing food or drink, the soft palate closes the backside of the nasal cavity. As a result food cannot come out through the nostrils. Another important function of the soft palate is to produce mucous. There might be a link between the development of the soft palate and evolution of the human oral system.

(3) Larynx - It is situated below the pharynx and at the top of the trachea. There are two folds of muscle situated on opposite sides of the larynx. These are the vocal cords. A flap of soft tissue at the back of tongue is the epiglottis. It acts as a lid at the time of taking food. This lid covers the opening of the larynx (so food particles can not enter the oesophagus) while keeping the larynx open during respiration. So, air can get into lungs through this passage. But it has no function in respiration.

(4) Trachea- This is a hollow tube which lies in front of the oesophagus and extends from the larynx downwards into the thoracic cavity. It is supported by incomplete rings of cartilage and smooth muscles. The inner layer of the trachea is covered with mucous membrane and cilia. Air flows through the trachea. But through the constant rhythmic beating of the cilia the trapped dust, germs and other unwanted particles are expelled.

(5) Bronchus- The lower end of the trachea is divided into two bronchi which lead to the right and left lung lobes respectively. These are bronchi. Each of the bronchi divides and sub divides repeatedly to form bronchioles. The structures of the bronchi are just like the trachea.

(6) Lungs- The lungs are the main organ of the respiratory system. The right and left lungs are situated on either side of the heart within the thoracic cavity. They are

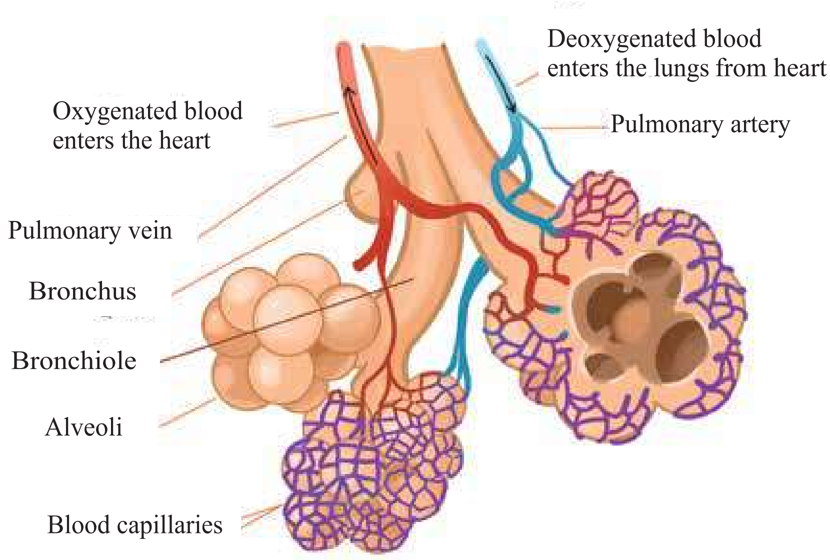


Figure: 7.04 Air sacs inside the lungs

spongy, soft and light reddish in colour. The right lung is three lobed and the left one is two lobed. The entire surface of the lung is covered in a double layered membrane which is named the pleura. The space between the two layers contains a fluid. This saves lungs from friction, as the lungs rub against the thorax during breathing movement. The lungs contain numerous air sacs called alveoli, small bronchioles and blood vessels.

The smaller bronchioles (alveolar ducts) terminates in crusts alveoli. So, air can enter from the nasal passage to the alveoli directly. Each alveolus (singular of alveoli) wall is composed of a single layer of epithelial tissue. The alveoli are surrounded by mesh work of capillaries.

When air enters the alveolus, it expands like a baloon and later contracts automatically. The wall of the alveoli and blood capillaries are so thin that gaseous exchange occurs between them.

Individual Activity

Activity : Draw a diagram of the respiratory system and label its different parts.

(7) Diaphragm- The diaphragm is a muscular sheet which separates the thoracic cavity from the abdominal cavity. It looks like a spread umbrella. When the diaphragm contracts, it moves downwards, and the volume of the thoracic cavity increases. When the diaphragm expands it moves upward, the throacic cavity contracts and returns to its normal position. The diaphragm plays an important role in respiration.

7.2.2 Breathing

All the organs related to breathing remain open only through the pharynx. The other ends of the organs remain closed. The air enters air sacs of the lungs easily through the nasal passage. Nerve impulses help in managing breathing. The inter costal muscles (muscles within the ribs) and diaphragm contract, and the diaphragm goes downwards and the thoracic cavity expands. The volume of the thoracic cavity increases and the air pressure decreases. So, the pressure within the thoracic cavity becomes less than the outer atmospheric pressure. This forces the lungs to expand and draw in air through the nose and trachea. This is inhaling. After the contraction the muscles relax. Then the diaphragm expands and the muscles relax, allowing the diaphragm and thorax to return to normal position. So, the air pressure increases, the lung shrinks back, forcing the moistened and carbon dioxide- enriched air out again. This is exhaling. In this way, breathing goes on constantly. This is external respiration.

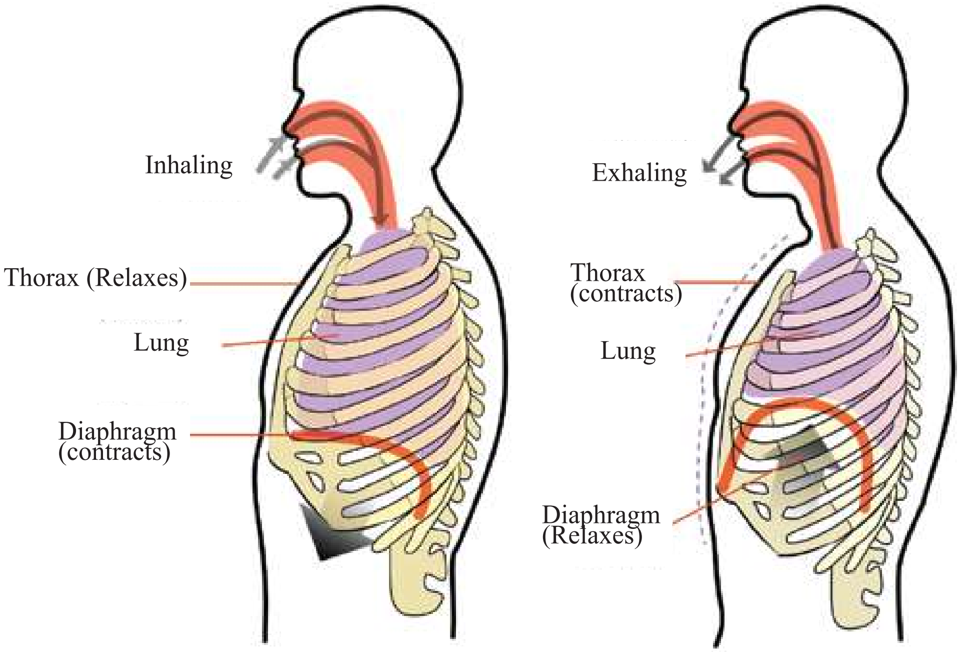


Figure: 7.05 Inhaling and exhaling

Gaseous exchange: Gaseous exchange means the exchange of oxygen and carbon dioxide. It occurs in between the air and blood vessels of the lungs. Gaseous exchange occurs in two steps, the absorption of oxygen and the giving out or expelling of carbon dioxide.

Absorption of Oxygen: Gaseous exchange in the lungs takes place through diffusion. In the blood oxygen does not remain free. A large amount of oxygen combines with the haemoglobin of the red blood corpuscles and forms oxyhaemoglobin. This is a temporary compound. Production of these compounds depends on the concentration of oxygen in the plasma. During blood transport, a large amount of oxygen diffuses from the plasma to the lymph.

This happens when the oxygen concentration in the lymph is less. So, the oxygen concentration in the plasma becomes less. Then haemoglobin begins to give up oxygen, which was bound with it. In this way at first oxygen enters the plasma and then into the lymph or intracellular fluid. Steps which occur during oxygen transportation are described below.

The exchange of gases between alveoli and blood and tissue occurs by diffusion. Diffusion of gases takes place due to a gas pressure difference between alveoli and blood. After entering into the blood from the lungs dissolved oxygen flows in two ways. A small amount of oxygen flows in the plasma and most of the oxygen makes a loose bond with the iron part of haemoglobin and forms a temporary compound called oxyhaemoglobin. From oxyhaemoglobin oxygen separates easily.

Haemoglobin+ oxygen→oxyhaemoglobin (unstable compound)

Oxyhaemoglobin→ free oxygen + haemoglobin

After entering the blood capillaries, oxygen separates and penetrates into lymph by diffusion first from the red blood corpuscle and then blood capillaries. Lastly, from the lymph, oxygen reaches the cell after penetrating the cell membrane.

Carbon dioxide transport: Carbon dioxide is produced by the oxidation of food. This carbon dioxide at first diffuses through the cell membrane into the lymph. Then, from the lymph CO_2 enters the blood plasma through capillary diffusion. Carbon dioxide is mainly transported as bicarbonate (by blood plasma as $NaHCO_3$ and by red blood corpuscles as $KHCO_3$) to the lungs. In the lungs the carbon dioxide is released from bicarbonate and passed to the alveoli. Then carbon dioxide is forced out, diffusing through blood capillaries and alveoli.

Individual Activity

Activity : Experiment to show the nature of exhaled air.

Apparatus : Two large test tubes, one 10 ml syringe without needle, two plastic tubes (one of which should be fitted airtight in the syringe) and lime water.

Procedure: Prepare two test tubes each containing the same amount of lime water. Then insert one end of both the plastic tubes in the test tubes in such a way that the end remains submerged inside the lime water. Now one end of the plastic tube needs to be fitted airtight at the opening of the syringe. But before that, the plunger must be drawn out upto 10ml. When the tube is attached to the syringe, the plunger should be pushed inside which will cause bubbles in the lime water kept inside. Repeat the same process to insert air inside. Now put the end of the plastic tube attached with the other test tube in your mouth and gently breathe inside it. Keep your mouth aside when you inhale. Observe lime water in both test tubes for 15 seconds. Continue the experiment for 15 seconds more if no change is observed.

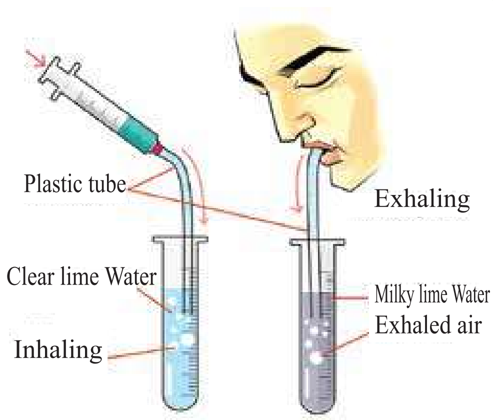


Figure: 7.06 Experiment to show the nature of exhaled air

Observation: You may observe that there was no change in the lime water where normal air was inserted through the syringe. But the lime water of the test tube where exhaled air was inserted has turned milky.

Conclusion: The presence of CO_2 in the exhaled air has turned the lime water milky. This is because the amount of CO_2 is more in exhaled air than in normal air. So, the lime water was not changed when normal air was inserted.

Individual Activity

Activity : Fill in the table :

Nostril	⇄		⇄		⇄		⇄		⇄	Alveolus	$\xrightarrow{O_2}$ / $\xleftarrow[CO_2]{}$	Blood

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7.3 Diseases of Respiratory System

The lungs are an important organ of respiratory system. This organ can be damaged by the infection of bacteria and viruses. The lungs may be affected due to air pollution, because of the presence of dust particles, and chemicals. Carelessness may cause complex diseases and infections. Complexities and death from common diseases can be decreased by learning about causes, symptoms, remedies, and prevention of common diseases of the respiratory system.

1. Asthma: Asthma usually occurs due to overactive immunity system. The immunity system works more severely than necessary when a foreign body enters into lungs. In many cases asthma patients have a family history of the disease. It is not a contagious or microbe borne disease.

Causes: Certain allergic foods (prawn, beef, hilsha-fish etc.), smoke, dust, pollen etc. entering the lung with the inhaled air, can be the cause of asthma. In infants, common cold may cause symptoms of asthma. A seasonal variation is noted. Symptoms of asthma increase in certain seasons round the year.

Symptoms: The symptoms of the disease are as follows-

- Sudden increase in respiratory distress.
- Suffocation, lip becomes blue, the veins of the neck swell.
- Rapid deep breathing is attempted and whizzing and whistling sound in the chest.
- As sufficient oxygen is not available in the alveolus, that results in the suffering of the patient.
- Sometimes white sputum may be discharged while coughing.
- Usually there is no fever.
- During respiration, the skin between two ribs is drawn inward.
- Patient becomes weak.

Remedies: By medical treatment the disease cannot be fully cured. But by proper medication prompt relief may be ensured.

- Avoid those food which creates respiratory distress.

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- Live in clean well -ventilated room.
- Avoid using or coming into contact with items like animal fur, artificial fiber etc. that aggravate the symptoms.
- Be careful and follow physician's advice.
- Avoid smoking, tobacco, jarda, gul.
- Serve the patient liquid diet during breathing problem.

Prevention

- Live in hygienic atmosphere.
- Avoid air pollution and things that may cause asthma in the workplace or house.
- Always carry inhalers and medicine and take them when necessary. It is to be noted that quacks treat patients of this disease with high dose steroids, which gives instant relief from pain but causes long lasting negative health consequences. This type of treatment as well as quacks should be avoided.

2. Bronchitis: Acute and chronic inflammation of the inner lining of any part of the bronchi and bronchial tube is called bronchitis. The disease is caused by bacterial infection. Once attacked by bronchitis there is a possibility of recurring attack. Usually, infants and elderly persons are attacked by this disease.

Causes: Smoking, unhealthy environment and pollution such as- industrial dust, smoke etc. are the main causes of this disease. Living in inhaling dust, polluted air, smoking cigarettes and cold are some of the causes of bronchitis.

Symptoms

- Cough, chest pain and breathing distress.
- When coughing the patient feels severe chest pain.
- Fever and gradual weakness.
- Can not eat solid food.
- Sputum is discharged with cough. If phlegm or sputum comes out with cough for continuous three months and if this disease attacks consecutively for two years, it is considered to be chronic bronchitis.

Remedies: Preventive measures include-

- Stop smoking, drinking alcohol, use of tobacco.

- Follow the physician's advice.
- Keep the patient in tolerable temperature and dry environment.
- Feed nutritious liquid and hot food, e.g. hot milk, soup etc.
- Taking full rest.

Prevention:

- Bad habits like smoking, drinking alcohol, taking tobacco should be stopped. Abstain from working in environment with dust or smoke.
- Children or elderly people must not get cold.

3. Pneumonia: Pneumonia is a lung disease. Excessive cold may cause this disease. Getting affected by cold after measles and bronchitis may lead to Pneumonia. It is a dangerous disease for children and elderly people.

Causes: Pneumonia is caused by *Pneumococcus* bacteria. Pneumonia may also be caused by other bacteria, viruses or fungi. This disease may even occur when enzymes or saliva get into the trachea.

Symptoms: These include-

- Deposition of mucous like liquid substances which produce cough.
- Coughing and breathing distress.
- High fever and chest pain.
- Severe respiratory distress; at the last stage whizzing sound in the chest.

Remedies: These include-

- Seeking timely advice from a physician and to follow the treatment given.
- Serving hot and liquid nutritious diet.
- Drinking plenty of water.

Prevention: Preventive measures are-

- To be careful that the children and elders are not attacked with cold.
- Live in well ventilated house.
- Keep the patient in tolerable temperature and dry environment.
- Avoid smoking.

4. Tuberculosis: Tuberculosis is a well-known air borne infectious disease. In some cases, people coming into contact with patients having skin affected by germs of tuberculosis or by taking infected cow's milk are more likely to develop the disease. It is to be noted that any man at any time may be affected by tuberculosis. Those who work hard are weak, live in damp and unhealthy environment, suffer for malnutrition, or remain exposed to patients of tuberculosis easily become the victim of tuberculosis. Most of us think tuberculosis is only a lung disease. This idea is not correct at all. Tuberculosis occurs at any organ of the body, such as, intestine, bone, etc.

Not every person infected with tuberculosis becomes very sick and the symptoms are not exposed easily. When the germs destroy white blood corpuscles, the body become weak, then the symptoms are exposed.

Causes: The disease is caused by *Mycobacterium tuberculosis,* a type of bacterium. However, some other bacteria that belong to the mycobacterium genus may also cause tuberculosis. If anybody live in an unhealthy environment then germ easily spread in body.

Diagnosis: This disease can be found out by sputum test, skin test (MT test), cyto- and histopathology test and chest X-ray. The test depends on the parts of the body affected by tuberculosis. Presently the research is going on how to detect the disease confirmly by blood test. Now a days DNA based test is very much available in our country for the detection of tuberculosis germ in the sputum and other sample of patients.

Symptoms and signs

- Weight loss, general weakness.
- Usually cough and cold continues more than three weeks.
- Coughing, sometimes with blood.
- Evening sweat and rise of low fever. Temperature of the body does not increase so much.
- Chest pain, indigestion, abdominal diseases.

Remedies: It includes -

- Continue treatment according to the advice of physician.
- Treatment of the disease is a lengthy process, treatment should continue untill the complete cure.
- Physician's instructions must be followed strictly.

- Patients with tuberculosis should be isolated or sent to hospitals for complete cure.
- Keep the used belongings of the patient separately.
- Patient's cough and sputum should be buried in the soil.
- Proper treatment and adequate nutritious diet should be arranged.
- Without consulting the physician, medicine should not be stopped.

Prevention: To get rid of this disease, all children should be vaccinated by B.C.G. The baby should be vaccinated within one year after birth. Though BCG vaccination gives children protection against deadly tuberculosis, it doesn't remain effective for grownups. So administering vaccination in childhood is not a lifelong protection. There are facilities of vaccination in different health centers of the country.

5. Lung Cancer: Among the various types of cancer, lung cancer is extensive and terribly prevalent. In our country it is the leading cause of death of male cancer patients. Tuberculosis or any other pneumonia causes one type of wound that afterwards turns into cancer.

Causes: Smoking is considered to be one of the main causes of lung cancer. Lung cancer may be caused by air and environmental pollution, coming in contact with pollutants like asbestos, arsenic, chromium, nickel, solid metal powder etc. at workplace or home. It is assumed that shortage of roughage in diet increases the possibility of the disease.

Symptoms and signs: The sooner primary symptoms of lung cancer are diagnosed and given treatment, the more is the chance of living longer. At the primary stage symptoms of lung cancer are found-

- long lasting dry irritating cough.
- chest pain, hoarseness of voice.
- gradual or day by day loss of weight, loss of appetite.
- asthma, frequent fever.
- repeatedly infected by pneumonia and bronchitis.
- feel pain in bones, weakness, paralysis of any gland, jaundice.

Diagnosis

At the primary stage lung cancer can be determined by–

- Examining cough and sputum.
- X-ray of chest.
- CT scan
- MRI

For final confirmation, cytopathology or histopathology tests are done.

Remedies:

- When the symptoms are found, consult the physician without any delay.
- After the disease is diagnosed, treatment should be taken as per the advice of the physician.
- Depending upon the necessity, use or apply radiotherapy. Radiotherapy destroy the cancer cell by radiation.

Prevention: According to the view, preventive measures include-

- Abstaining from smoking and drinking alcohol.
- Not taking excess fatty food.
- Regular exercise.
- Making the habit of taking adequate amount of vegetables.

Exercise

Short answer questions

1. What is cellular respiration?
2. What is the function of Pleura?
3. What is Bronchitis?
4. What is the function of the Diaphragm?
5. What are the causes of Pneumonia?

Essay type questions

1. Write down the symptoms of tuberculosis.

Multiple choice questions

1. Which is the cause of tuberculosis?

   a) Virus b) Bacteria

   c) Fungi d) Protozoa

2. Gaseous exchange in plants occur through–

   i) stomata

   ii) lenticels

   iii) root hair

   Which one is correct?

   a) i & ii b) i & iii

   c) ii & iii d) i. ii & iii

Read the stem and answer the questions 3 and 4.

Rita went to the doctor with a complaint of weakness. The doctor told her that she had a deficiency of a particular blood cell. To meet this insufficiency he advised her to take more nutritious food and vegetables.

3. Which one is deficient in Rita's blood?

   a) Red blood corpuscles b) White blood corpuscles

   c) Platelet d) Plasma.

4. The particular cell-

   i) is a compound of iron

   ii) reacts with oxygen

   iii) contains carbon dioxide

Which one is correct?

a) i & ii b) i & iii

c) ii & iii d) i. ii & iii

Creative questions

1.

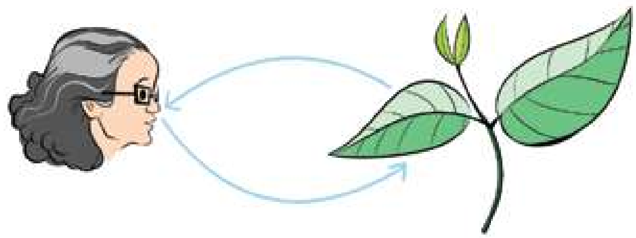


Figure-P Figure-Q

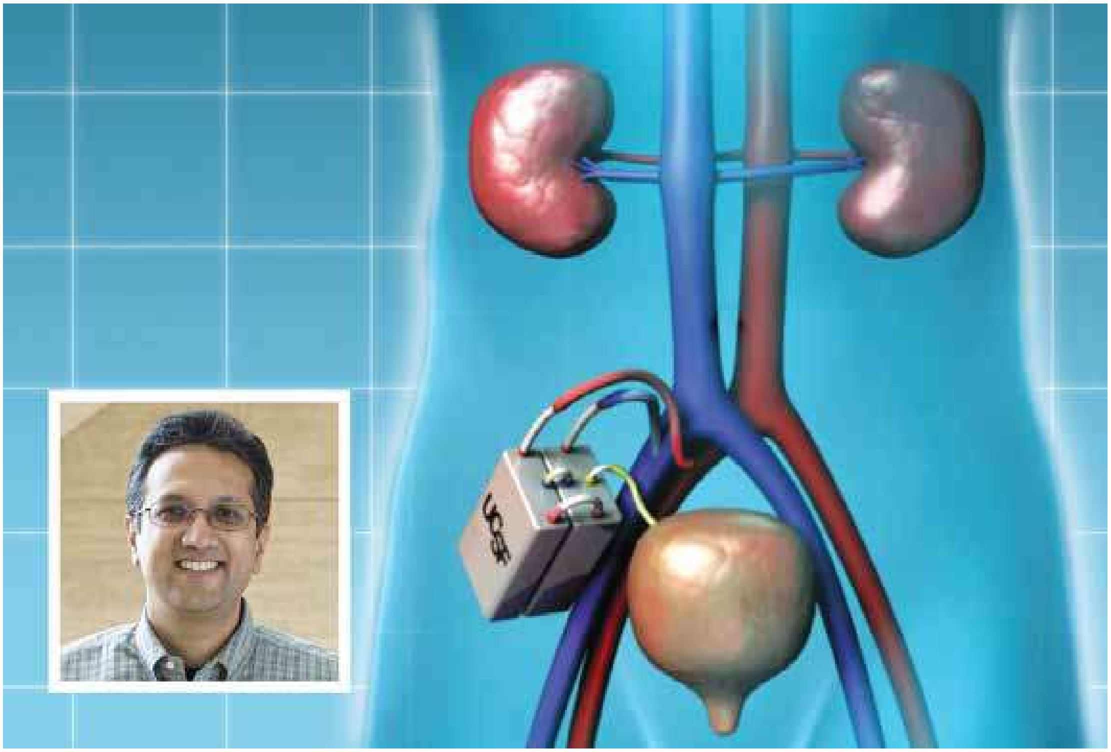
a) Which cell carries oxygen in the blood?
b) What does it mean by trachea?
c) Explain the process meant by P of above figure.
d) P and Q shown in the picture are dependent on one another in connection with gaseous exchange. Analyse with your reason.

2. Rashed and Jamil work at a ship breaking industry. Both of them called a doctor for chest pain, cough and other complains. After different types of tests, the doctor diagnosed that Rashed's respiratory organ had irregular cell division. On the other hand, Jamil's disease has spread in intestine and bones along with respiratory organs.

a) What is the diaphragm?
b) What is meant by external respiration?
c) Explain, how does the disease spread in Rashed's body?
d) Which one of the two diseases of Rashed and Jamil is comparatively easier to be cured? Analyse.

Chapter Eight

Excretory System



A Bangladeshi scientist named Dr. Shuvo Roy invented an artificial kidney which is compatible for replacement in human body.

A good number of chemical reactions take place inside the cells of an organism. So, all the physiological phenomena are performed neatly. Organisms remain alive. Some products produced by chemical reactions are essential for the body. But some are poisonous, and these must be removed from the body. For example, the breakdown of glucose during respiration produces carbon dioxide. This is carried away by the blood to the lung and is removed from lungs to the outside of the body. Kidney eliminates nitrogenous waste product and excessive acid from the body by same way. Elimination of nitrogenous waste products and various diseases in the kidney are discussed in this chapter.

At the end of this chapter, we will be able to-

- explain excretion in the human body;
- describe the production of excretory products in the human body;
- describe the structure and functions of the kidneys;
- describe the structure and functions of nephrons;
- explain the role of the kidneys in osmoregulation;
- describe the formation of kidney stones, remedies and prevention;
- describe the symptoms of kidney failure and what measures are to be taken in these respects;
- explain the role of dialysis to maintain the normal functions of the kidneys;
- explain the concept of kidney transplantation and posthumous kidney donation;
- describe the diseases of the urinary tract and measures taken to keep it free from diseases;
- investigate public opinion about posthumous kidney donation;
- draw a labeled diagram of human kidneys and nephrons;
- draw a poster to create social awareness about posthumous kidney donation;
- draw a leaflet to create awareness to keep kidney and urinary tract (ureter) free from diseases;
- create awareness about to keep kidney and urinary tract healthy;
- create social awareness about posthumous kidney donation.

8.1 Excretory

Excretion is the biological process through which harmful nitrogenous waste products produced by metabolic activity are removed from the body. These substances are of no use for the body, but may cause various diseases if they remain inside the body for long. It can ever cause death. The system through which nitrogenous waste products are excreted from the body is called the excretory system. Excessive water, salt, and organic substances are excreted or expelled from the body to maintain physiological balance. The kidney is an excretory organ. The basic unit of the kidney is the nephron.

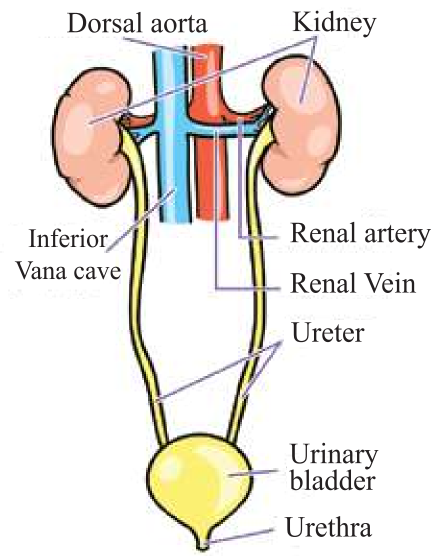


Figure: 8.01 Excretory system

Excretory products: Excretory products are mostly nitrogenous waste. Human excretory products are expelled from the body as urine. As normal urine mass is almost 95% of water. Other components are urea, uric acid, creatanine and different kinds of salts. The colour of the urine is light yellow due to the presence of a pigment called urochrome. Excessive intake of proteins increases the acidity of urine. On the other hand fruits and vegetables generally make urine alkaline.

8.2 Kidney

The excretory organ of the human body is the kidney. Two kidneys lie at the back of the abdominal cavity, on either side of the vertebral column and the lower part of the ribcage, attached to the back wall. They are red brown in colour and bean shaped. The outer side of the kidney is convex, and the inner side is concave, with an indentation called the hilus or hilum. The ureter and renal vein comes out from the hilum and the renal artery enters the kidney. Two ureters arise from two kidney, proceeding downwards to open into the urinary bladder. The funnel shaped extended part (space) of the ureter is called the renal pelvis.

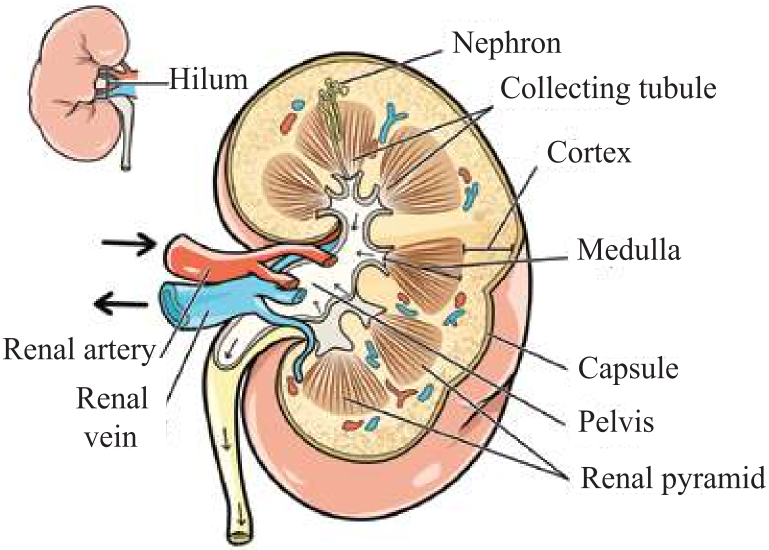


Figure: 8.02 L.S of Kidney

Kidneys are enclosed with a special fibrous membrane, called the renal capsule. Adjacent to the renal capsule is the cortex, and the inner side (part) is the medulla. Both of these regions are composed of connective tissues and blood vessels. Generally, there are 8-12 renal pyramids in the medulla. The expanded apex of each pyramid is called renal papilla. These papilla project directly into the ureter.

Each kidney contains a particular type of tubules called uriniferus tubules. Each uriniferous tubule has two parts, the nephron and the collecting tubule. Urine is produced in the nephron and the collecting tubules carry urine to the pelvis.

Nephron : The functional unit and the secretory part of uriniferons tubule of the kidney is the nephron. Each human kidney contains about 1million to 1.2 million nephrons. Each nephron is composed of a renal corpuscle, or malphigian body, and renal tubule.

Each renal corpuscle is divided into two parts, the glomerulus and the Bowman's capsule. The Bowman's capsule encloses the glomerulus. Each Bowman's capsule is a cup- shaped expanded organ, composed of two epithelial layers. Inside the Bowman's capsule is a small cluster of blood vessels called the glomerulus. Afferent arterials from the renal artery enters the capsule, and breaks into about 50 capillaries. These capillaries divide again and form a mass of fine capillaries. These capillaries unite together and form efferent arterials to leave the Bowman's capsule.

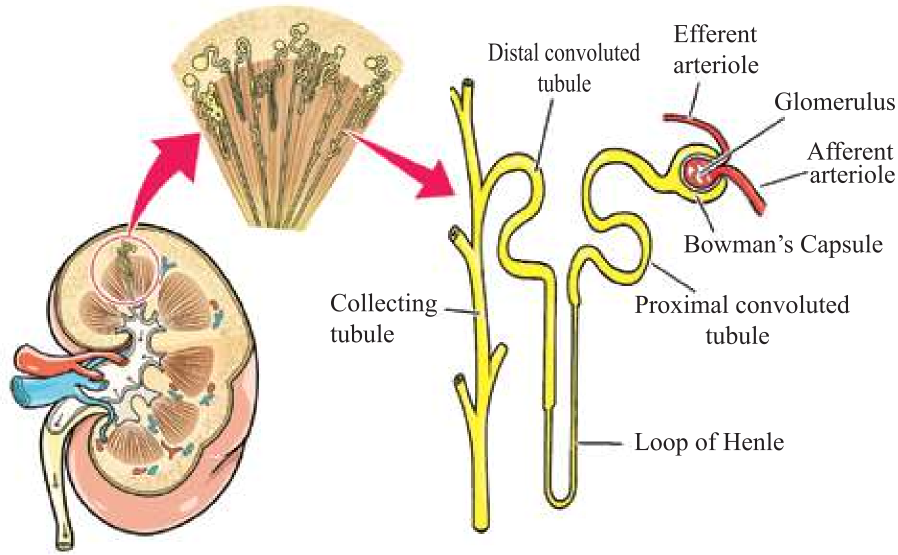


Figure : 8.03 A nephron

The glomerulus acts as a filter and produces filtrate from blood. The liquid filtrate is called ultra-filtrate. This ultra-filtrate, when passing through the tubules, repeatedly goes through absorption and excretion. Finally the liquid filtrate that remains is urine, which passes to the ureter through the collecting tubules and finally deposits to the urinary bladder, which spreads up to the tubules called renal tubules. These convoluted tubules are behind the Bowman's capsule. Each renal tubules is divided into three regions: the proximal convoluted tubules, Henley's loop and the Distal convoluted tubule.

Individual Activity:

Activity: Draw a labelled diagram of kidney and a nephron.

Function of Kidney: A normal adult man expels almost 1500 milliliter urine daily. Urine contains nitrogenous waste products, such as, urea, uric acid, ammonia, creatinine etc. These are harmful to health. The kidneys play an important role in eliminating these unwanted and harmful waste products. Each nephron of the kidney is continuously producing urine through a complex process. This urine reaches the pelvis of the kidney through collecting tubules and proceeds through the funnel- like extended part of the pelvis and enters the ureter. The ureter carries urine to the urinary bladder, where it is stored temporarily. When the urinary bladder fills with urine, a sensation to urinate is created and allows urine to pass out of the body through the urethra. In this way, kidneys help expel nitrogenous waste product from the body. The kidneys maintain the balance of mineral salts e.g. sodium chloride, potassium chloride etc. It also controls blood pressure and maintains the balance of water, acid and base of blood.

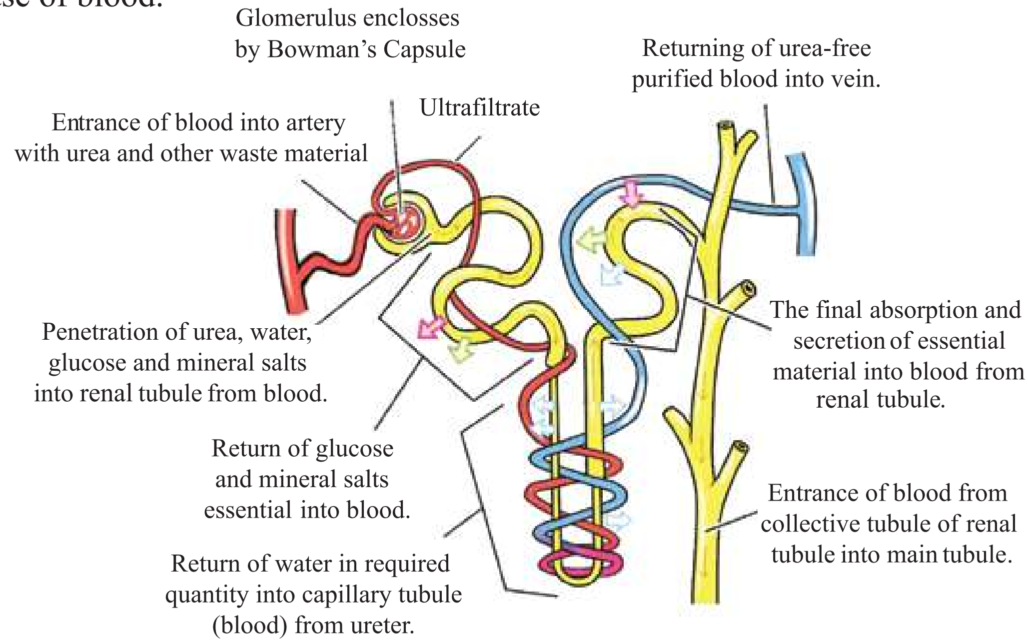


Figure : 8.04 Function of Nephron

Individual Activity

Activity: Write down how and which organ participate in waste product elimination mentioned in the lower table.

Waste products	Organ	Remark
Carbon dioxide Nitrogenous waste products Urea, Uric acid Excessive water		

Role of the Kidneys in Osmoregulation

For all physiological processes, an adequate amount of water is necessary. Most of the water is removed from the body as urine. The main function of the kidney is to keep the balance of water. The nephrons of the kidney maintain water equilibrium through reabsorption. Excretory fluids, water and other substances are filtered in the glomerulus. In case of failure of the kidneys, water accumulates in the body. The whole body, including eyes and face, may swell up, and it can create high blood pressure. These are symptoms of errors in osmoregulation. In chapter six regarding osmosis has been discussed. If a solution is placed on one side of the selectively permeable membrane and on the other side solvent of that solution is placed (in this case water), then the osmosis will occur in the solution from the side of the pure solvent. It is possible to stop osmosis by applying pressure from the side of the solution. For that the minimum pressure that has to apply is called osmotic pressure of that solution. The amount and concentration of water and salt in the organism is controlled in such a way that the overall osmotic pressure remains almost unchange. This process is called osmoregulation or water equillibrium.

Kidney stone: Normal activities of the kidneys can be hampered due to some diseases (illness). Burning sensation of kidney, problems in urination and kidney stone may occur. The symptoms of kidney diseases are: the whole body may swell up (waterlogged), loss of albumin during urination, urine with patches of blood, burning sensation during urination, urinating often, or in some cases urination reduced or stopped. Small stone like substances produced by the kidney is known as the kidney stone. Any one can be attacked by these diseases. But males have the higher possibility of stone formation than females. Excessive body weight (obesity), infection in the kidneys, and intake of insufficient water are the causes of kidney stones.

Initially the formation of kidney stones causes no remarkable problem. Problems occur when the stone goes downward into the ureter and obstructs urination. A very dull and steady pain in the lower back is the symptom of this disease. Blood passes into the urine. Fever starts with shaking. Treatment depends upon the size and location of the stones. Stones can be removed by taking sufficient water and treatment. Stones can be removed by modern methods such as uteroscopic, ultrasonic lithtripsi or surgical operation.

8.3: Kidney failure, Dialysis and kidney transplant

Kidney failure occurs gradually from diseases such as nephrities, diabates, hypertension (high blood pressure), stones etc. Side effects of some medicine, severe diarrhoea, excessive blood loss etc. are also causes of sudden failure of the kidneys. Symptoms of kidney failure are, difficulty in urination and increased level of creatinine in blood. A kidney machine (dialysis machine) can be used to remove the harmful waste products from a patient's blood. The patient has to periodically use the kidney machine to purify the blood.

Dialysis: When the kidneys are badly damaged or inactive, then the blood can be filtered (purified) by a scientific method called dialysis. Generally dialysis is done by a dialysis machine. One end of the dialysis tube of the dialysis machine is led to the artery of patient's wrist and another end is led to the vein of the same wrist. Blood from the artery passes into the dialysis tube. The wall of the dialysis tube is partially semipermeable, so urea, uric acid, other harmful substances, are removed (as filtrate). The purified blood enters into the patient's body through the vein. The dialysis tube is submerged in a liquid similar to that of blood plasma. In this way, harmful nitrogenous waste is excreted out through dialysis machine. But this process is very expensive and time consuming.

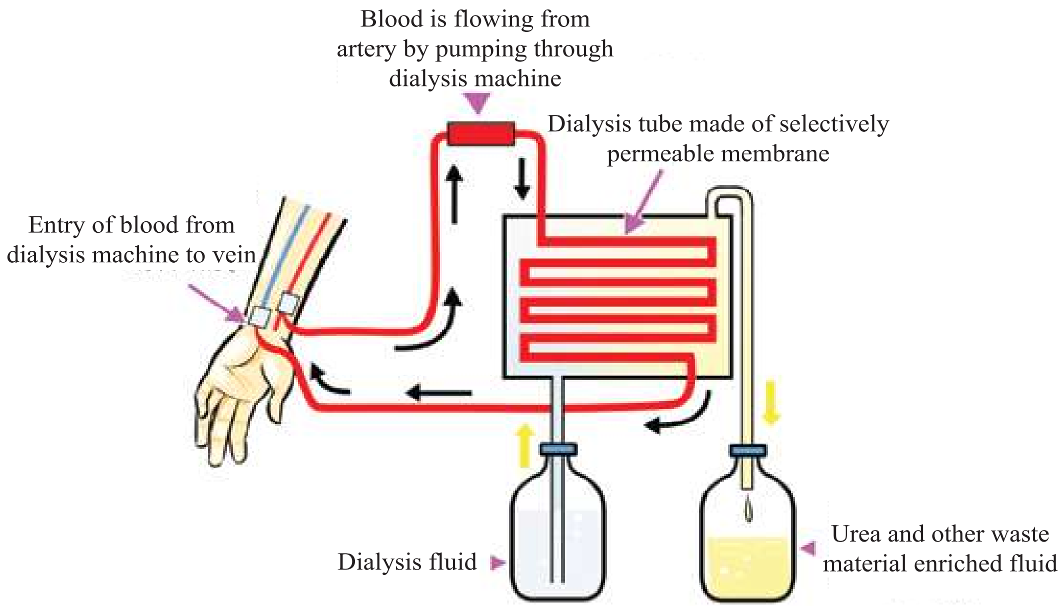


Figure: 8.05 Dialysis machine

Transplantation: When the kidneys become damaged or inactive, they can be replaced by a healthy kidney of a healthy person. This is called transplantation. Kidney replacement can be done in two ways: a kidney taken from close relative or from a dead person (posthumous). Close relatives mean the patient's father, mother, siblings, uncle, aunt. A dead person would be a person who is brain dead but the organs are kept alive artificially. Like posthumous eye donation posthumous kidney donation also can help a kidney failure patient for survival. Donation of posthumous kidney is a good service to mankind.

Millions of kidney failure patients get a healthy life by transplanting kidneys. In our country, kidney transplantation has been done very successfully. Due to legal complications in our country, persons other than close relatives cannot donate kidneys and due to this, patients are deprived from getting a healthy kidney. Only one kidney is enough for a person for his /her survival, so kidney failure could be treated by transplanting one kidney. Before transplantation, matching of tissue is necessary. The probability of matching of kidney tissue is higher with patient's father, mother, siblings and close relatives.

Leading an unhealthy life and drinking insufficient water may cause urinary tract or ureter disease. An Infection in the ureter causes burning sensations along with other symptoms. With proper treatment most patient recover completely. Previously it was though that everyone should drink eight glasses of water daily. Modern research has shown that intake of water varies with sex, nature of job, types of physical illness and weather. Excessive water should not be drunk unless necessary. Water should be taken only to fulfil thirst.

Precaution: Many of us drink saline while sweating in hot weather, even if we are not suffering from diarrhoea or vomiting. We drink saline if we are tired or even without any reason. This is not right, especially in case of elderly people. It can bring danger to their health. Even in case of suffering from diarrhoea and vomiting, people should be treated with the prescribed amount of saline as suggested by a doctor. In case of simple tiredness or sweating, it is enough to drink some water mixed with lemon juice and a pinch of salt. Sugar can be added for non-diabetic patients.

Individual Activity

Activity: Draw a poster regarding posthumous kidney donation and place it in the classroom.

Measure to keep the urinary tract healthy: Everybody should be careful about tonsillitis and scabies of children because it might be the reason of kidney disease. High blood pressure and diabetes should be kept under control. Immediate treatment for diarrhoea, blood loss, avoiding smoking and pain relieving medicine, drinking adequate amount of water, lead a healthy life.

Individual Activity

Activity: Make a leaflet in a group regarding how to keep the kidneys and the urinary tract healthy.

Exercise

Short answer questions

1. What is dialysis?
2. What is the malpigian organ?
3. What is the pelvis?
4. What is meant by excretory products?
5. What is meant by kidney stones?

Essay type questions

1. Explain measures to keep the ureter sound.

Multiple choice questions

1. Where is urea produced?

   a) Kidney b) Liver

   c) Body cell d) Renal artery

2. Decreases the possibility of forming kidney stones-

   i) decreasing body weight

   ii) drinking insufficient water

   iii) intaking less amount of protein

Which one is correct?

   a) i & ii b) i & iii

   c) ii & iii d) i, ii & iii

Read the stem and answer questions 3 and 4.

Tanni does not follow the rules of drinking water and taking other foods. Recently she excretes less urine and feels pain in her lower back.

3. Causes of producing less urine in the body of Tanni-

   i) excessive sweating

   ii) taking less fruits

   iii) taking salty food

Which one is correct?

a) i & ii
b) i & iii
c) ii & iii
d) i, ii & iii

4. The causes of this problem in the body of Tanni-
   i) deposition of water in the body
   ii) inflammation in urinary duct
   iii) elimination of sugar with urine.

Which one is correct?

a) i & ii
b) ii & iii
c) i & iii
d) i, ii & iii

Creative questions

1.

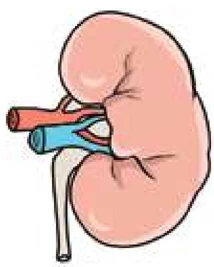


Figure A

a) What is the medulla?
b) What is meant by the glomerulus?
c) Explain why Figure-A is compared with a filter?
d) If Figure-A is damaged or inactive, what measures will you take to prevent damage to Figure A? Give your opinion.

Chapter Nine

Firmness and Locomotion

Humans move from one place to another in search of food, protection and breeding in unfavourable condition. The process by which animals move from one place to another by their own effort is called locomotion. The system, which gives the structure, definite shape and protection of different organs from outer injury and helps in locomotion, is called the skeletal system.

In this chapter we will learn about the structure of the skeletal system, its function, and ways of protection.

At the end of this chapter, we will be able to-

- describe the human skeleton;
- explain the role of the skeleton in firmness and locomotion;
- explain the function of different kinds of bone and bone joints;
- explain the function of muscles;
- explain the functions of tendons and ligaments;
- describe the causes, symptoms and remedy of osteoporosis;
- describe the causes, symptoms and remedy of arthritis;
- investigate the reasons of osteoporosis and arthritis;
- draw and label different parts of the skeleton;
- make other conscious about the soundness of bones.

9.1 Introduction of human skeleton

For the construction of a house at first a structural framework is essential. The skeleton is the framework of our body. The human skeleton is composed of a combination of 206 long, small, flat, unequal bones. It gives the definite shape to the body and protects the internal organs like heart, lungs, stomach, intestine, brain etc. The number of bones in a child skeleton is more than the adult. Without a strong bony structure a fixed shape is not possible. All bones and associated parts together constitute the skeleton.

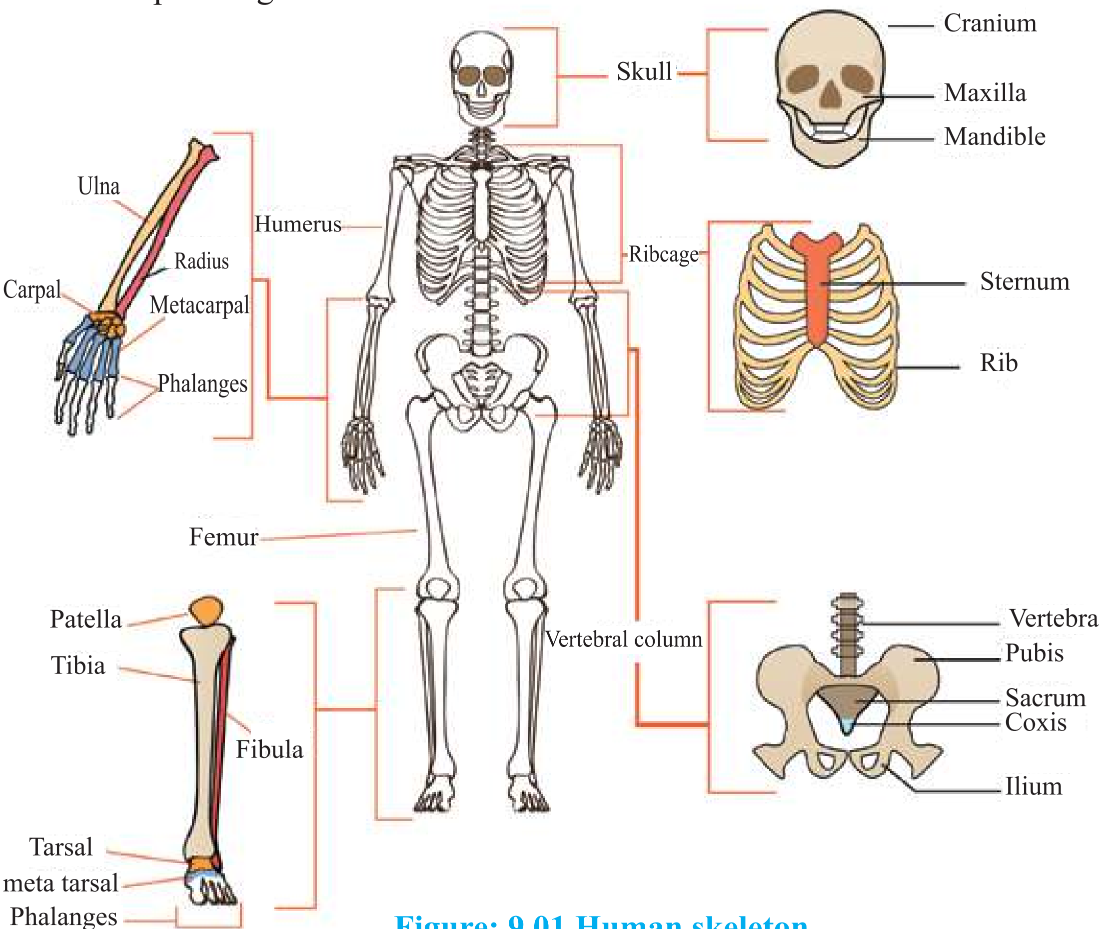


Figure: 9.01 Human skeleton

Bones and bone joints both are the parts of a skeleton. Bone joints are connected together with the various parts of the skeleton and assists in movement. Bones remain attached with voluntary muscles that help the movement of different organs. The skeletal system is composed of bones, cartilages, ligaments, tendons, bone joints and muscles.

Human skeleton is divided into two parts:

(1) Exoskeleton and (2) Endoskeleton.

(1) Exoskeleton : The parts of the skeleton that exist outside the body e.g. nail, hair etc.

(2) Endoskeleton : The part of the skeleton which can not be seen from outside is called endoskeleton. Actually skeleton means the endoskeleton inside our body. The endoskeleton is mainly composed of cartilages and bones.

9.1.1 Role of skeleton in firmness and locomotion

The skeleton has the following functions :

(a) Structure and firmness of the body- The skeleton forms the hard structure of the body and gives a definite shape to the body. It joins lower organs with upper organs.

(b) Protection and weight carrying- The skull protects the brain, the spinal cord within the vertebral column or backbone, and the lungs and heart within the thorax. Muscles are attached to the skeleton and skeletal muscles are involved in carrying the weight of the body.

(c) Movement and Locomotion- Hands, legs, shoulders and the pectoral girdle and pelvic or hip girdle help in movement. The muscular system has an important role in this act. Due to the attachment of muscles with the bones, we can move the bones and our bodies move.

(d) Production of red blood cells- Bone marrow produces red blood cells.

(e) Storage of mineral salts- Bones store mineral salts (calcium, potassium, phosphorus etc). This is why the bones remain hard and strong.

9.1.2 Bone, Cartilage and Joint

Bone: The bone is a modified form of connective tissue. It is the strongest tissue of the body. The matrix of the bone (or intercellular substance of the bone) is composed of organic compounds. Bone cells are scattered within the matrix. The older bones decay and new bones develop simultaneously. Different kinds of bone diseases occur if the balance (decay and development) is disturbed. In later age, bone decay is relatively higher than bone formation. Bones are mainly composed of different compounds of phosphorus, sodium, potassium and calcium. It contains approximately 40-50%. Living bone cells contain 40% organic and 60% inorganic substances. To develop bone cells, vitamin-D and calcium enriched foods are needed. Due to the deficiency of these substances, normal growth of bones is resisted. The Sunlight hits the cholesterol of the skin and brings some changes which in turn brings some gradual changes in the liver and kidney and thus, through this continuous process, vitamin-D is synthesized. So it is necessary to come in contact with adequate sunlight. There is a possibility of suffering from deficiency of vitamin-D for those who always stay at home and wear clothes that covers the whole body.

Cartilage: Cartilage is not hard just like bone. These are relatively soft and elastic or flexible. It is a different form of connective tissue. These cells are found solitary or in pairs and are densely scattered out within the matrix. From the cartilaginous tissue a kind of hard semi transparent organic substance is secreted. This is called chondrin. Matrix is composed of chondrin. It is light blue in colour. In living cartilaginous cells the protoplasm is transparent, with a round nucleus and cavity is noticed within the chondrin. These are called capsules or lacunae. Chondrocytes and chondroblasts are inside it. All cartilage is enclosed by a layer of fibrons connective tissues that is called the perichondrium. This layer is glazing white in colour. So, cartilage looks white, bluish and glazy shining. There are various types of cartilage within the body, e.g. the cartilage in the pinna. Cartilages is found in different joints, or on the articulating surface of some of the bones.

Individual Activity

Activity: Find out the differences between bone and cartilage.

Bone joint or articulation: The joints between two or more bones are called bone joints. In every joint, bones are joined firmly together by flexible elastic tissues called ligaments. So, the bones can not be dislocated easily. The joint helps in the movement of limbs. All the joints of our body are not of the same type. Some are fixed, e.g. intervertebral joint. Some are freely moveable e.g. joints of hands and legs.

Synovial joint: When two ends of two bones touch, it makes a joint to form a synovial bone joint. When more than two bones make a joint, it is called complex synovial joint.

The parts of synovial joints are: bone ends covered with cartilage, and synovial fluids and a cover or capsule which is a tough fibrous tissue or ligament that firmly holds the joint. The synovial fluid and the cartilage of the joint reduces friction so that less energy is consumed for movement of joint.

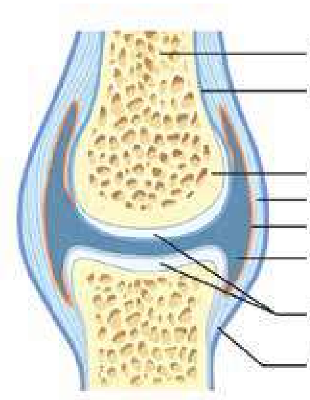


Figure: 9.02 Synovial joint

Bone joints are of different types.

(a) **Fixed joint-** The bones are joined firmly, so it is immoveable. Example- joint of the cranium.

(b) **Slightly movable joint-** These joints are joined with one another and has a small sliding surface. So, we can bend the body. For example-joint of backbone.

(c) **Freely movable joint-** These joints can be moved easily. For example- hingle joint, synovial bone joint and socket joint is only freely movable ball.

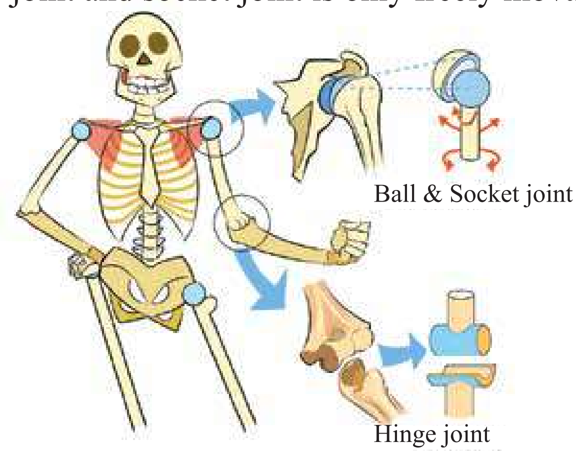


Figure: 9.3 Ball and socket and hinge joint

(i) Ball and socket joint : Joints where the round one head of the bone fits into a cup shaped socket or cavity of another bone in such a way that it allows the bone's movement in all planes.This is also a type of synovial joints.

For example: Shoulder joint, ball and socket joint of thigh bone.

(ii) Hinge joint: The elbows, knees, joints of the finger are the examples of hinge joints. It moves like a hinge of a door. It can be moved in one plane only. These are also examples of synovial joints.

Individual Activity

Activity: Draw the different parts of the human skeleton and label them.

9.2 Muscles

You have learned earlier about muscles in class seven. The muscular system consists of involuntary muscles of the internal organs, the wall of the blood vessels, the cardiac muscles of the heart, and the voluntary muscles that are attached to the bones. The muscular system performs various important functions, such as:

- Movement of organs, help in movement, placing the organs in orderly manner and balancing.
- The muscular system along with the skeletal system gives a definite structure of the body. Muscles store glycogen for the uses of the source of power for emergency need in future.
- The cardiac muscles are of special type, it maintains heart beat and blood circulation.
- Muscles keep active role in the expulsion of stool from the body and in the movement of food particle inside the alimentary canal.

9.2.1 Role of bones and muscles in human locomotion

The muscles and bones perform an important role in locomotion. The bone constitutes the structure of the body (i.e. skeleton) and muscular system makes the covering of this structure. Voluntary muscles are attached to the bones by a strong elastic part named a tendon. Muscle contraction is the result of nerve impulses. With the withdrawal of impulses the muscle again extends or relaxes. This contraction and relaxation of muscles, attached with the bones, helps in movement. In this way muscles help in stretching or extension of limbs. Contraction of the muscle draws a bone or limb away from the body or towards the body, helps in lowering a part, lifting a part or rotating a part etc. The role of muscles in the movement of bones is described with an example: observe how muscles work to bend or extend the elbow. The arm can bend at the elbow. The biceps muscle is attached to the scapula at the top and the radius at the bottom. By the stimulation of voluntary nerves when it contracts, the biceps pull the radius and ulna towards the body, so the arm bends. At that time the triceps muscle relaxes and also expands. To push the arm back down again, an opposite phenomenon occurs. That means by stimulation of voluntary nerves, the triceps muscle contracts and straightens or extends the radius and ulna. At the same time, the biceps relaxes and also expands. In this way we can bend and extend our arm by the simultaneous contraction of the biceps and triceps muscles. In this way various muscles help in the movement of different organs.

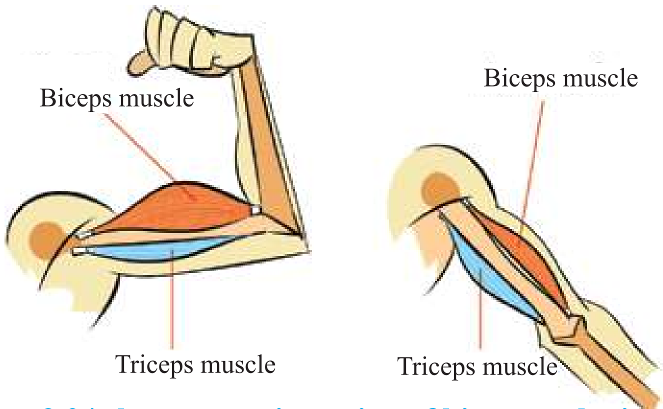


Figure: 9.04 shows opposite action of biceps and triceps muscle in movement of forearm.

9.2.2 Tendon and ligament

When we say that muscles are attached to the bones or one bone is attached to another bone with the help of a band then a question may arise, how and why this happens. The terminal portion of muscles form a rope like strong structure which is attached to the bones. This strong terminal portion of the muscle is called a tendon. Tendons are composed of dense, white fibrous connective tissues.

Unbranched white fibers are scattered in the matrix. These are composed of parallel bundles. Numerous fibers form a bundle. These bundles together make a bunch of bundles. The outer surface of these bundles is surrounded by areolar tissue and make a big bunch. Blood vessels, lymphatic ducts and nerves enter into the tendon through this areolar tissue. The elasticity of tendon is comparatively very low.

The fibers of the tendon are attached with the sarcolema of the muscle fibers. At the junction between muscles and tendons the areolar tissues that surround the bunch of bundles of tendon forms a continuous connection with the muscle bundles to build a strong connection. The tendon is strong and has less chance of tearing or breaking than that of a muscle or bone, but if it does tear, there is no chance of repair. The tendon is a rope like structure which is attached to the bone and constitutes a structure of the body that renders firmness, helps in the formation of ligament and makes a mechanical defence against tensile strength.

Bones are attached to each other by a thin, cloth-like, soft but strong, elastic band like structure. These are ligaments. They are composed of a combination of white and yellow fibers. The number of elastic yellow fibers is excessive. A fine, branched network of elastic fibers is scattered in this kind of tissue. The fibers stay separate instead of in bundles. Their elasticity is comparatively high and are composed of elastic protein. There are fibroblast cells in the fibers. Just like a hinge attaches the door to its frame, in the same way tendons and ligaments are firmly attached to the bones. So, the organ can bend, stretch and move and the bones are not dislocated or separated.

Figure: 9.05 tendon and Ligament

Individual Activity

Activity: Draw this table in your note book and fill it.

Characteristics	Tendon	Ligament
Structure		
Function		
Elasticity		

9.3 Diseases of Bones

(a) Osteoporosis : You have learned earlier that, calcium is an important ingredient for the formation of bones and for their strength. Calcium and vitamin enriched food is essential for the growth of bones. Osteoporesis is a calcium deficiency disease.

Generally, elderly males and females suffer from this disease. There is a higher chance of having this disease in males who are taking medicine with steroids and the females after their menopause. Those, who lead lazy life, do less physical labour have a higher chance of being attacked with this disease. Besides this, there is a maximum possibility of osteoporosis in a person if he/she has suffered from arthritis for a long time.

Causes: This disease develops due to the deficiency of mineral salts, particularly of calcium. After reaching the menopause stage, the density and thickness of bones declines in females, and the bones become brittle.

Symptoms:

• bones become brittle, thickness decreases

• muscle strength reduces

• feel back pain

• pain in bones

Diagnosis : The disease can be diagnosed by examining the density of the bone with the help of density measuring equipment. At the preliminary stage of the disease, the symptoms are not noticed. Suddenly hip bones or any other bone may fracture.

Remedies:

• Man and woman who are above 50 should take 1200 milligram calcium or amount according to the advice of doctor's.

• Drink skimmed milk and other dairy products.

• Consume orange juice, green vegetables, soya product and calcium enriched food.

Prevention:

• Come in contact with adequate sunlight.

• Taking vitamin- 'D' and calcium enriched food.

• Regular exercise (those who are already suffering from osteoporosis should take doctor's advice before starting exercise).

• Take balanced and cellulose-rich food.

(b) Rheumatoid Arthritis: Of the hundreds of type of arthritis, rheumatoids arthritis is one of them. Generally elderly people suffer from this disease. A young person's pain in the joints may be a symptom of rheumatic or any other disease (to be seen in chapter-6). Treatment varies according to the nature of pain in bone joints. Two persons may suffer from two different joint pains but show the same symptom. In this case both of them need different treatments. So treatment should not be stopped without doctor's consultation. It may bring bad effects instead of benefits.

Symptoms

- Inflammation and pain in bone joints.
- Stiff bone joints.
- Pain during articular movement.
- Joint swelling.

Remedies: The disease is not fully cured for elderly people. But the following measures may relieve the disease to some extent.

- Avoid hard labour and heavy work.
- Apply luke warm heat in the affected joint.
- Do light exercise to keep the joint moveable.
- According to the doctor's advice taking pain relieving medicine and proper treatment can relieve of this disease.

Prevention:

- Regular exercise according to the doctor's advice.
- Taking balanced and fibrous food.

Individual Activity

Activity: Collect information about life style, and consumption of food for the women who are above 50. Find out the causes of osteoporosis, arthritis among them and write them down.

Exercise

Short answer questions

1. What is bone joint?
2. What are the five functions of skeleton?
3. What are the differences between tendon and ligament?
4. What are the characteristics of a synovial joint?
5. What are the differences between bone and cartilage.

Essay type questions

1. Write down the causes and symptoms of osteoporosis.

Multiple choice questions

1. Which one is a characteristic of bone?

   a) Elastic b) Soft

   c) Strong d) Fibrous

2. Tissues of tendons are –

   i) white and glossy

   ii) unbranched and waved

   iii) fibrous and in cluster

   Which one is correct?

   a) i & ii b) i & iii

   c) ii & iii d) i, ii & iii

Observed the stem and answer the questions 3 and 4.

60 years old Rahima Begum can not work due to pain in her hand and foot. The doctor has said, she is suffering from osteoporosis due to calcium deficiency.

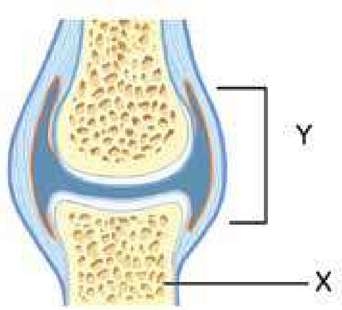
3. Which one is a symptom of this disease?
   a) increase the density of bone
   b) bone becomes brittle
   c) feel pain in waist
   d) increasing muscle strength

4. Which one is a preventive measure of this disease -
   i) taking roughage based food
   ii) to avoid lazy life
   iii) taking less vitamin 'D' enriched food

which one is correct?
   a) i & ii
   b) i & iii
   c) ii & iii
   d) i, ii & iii

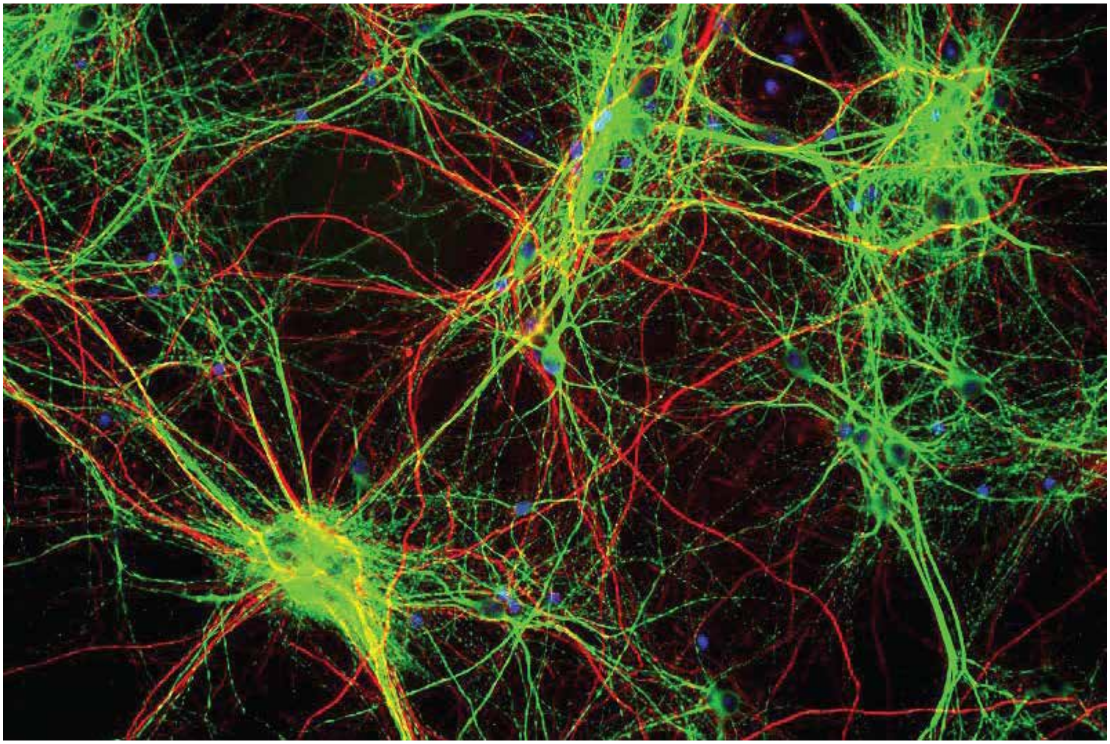
Creative questions

1. 12 years old Binita is healthy and restless. She spends most of the day time running and playing. One day while she was running she fell down and the ligaments of her leg were injured.
   a) What is bone?
   b) What do you mean by arthritis?
   c) Explain why the injured part of Binita's body can be compared with a hinge.
   d) What type of co-ordination is necessary to carry out the activities done by Binita? Analyse it.

2. 

   a) What is tendon?
   b) What does it mean by osteoporosis?
   c) Explain why the cell structure of 'X' of the figure is different?
   d) How does co-ordination between X and Y of the figure plays a role in the movement of organisms? Analyse it.

Chapter Ten
Co-ordination



We know that, various physiological actions and reactions are happening within the body. These activities happen all together. Co-ordination of these activities is necessary because if there is a lack of co-ordination, then abnormalities occur. In plants there is co-ordination to perform all physiological processes, such as: reproduction, metabolism, dormancy, germination, growth, movement, etc.

The human body performs different activities with the co-ordination such as: brain and hormones. The co-ordination of plants and human are discussed in this chapter.

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At the end of this chapter, we will be able to-

- explain the co-ordination system in plants;
- explain the co-ordination system in animals;
- explain the functions of the different parts of the nervous system;
- explain the structure and functions of a neuron;
- explain reflex actions;
- explain emotional transmission;
- explain the main functions of hormones;
- describe irregular secretion of hormones that creates physical problems;
- describe the causes and symptoms of stroke;
- describe instant measures to be taken against stroke and its treatment;
- describe nervous disorders' symptoms, causes, and remedies;
- analyse the effects of tobacco and drugs in coordinating activities;
- investigate the cause of physical disorders regarding hormones;
- raise awareness regarding the harmful effects of drugs or addiction;
- draw a leaflet or poster regarding the harmful effects of drugs or addiction;
- be aware of the harmful effects of tobacco and drugs on the nervous system.

10.1 Coordination in Plants

Like animal different physiological activities are simultaneously and continuously carried out in a plant cell. These activities are accomplished through some systems and methods. The coordination of physiological activities is an essential act. If there is no coordination in plant life, many abnormalities will arise.

In the life span of a plant the stages in the life cycle, such as germination, growth and development, flowering, the development of fruit, aging, dormancy etc. follow a set of systematic rules. The significance of weather and climatic factors on these processes is also notable.

With the growth and movement, the different physiological activities in plants are complex and ceaseless. Despite this, these activities are accomplished following special regulations and systems. One activity does not interrupt another in any way. Through the evolution of lac-crore years such type of delicate coordination has earned.

10.1.1 Phytohormone

The biochemical substance which is produced in the plant body and regulates growth and development of the plant and the formation of different organ is called a hormone. Plant hormone is called phytohormone. Some describe phytohormones as plant growth substances. According to the most scientists, any chemical substance, being produced in cells and translocated to other distant cells, and controls their activities and the substances are called hormones. Every cell of a plant has the ability to produce hormones. The main natural phytohormones are auxin, gibberellin, cytokinin, abscisic acid, and ethylene. The hormones, which are usually found in plant, are auxin, gibberellin, cytokinin and abscisic acid. Hormones are not plant nutrients but it regulates the activities of the plant.

Other than the hormones mentioned above, there are some other hormones which could not be separated or identified. They are called postulated hormones. They mainly help activities related to the development of flowers and reproductive organs. Florigen and Vernalin are the main hormones of this type. It is presumed that florigen is formed in the leaves and, being translocated to the base of the petiole, transforms the vegetative buds into floral buds. So, florigen helps a plant in its flowering.

The main phytohormones are mentioned below:

(a) Auxin: Charles Darwin first discovered this phytohormone, and later Kogl and Haagen Snit called it auxin. Charles Darwin studied the effect of light on the coleoptiles of plants. When the light shines on one side of coleoptiles, it turns towards the source of light, but in darkness it grows erectly. By performing experiments, scientists found that a chemical substance at the top of the coleoptiles is responsible for that type of movement. This substance is auxin. After the application of auxin, roots grow from grafted buds, preventing the premature shedding of fruits. In plant cells the movement of auxin happens downwards. The rate of osmosis and respiration is increased due to auxin. It also plays a role in producing fruits without seeds. Auxin is not just a hormone, it is a common name or class of phytohormone, all of which are involved in somehow controlling the growth of the plant. For example, indole acetic acid (IAA), indole butyric acid (IBA), naphthaleneacetic acid (NAA) etc.

(b) Gibberellin: The causal organism of Bakanae disease of rice is a kind of fungus, which causes an over growth of the rice plant. An organic substance can be extracted from it, due to which the overgrowth of rice plant occurs. This substance is gibberellin. Most of the gibberellins are found in mature seeds but they are also traced in seedlings, cotyledons and meristematic regions of the leaves. Elongation of the internodes are influenced by the phytohormone. So, the plants grow excessively in length. If this hormone is applied to a stunted plant, it grows more in length than a normal plant would. It plays a role in blooming flowers and in shortening the period of dormancy in seeds and in germination.

(c) Cytokinin : Cytokinin is found in fruits, cereals and the water of green coconuts. It is also found in the roots of some plants. This generally stimulate the process of cell division, mixed in different level of concentrations with Auxin. The hormone also plays a role in the growth of cells, the development of organ or plant parts, breaking the dormancy of seeds and organs, and in delaying the aging process. During the cell division cytokinesis occurs in a cell because of the effect of cytokinin.

(d) Ethylene: This hormone is a gaseous substance. It helps the fruit to ripen. It is also found in fruits, flowers, seeds, leaves and roots. Ethylene breaks dormancy in seeds and buds. It also plays a role in the growth of seedlings by stems growth and triggers the initiation of growing flowers and fruits. Ethylene accelerates the shedding of leaf, flower and fruit. It is also used to ripen fruit artificially.

Uses of hormones: Auxin and other hormones help in growing roots in graft tissue. A kind of auxin named indole acetic acid improves the effectiveness of cambium. As a result, uncontrolled cell clusters are developed and the injuries are healed up. By applying auxin, the shedding of fruits is delayed. Auxin and gibberellin are also used in producing fruits without seeds.

Growth

The effect of light and temperature on the development of different organs of the plant is remarkable. Through different synthesizing methods, the formation of distinct elements causes the development of new organs. Probably in the presence of light, the hormone auxin becomes inactive and so, in the dark (absence of light), the concentration of auxin increases. Some scientists believe that auxin in lighted part moves to the dark region and there growth occurs at a higher rate. The growth of lighted part, being inhibited, turns more towards light.

The tip of the plumule or radicle can feel the stimulus of gravitation. This is called geoperception. Owing to gravitation, the components of the cell are translocated downwards. They cause a pressure on the wall of cell laterally. This is why gravitational movement is accomplished.

The flowering of most plants depends on photoperiod. For example, the Chrysanthemum is a short day plant. Long day light causes inhibition to their flowering. The rhythm of the light and dark periods in a plant is an example of a biological clock.

On the basis of the rhythm of light and dark in plants, plants are divided into three categories :

(a) Short Day Plant: Average daily photoperiod of 8-12 hours is required for flowering. For example, Garland chrysanthemum and Dahlia.

(b) Long Day Plant: Average daily photoperiod of 12-16 hours is required for flowering. For example, Lettuce and Ridge Gourd (Jhinga).

(c) Day Neutral Plant: Photoperiod has no role on flowering. For example, Garden Cucumber and Sunflower.

Like light, heat and cold also play a role in the growth of plant and flowering in them. If cold is applied to the germinating seeds of many plants, their flowering period gets advanced. The acceleration of flowering of plants by applying cold is called vernalization. Scientists have proven temperature effects the flowering of plants. Flowering is prolonged if the wheat of winter is cultivated in summer. If 2°-5° C temperature is applied on the seeds after sowing, normal flowering occurs in them. So, you can see that the stimulant like light, gravitation, heat effects the growth of plant.

In this way, plants develop the coordination in their physiological activities.

Movement

Like other living organisms, plants are able to perceive stimuli. This is why the reflex made by external and internal stimuli cause movement in plants. Some movements in plants happen because of growth and other movements occur in plants because of internal and external stimuli. Movement always occurs due to some factors.

Movements in plants can be categorized into two: movement of locomotion and movement of curvature. When any part of a plant holistically moves from one place to another it is called movement of locomotion. For example, this type of movement is found in the gametes and zoospores of some fungi and higher plants. It is also found in some bacteria and algae, for example, *Volvox, Chlamydomonas* and diatoms.

Figure: 10.01:Response of plant towards light.

Higher plants anchored in soil cannot move from one place to another. But they can move and curve their organs or parts of organ to some extent. This type of movement is called movement of curvature.

Movement of the stem towards light, movement of the root towards dark and twining of tendril around suitable host are the examples of movement of curvature. Movement of locomotion and movement of curvature are of many types. Among them phototrophic movement is notable.

Phototrophic movement or phototropism

Phototrophic movement is a kind of movement of curvature. The stem and branches of a plant always move towards light and the root always moves away from light. The movement of the stem towards light is called positive phototropism and the movement of root away from the light is called negative phototropism.

Individual Activity

Activity : Observe a plant for a week keeping it by the side of a window of your classroom and present the results obtained, with reasons.

Individual Activity

Activity : Test the movement of germinated chickpea root towards gravity and present the results with reasons.

10.2 Co-ordination in animals

Influence of Hormones : Necessary co-ordination in animals is done by nerves and hormones. An animal's activities (movement, or behavioral change) occurs due to hormones. Hormones are secreted from different ductless glands, which control each other. The activities of hormones are controlled by the nervous system. Activities of hormone can be considered to be workers. As a whole which worker works, where, and how long he will work are all controlled by the manager. Like this, the nervous system controls the activities of the hormones. The hormones have a long term effect on the function and development of the nervous system.

At first there was an idea that a hormone is a stimulating substance. But later it was found that all hormones are not stimulating in function, some are inhibitors. A very small amount of hormones is required to control particular physiological functions. As a stimulator or inhibitor hormones control growth, development and functions of various tissues. The influence of hormones on an individual's behaviors, nature, and emotional impulse is very important. Hormones are carried by the blood from the place of origin to distant places where they stimulate certain cells or organs to respond. So they are often called chemical messengers.

Animals use hormones for co-ordination. If an ant gets a trace of food, it secretes a hormone from the source to its destination known as a pheromone. Other ants go to the source of food by following the path of this pheromone. After eating all the food ants stop secreting the pheromone, and so influence the other ants not to go there again. Some insects secrete pheromones in the air even from 2-4 kilometer distance. Humans make use of pheromones to destroy harmful insects. This process is very environment friendly to control harmful insects.

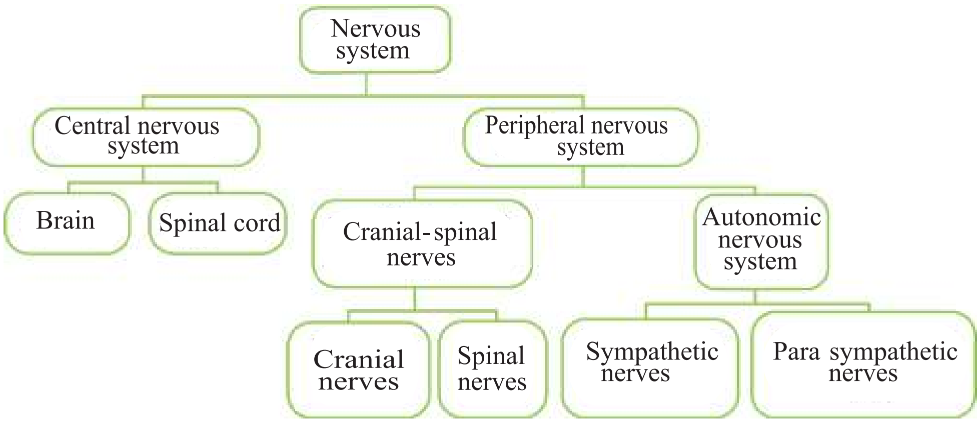
Influence of nerves : Different organs take part in different activities, such as : walking, sitting, talking, thinking, laughing, crying etc. To regulate these organs, coordination and integration are necessary. The nervous system and hormones together direct, control and co-ordinate all those activities. The system, through which the animal responds to stimuli, maintains connections of various organs, co-ordinates activities, and physiological processes and maintains relations with the environment, is called the nervous system. To perform different activities our body needs the co-ordination of millions of cells. The nervous system plays an important role in coordinating the different activities of a body.

All the activities of the body are performed by receiving stimuli from the environment and producing responses. The outside of the body is the external environment and the inner side is the internal environment. Stimulus from the external environment is sound, sight, taste and touch. These create stimulation at sensory nerves of the ear, nose, eye, tongue and skin. Internal stimulants are heat, pressure and various chemical substances. Some nerve impulses originate inside the central nervous system. This two types of stimuli can create stimulation to the sensory and motor nerves. Impulses which pass along sensory neuron fibers to the brain. The brain receives impulses from the sensory organs and then sends impulses through the motor nerves to the glands and muscles, causing them to function accordingly.

10.3 Nervous system

Nervous system: The nervous system coordinates with different organs and systems, carries impulses to different parts of the body, and maintains a relation with the environment by responding to stimuli.

The nervous system:



10.3.1 Central Nervous System

Central nervous system consists of the brain and the spinal cord. The brain is protected by the skull.

Brain: The swollen part of the nervous system, at the top of the spinal cord and inside the skull, is called the brain. The brain is the director of the nervous system. The brain is divided into three parts: a) Fore brain b) Mid brain and c) Hind brain.

a) Fore brain or Prosencephalon : The largest part of the brain is the cerebrum, which consists of two completely divided lobes, the right and the left. They are separated by deep furrows. These are the cerebral hemispheres. Though there is a deep furrow between two lobes, they are still connected by a bunch of nerves named the corpus callosum. The right hemisphere controls the left side of the body and the left hemisphere controls the right side of the body. This part of the brain has a folded and wrinkled surface. It is covered by a membrane called maninges. The left lobe of the cerebrum is comparatively well developed. The cerebrum is also called the fore brain. The exterior surface of the cerebrum is named the cortex and is composed of numerous neurons and is gray in colour. So, the other name of the cortex is grey matter. The deeper layer of the cerebrum consists of axons of neurons which is covered by white coloured mayaline. So the white matter is situated in the depth of the cerebral cortex.

Cerebrum is the higher organ which receives nerve impulses and sends responses (nerve impulse) to the various organs of the body. Cerebrum is the centre for body movement i.e., for every activity and sensation. Conscious activities, e.g. speech, vision, hearing, intelligence, memory, thinking, will and activities of voluntary muscles are controlled by the cerebrum. It also helps in taking decisions and in responding to stimulation. Among all the animals the evolution of man forebrain are most progressive and most developed.

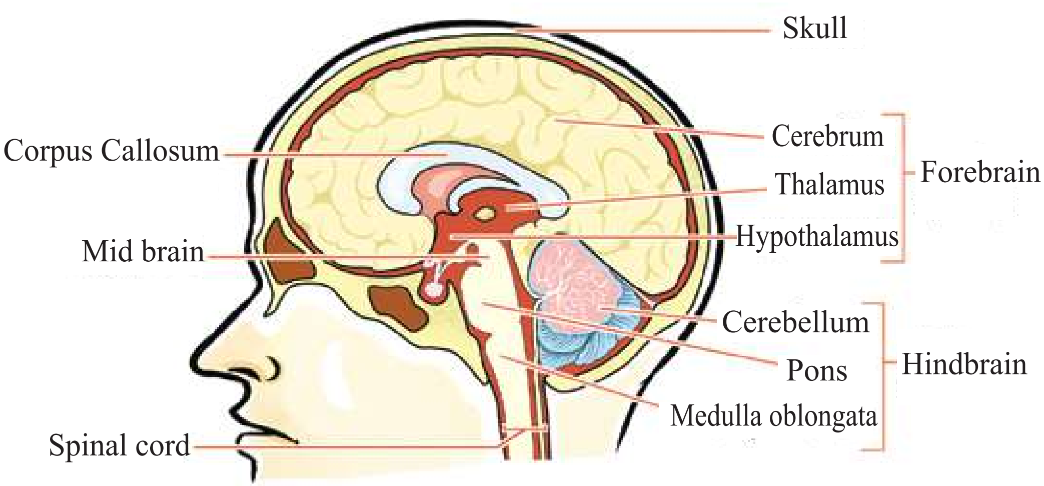


Fig: 10.02 Human brain in Sagital Section

b) Mid brain or Mesencephalon : The upper part of the hind brain is the mid brain or mesencephalon. It is a bridge between the fore brain and the hind brain. Its functions is to co-ordinate the activities of various muscles and maintain balance. It also plays an important role in vision (seeing) and hearing.

c) Hind brain or Rhombencephalon : This consists of cerebellum, pons and medulla oblongata.

(i) Cerebellum: Cerebellum is located at the back part of the pons. It is divided into the right and left lobes. Its exterior part is composed of grey matter and the inner part of white matter. The cerebellum controls muscle stress, co-ordinates movement, balance, control and the activities of voluntary muscles.

(ii) Pons : The pons is located in between the medulla oblongata and mid brain. It is cylindrical and consists of a bunch of nerves. It forms a connection between the cerebellum and the medulla oblongata.

(iii) Medulla oblongata : It is the most posterior part of the brain. Its front part is connected with the pons and the back to the spinal cord.

There are 12 pairs of cranial nerves, extending from the cerebrum and medulla oblongata. Within these eight pairs of nerves originate from the medulla oblongata. These nerves control the functions of the heart, lungs, pharynx, and swallowing of food. These nerves are also associated with functions, such as : hearing, balancing.

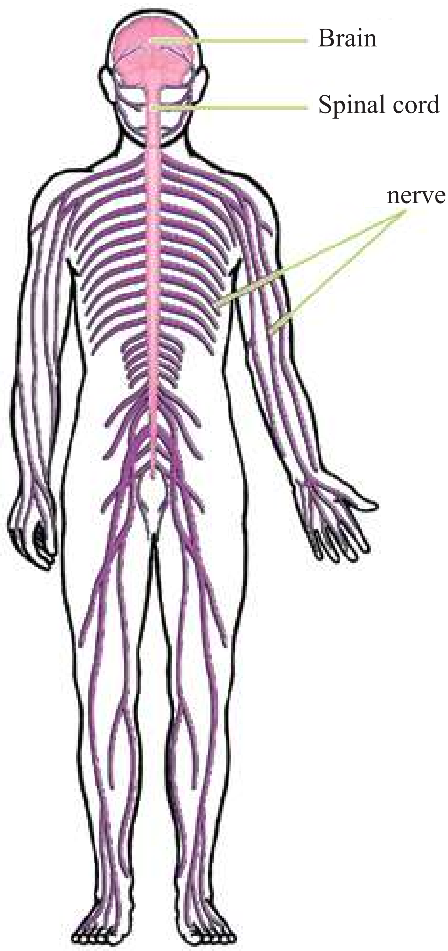


Figure: 10.03 Human nervous system

12 pairs of cranial nerves originate from the brain and spread to different regions: mouth cavity or buccal cavity, tongue, eye, nose, ear. These nerves are sensory or motor or mixed in nature.

Spinal cord : The spinal cord originates from the posterior part of the medulla, leaves the skull through the foramen magnum, and extends upto the lumber vertebra. It is protected by the vertebral column. The spinal cord is composed of grey matter and white matter. But their position is quite opposite to the brain.

The white matter is at the outer part and the grey matter is at the inner part. 31 pairs of nerves originate from the spinal cord and pass through the hole located in between the vertebrae. These are the nerves of the neck, shoulder, chest, back, hands and legs. These nerves are mixed in nature.

Nervous tissue

Tissue that can receive stimulus from the environment and can transmit accordingly to make an appropriate response, is called nervous tissue. Nervous tissue is composed of many nerve cells or neurons. The neuron is the basic functional unit of the nervous system.

Structure of neuron: The neuron is made up of two parts a) cell body and b) Elongated part.

a) Cell body: The part of the neuron which contains a nucleus, and cytoplasm, remains bounded by plasma membrane, and is round, oval, or star shaped is known as cell body. The cytoplasm contains mitochondria, golgi bodies, lysosome, fat, glycogen, nissel's granules.

b) Elongated part: A variable number of nerve fibers extends from the cell body, which are called elongated part. Elongated parts are of two types, e.g.-

(i) Dendron: There are small branched elongations around the cell body called dendrons. The branches coming out from the dendron are called dendrites. The number of dendrites in a cell body may be from zero to more than one hundred. Dendrites receive stimuli from other nerves.

(ii) Axon: A long extension originates from the cell body called Axon. A thin layer encloses the axon called the neurilemma. There is a fatty layer between the neurilemma and the axon. It is called the myelin. The end part of the axon is divided into axon terminals and, these terminals send a impulse to the dendrites of other neurons. Numerous axons and dendrites units together form a nerve.

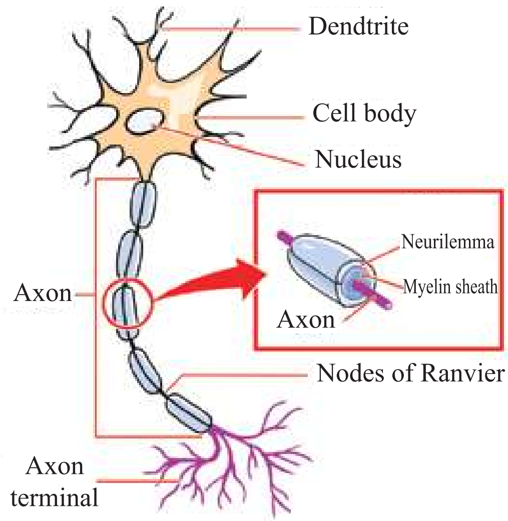


Figure : 10.04 A neuron

The myelin sheath is not continuous. Generally, it is interrupted at regular intervals. There is a direct connection of neurilemma and axon at the interrupted parts. This non-myelinated part is known as node of Ranvier. The membrane which covers the main axis of the axon is called the axolema.

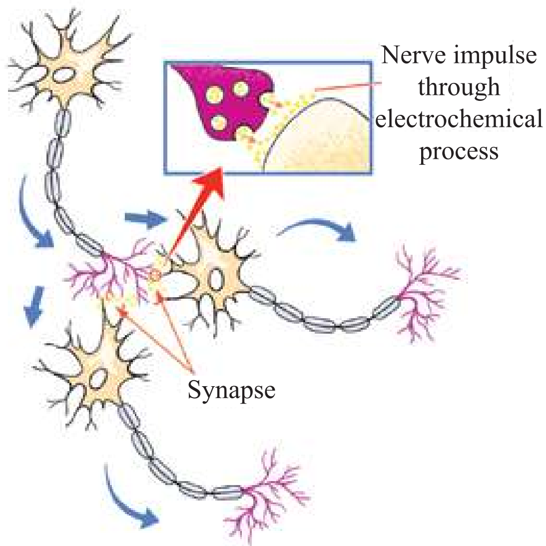


Figure : 10.05 Nerve impulse

The terminal end of one neuron does not join directly to the next (2nd) dendrite of the neuron cell. This junction of two neurons is called the synapse. Nerve impulses are transmitted through axon terminal synapses to neuron by an electrochemical process. A liquid is present in the synapse, called the neurohumor or neurotransmitter. Nerve impulses are transmitted from one neuron to another by crossing synapse. Through this, nerve impulses or stimuli travel in one direction only. In the human brain there are nearly hundred billions of neurons and each neuron is connected to seven to ten thousand neurons through synapses.

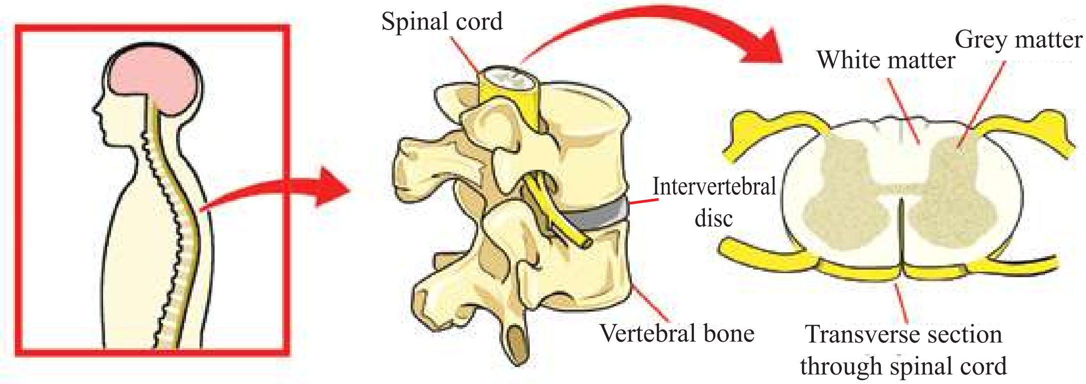


Figure 10.06 : Spinal cord

The main function of the nerve is to conduct nerve impulse. Sensory neurons receives stimulation through receptors and transmit it to the brain, then motor nerves send those impulses from the brain to effectors.

Individual Activity

Activity: Draw a labelled diagram of a neuron.

Shine a torch light in your friend's eye. Immediately his pupil contracts. Why does this happen? The impulse reaches the brain from the retina and brain instructs the circular muscle of the lens to contract. So, the pupil becomes small. The sudden stimuli causes an automatic reaction, so the eye closes instantly.

Reflex action : A reflex action is a sudden response or automatic reaction. If needle pricks the hand or we touch a hot object, we immediately move the hand from the source of stimulation. This is the result of a reflex action. We can not willfully control the reflex. These actions are controlled by the spinal cord, not by the brain. That is, the immediate response to a specific stimulus, controlled by spinal cord instead of brain, is called a reflex action. Example: A needle prick on the finger while sewing carelessly may cause a sudden jerking away of the hand. That is a reflex action. The events in such a reflex action are as follows :

At the time of pricking the dendrites of the sensory neuron of finger's skin accepts the stimulus. The skin acts as a receptor. This stimulus transmits from the finger to the grey matter of the spinal cord through the axon of the neuron. The relay neurons transmit impulses from the spinal cord to the dendrite of motor neuron. Here impulse is transmitted from the axon of the sensory neuron located at the grey matter of the spinal cord to the dendrite of the motor nerve by electro chemical process. So the impulse from the dendrites ultimately reaches the muscle and the muscle contracts (according to the command of the central nervous system). So the hand moves away from the source of the stimulation automatically.

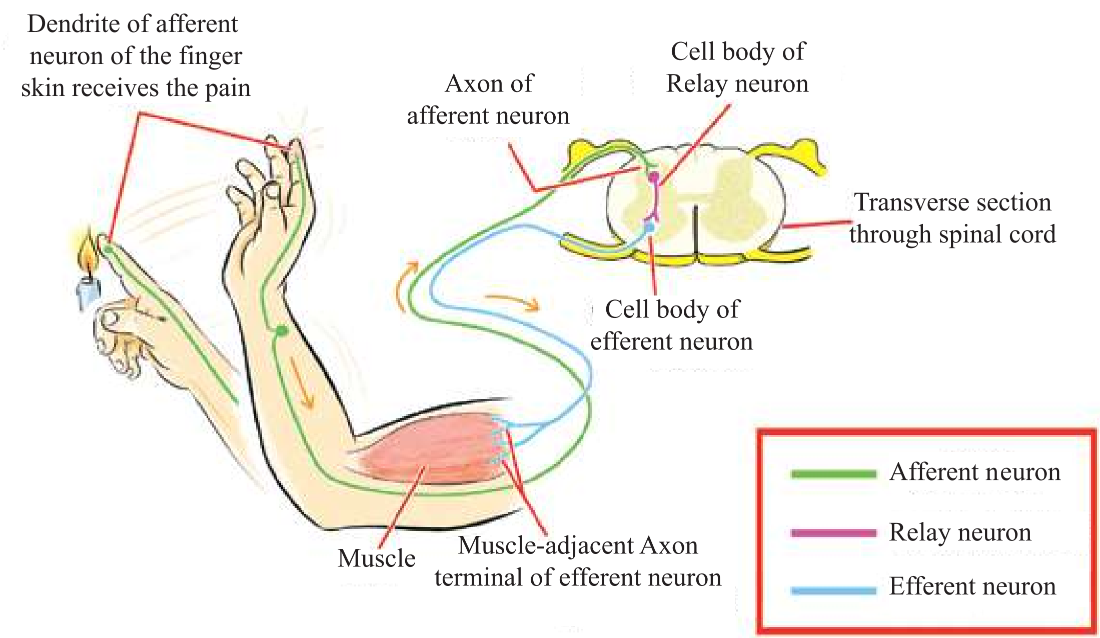


Figure 10.07 : Reflex arch in human

10.3.2 Peripheral Nervous System

12 pairs of nerves originate from the brain and 31 pairs of nerves originate from the spinal cord, divide into small branches and spread all over the body. These nerves together are called the peripheral nervous system. The cranial nerves originating from the brain control the functions of the organs, (eye, ear, nose, tongue, teeth, face, heart, stomach etc). The nerve originating from the spinal cord helps in the movement of organs and carries the rest of the impulses of body to the brain.

Autonomic nervous system: The organs, which are not controlled at will, are regulated and controlled by the autonomic nervous system. The functions of the internal organs of the body e.g- heart, intestine, stomach, pancreas etc. are therefore regulated by the autonomic nervous system. As there is no direct influence of this brain and spinal cord on the functions of this system is largely independent.

Transmission of Impulse: Numerous neuron fibers are connected to each other. Impulses transmit through them and finally reach the brain. The velocity of this movement is approximately 100 meter per second, though it varies depending on the nature and type of neuron. The message is taken by the nerves from the environment, and the nerves carry it like a wave and send it to the brain. These are called nerve impulses. As a result of the neuron's activity, impulses are transmitted to the different parts of a body. If a nerve impulse is transmitted to a muscle, then the muscle responds by contracting. So, we can move our different organs according to our need. If this impulse reaches a gland, it secretes chemical substances. If a sensory nerve is stimulated, it transmits towards the brain, and one can feel the sense of touch, sight, pain etc.

How a nerve impulse works can be explained with the example given below. Suppose, a teacher is giving dictation and you are writing. In this event the light reflected is from the book and stimulates the retina of your teacher’s eye and creates an impulse. This impulse reaches the sight centre of the brain. The centres of thought, memory etc. sends message or impulses to the voluntary muscles of the face. Muscle accepts the impulse and contracts. Here the teacher's muscles involved in speaking are the effectors or response organs.

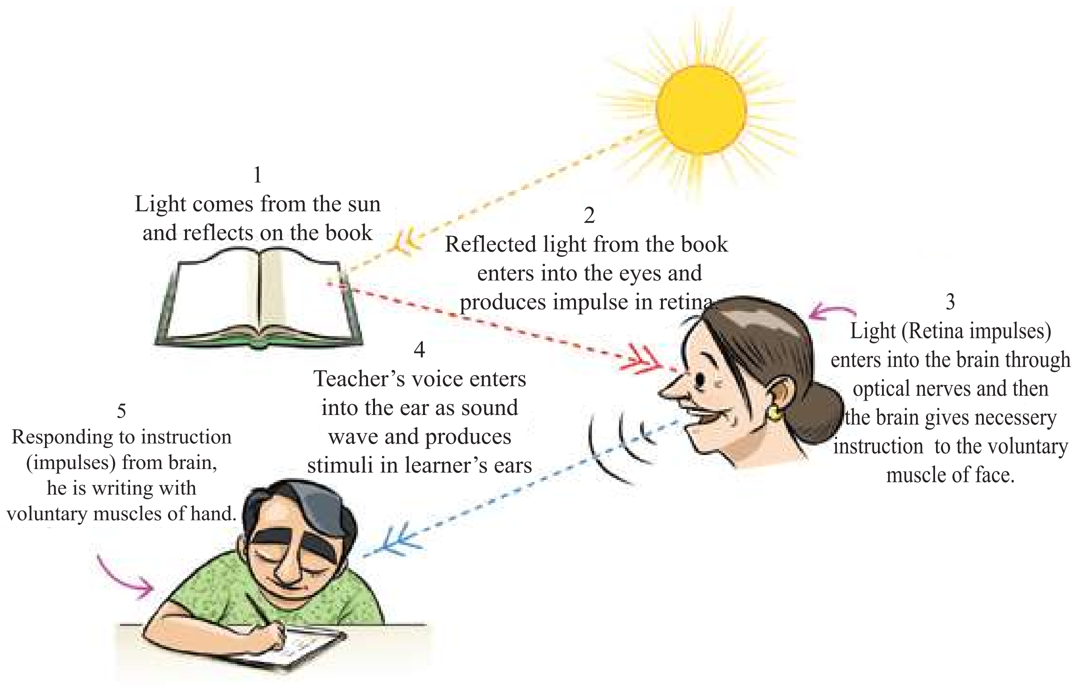


Figure 10.08 : Impulse transmission process

The teacher's speech creates a sound wave. This sound wave stimulates the ear drum of the student and reaches the auditory centre of the brain through the auditory nerve. From there, impulses transmit through the centre of memory, thinking etc. and reaches the voluntary muscles of the student's hand through motor nerves. Then the muscle responds and the student starts writing. Here the students muscles are the effectors or organ response.

10.4 Hormone

There is a special kind of gland in certain animals and in humans. The chemical substance secreted from these glands are carried by the blood and control various physiological processes. The secretions produced by the ductless glands or endocrine glands are known as hormones. These glands have no separate ducts to transport hormones. Hormones are carried by blood flow and reach specific cells, influence the biochemical function within the cells, and regulate the biological process. Hormones are secreted from the glands according the body's needs. But over and under secretion of hormones can cause various undesirable reactions.

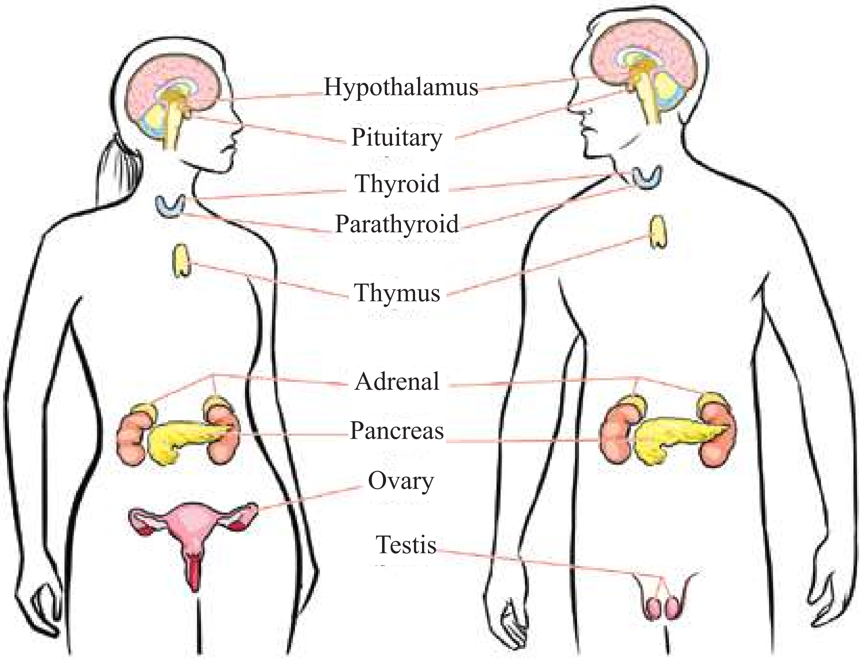


Figure 10.09 : Main endocrine gland in human body

10.4.1 Introduction of main endocrine gland, functions, and secreted hormones

(a) Pituitary gland: The pituitary gland or hypophysis is situated beneath the brain. It is the main hormone producing gland in the human body, because it secretes several hormones. Some of these have an influence on other endocrine glands. It is the smallest in size, but it is a very important endocrine gland. It secretes thyroid stimulating hormones (TSH), gonadotropin, thyrotropin, prolactine, somatotropin etc. Not only it effects the other glands it also secrets the growth hormone of human body.

(b) Thyroid gland : The thyroid gland is situated at the upper part of the trachea. It produces thyroxin hormone. Hormones secreted from the thyroid gland generally controls human growth and the rate of metabolism. It also secretes another hormone, calcitonin, which helps in calcium metabolism.

(c) Parathyroid gland : Humans have four parathyroid glands which are situated in the posterior part of the thyroid gland. These hormone regulates calcium and phosphorus metabolism by secreting parathormone hormone.

(d) Thymus gland : The thymus gland is located in the neck. The thymus gland helps in developing resistance power against diseases. In childhood it is developed, but with the growing of age the size decreases. This gland secretes thyroxin hormone. In adult age, this hormone is absent. In rare case, if sometimes found, it contains a very negligible amount of hormones.

(e) Adrenal gland : The adrenal glands are located just above the kidneys. Adrenal glands regulate essential metabolic processes. Basically this gland helps to relief the acute mental and physical stress. These glands secrete adrenalin hormone.

(f) Islets of langerhans : The islets of langerhans is situated in the pancreas. The group of cells in islets of langerhans regulate carbohydrate metabolism. Its ductless cells secrete insulin and glucagon which regulates the level of glucose in blood.

(g) Gonad or reproductive organ : These glands are situated in the ovary of a female and in the testis of a male. The hormones secreted from these glands control development of sex organs and secondary sexual characters. It also controls the development of the reproductive cycle and reproductive behavior. In mature males and females, reproductive organs produce testosterone and oestrogen respectively.

10.5 Abnormalities due to Hormone

(a) Thyroid problem: Sea water contains iodine. So, marine fishes are one of the main sources of iodine for human beings. Food, containing iodine, helps to produce the thyroid hormone. Places far away from the sea, such as - at the foot of the Himalayas, Nepal or in the north region of Bangladesh the number of goiter patient is high. A deficiency of thyroid hormones creates an obstruction in mental development. It causes rough skin, round face and distinct facial features. A good effect can be obtained by taking iodide salt, banana, sea fish, fruits, arum etc. A detailed discussion has been made on it in chapter five.

(b) Diabetes : Within the pancreas there are ductless glands called islets of langarhan's. These glands secrete the hormone insulin. Insulin regulates the metabolism of carbohydrates. If the pancreas fails to produce the required amount of insulin, then the level of glucose increases in the blood above the normal level. Then, glucose is released in the urine. This condition is called diabetes mellitus. Diabetes is of two types: Type - 1 and Type - 2. In Type - 1, the patient's body does not produce insulin at all. So, the patient has to take insulin injections regularly. Insulin is partially produced in Type- 2 patient's body. In this situation the patient has to take medicine orally to help pancreatic cells to produce adequate amount of insulin. Sometimes, in the case of Type- 2 diabetes, there may be the chance of permanent deficiency of insulin, or if medicine is prohibited due to other diseases, then there is no option but to take insulin injections. This disease is usually genetically transmitted or occurs under the influence of the environment. It is not an infectious or contagious disease. When the level of glucose increases in the blood above the normal level, then the symptoms are frequent passing of urine, excessive thirst, excessive hunger, gradual loss of weight in spite of excessive eating, feeling tiredness and weakness, disturbed vision, roughness of skin, and delayed healing of wounds.

Earlier it was assumed that only the elderly suffer from this disease. But this idea is not correct. People of any age can suffer from this disease. But people, who do not work physically or are obese or overweight have a greater chance of developing diabetes mellitus. This is a hereditary disease. If a close family member, like father, mother, granderfather, grandmother suffer from diabetes mellitus, then there is a greater chance of developing the disease. Because of genetics some children produce less insulin, resulting in insulin deficiency related disease.

Diagnosis and treatment of Diabetes mellitus: Diabetes can be detected by testing the urine and blood sugar levels. This disease can not be fully cured, but by treatment it can be kept under control. According to the views of doctors, the disease can be controlled by following three 'D' s. These are Discipline, Diet and Dose.

(i) Discipline: Disciplined life is the best medicine for a diabetic patient. Except this regular intake of adequate quantity of a balanced diet, according to the advice of physician regular exercise, cleanliness and foot care, regular checking of urinary glucose and consulting physician or doctor if any problem arises.

(ii) Diet: Dietary restriction is one of the main measures to control diabetes. A balanced diet should be taken regular and timely according to doctors advice and sweet items should be avoided. By following a doctor's suggested food menu, one can get good results. There is no connection of eating or avoiding sweets with those who do not have any diabetes mellitus.

(iii) Dose: Without doctor's advice no medicine should be taken. On doctor's advice, oral drugs or injectable insulin may be taken regularly. If the patient is not treated properly, his respiratory rate may decrease, while the sugar level of the blood increases. The patient may have a heart attack. If a diabetes patient faints in that case, the patient needs to be helped to sit and should be made to drink sugar or glucose mixed water to drink. This can help to avoid critical moments.

(c) Stroke : A stroke is, when the activity of the nervous system is hampered due to the lack of blood supply to the brain. A stroke happens in brain, not in heart, though there is a misconception about it. A stroke can happen either by brain hemorrhage or by blood clotting in the brain. In both cases it obstructs blood supply to the brain. A brain hemorrhage is the most dangerous. Generally, high blood pressure is the cause of a brain hemorrhage.

Symptoms : The symptoms occur suddenly. They are- vomiting, severe headache, a patient becomes unconscious within a few minutes, shoulder may be hard, muscle relaxes, respiration and pulse rate decreases, face turns red. Sometimes without any acute symptoms only face may be shapeless or patient may be fainted for a little time due to stroke. To measure the level of severity of a stroke, patients should be kept under observation.

In such an emergency the patient should be transferred immediately to a hospital and ensured proper treatment. By proper treatment the patient may survive. If the patient survives, they may become conscious after a few days. Then the patient becomes restless and gradually the paralysed organ's firmness gets back. If the speech controlled centre is harmed, then the patient may mumble. The muscles of attached paralysed organ (such as- hand) may gradually get back its power of movement but the patient may lose the power of doing minute work forever. At the primary stage the patient recovers quickly but after two months the improvement slows down. Nerves which are suddenly attacked temporarily lose their activity. These types of strokes show rapid recovery. The nerves, which are affected completely, lose their ability to work forever.

Diagnosis and treatment: It may be ensured by detecting if there is any blood clotting or brain hemorrhage. In many cases the exact cause of the stroke can not be ascertained. It is not possible to stop bleeding in the case of hemorrhage. Take measures to keep high blood pressure under control. Surgical operation can be done if it is necessary. Proper nursing, cleanliness, ensuring diet are very necessary. According to the necessity arrangements can be made to feed the patient by using a tube. According to the adviced of the physical medicine specialist and physiotherapist. It is also necessary to move the paralysed organs, to resist stiffness of the joints. On gaining sense the patient is to be encouraged to move on his or her own. When stroke symptoms are found, ensure proper treatment as early as possible to obtain desired results.

Prevention : Avoid smoking, keep high pressure under control, diabetic patient should take medicine regularly, keep free from anxiety and lead a normal life.

10.6 Physical disabilities due to nerve disoder

(a) Paralysis : Loss of sensation and motion (voluntary muscle) in a part of the body is termed paralysis. When there is damage in a part of the brain, the stimulation receiving muscles lose their activeness. Then the body is paralysed. Partially or fully paralysis may occur. As a result, any organ of one side or both side lose their activities, such as the paralysis of both the hands and legs.

Cause: Generally stroke is a cause of paralysis. Neck or spinal cord injury or accidents may also be the cause of paralysis. Nerve disease, damage of spinal cord may also be the cause of paralysis.

(b) Epilepsy: Epilepsy is a type of brain disease that starts with convulsions. In many cases the patient becomes unconscious. Epilepsy is also known as fainting disease. Because of this disease, the patient loses his ability to work temporarily and may fall on the ground with convulsive movement. Water and fire have no direct connection with epilepsy. If the patient falls in water, they may not be able to get up from water on their own and may die by drowning. Due to that reason this type of patient should be kept away from pond, fire and other dangerous substance or place.

The main cause of epilepsy is not yet known. Epilepsy disease become visible among those who has already suffer from stroke. Epilepsy may have some causes such as meningitis due to head injury, encephalitis, congenital brain disorder or brain tumor. Epilepsy may attack at any ages. In some cases of epilepsy there is no long term influence but in some cases there may be a chance of permanent damage of the brain. So diagnosis must be done by a specialist and treatment should be done accordingly.

(c) Parkinson disease : Parkinson disease is a condition of the brain that causes jerking of the hands and legs. The patient becomes unable to walk and move. Generally the disease starts after the age of 50 years. But in exceptional cases young people may suffer from this disease; in this case it is usually hereditary.

Nerve cells produce a substance called dopamine which helps in muscular movement. Due to Parkinson disease dopamine producing cells are gradually destroyed. Without dopamine, nerve cells become unable to send stimulation to the muscles. So, the muscle loses its effectiveness. With the growing of age, muscles of a patient with parkinson disease becomes more inactive. As a result it become tough on the part of the patient to move and write.

Parkinson disease gradually turns severe. At the preliminary stage of the disease it begins with tremor and patient has difficulty moving his leg or foot. Additionally tremor of eye lids, constipation, trouble in swallowing of food, problem in walking straight, stiffness in face, pain in muscles; feeling uneasiness at the time of standing, walking, etc. are the symptoms of this disease.

With the consultation of a doctor, taking physiotherapic treatment, balanced diet and leading a healthy life the patient may feel better.

Individual Activity

Activity: Investigate the cause of physical distress and difficulties created by hormonal problems and write a report on it.

10.7 Influence of tobacco and drugs on co-ordination.

In Bangladesh tobacco, ganja, charas, bhang, affim, morphin, cocaine, alcohol and heroin etc. are known as addictive substances. Except this, in many countries of the world some medicines are prepared artificially from cocaine or similar substances. These medicines create addiction. Example- Sedative pill.

There are many reasons for drug addiction in humans, such as : inquisitiveness regarding addictive drugs, influence of friends, trying out a new experience, looking for easy happiness, use of addictive substances in the family, easy availability of addictive substances, family dispute and discontentment, unemployment, economic insolvency, frustration, lack of awareness about the harmful effects of addictive substances. Recent research on drug addiction shows that, the main cause of drug addiction is deterioration of normal relationships with family and society.

Use of tobacco, chewing jarda or smoking increases nicotine levels in blood. At first nicotine stimulates nerve cells and afterwards it creates the demand of nicotine in the body. To meet this demand, people become addicted to smoking and using jarda. Nicotine destroys the effectiveness of nerve cells. Hands, legs and head trembles involuntarily. It causes problems, such as : difficulties in putting thread in the needle, drawing a straight line, writing etc.

Addiction has a bad effect on the nervous system. Due to addiction a person is compelled to take addictive substances. His thinking capability is gradually destroyed because of the addiction. An addicted person loses his attention to his work and fails to lead a normal life. Excess addiction makes him unconscious or senseless. Addicted person feels extreme physical discomfort if he fails to take drugs. Sometimes he might have an attack of convulsion. The drug addicted persons often become associated with crime to obtain the money to purchase drugs. There are treatment and rehabilitation centers for drug addicted persons. So, one can get rid of the bad habit by taking treatment from rehabilitation centers. This needs co-operation and sympathy of family members towards the addicted person.

Harmful effects of addiction: Taking addictive substances may cause harmful effects, such as, physical, social, economic, etc.

Measures to get out of this situation

- Keep family and social environment friendly and healthy.
- Increase moral education.
- Arrange employment for the unemployed.
- Stop easy availability of addictive substances.
- Stay away from bad company and raise awareness about the harmful effects of drugs.
- Initiate social mobilization and strongly enforce laws regarding addiction.

We should not hate or neglect the addicted persons. They are to be handled sympathically and arrangements should be made to rehabilate them. Take the assistance of rehabilitation centers if it is necessary. In Bangladesh the Directorate of Narcotic Control was established and started functioning in 1990. Day by day its field of work is widening. In this program law making, its implementation, control, treatment and rehabilitation are noteworthey.

Individual Activity

Activity: Draw a poster or leaflet regarding the bad effect of tobacco and addictive substances and present it to the students in the classroom.

Exercise

Short answer questions

1. What is a phytohormone?
2. What is gravitational feeling?
3. What is the nervous system?
4. What constitutes the central nervous system?
5. Write down the causes of paralysis?

Essay type questions

1. Discuss the role of hormones in the growth of plants.
2. Write down the symptoms of thyroid problem?

Multiple choice questions

1. What hormone is secreted by the thymus gland?

   a) Thyroxine b) Parathyroxine
   c) Thymoxine d) Thyrotrapine

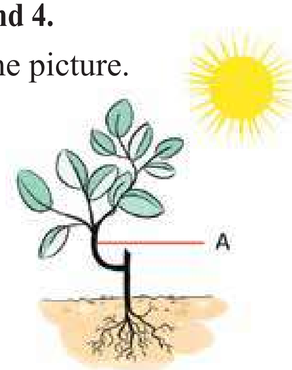
2. Islet of langarhans –

   i) helps in carbohydrate metabolism.
   ii) secretes insulin hormone.
   iii) controls metabolism of the body.

Which one is correct?

   a) i b) i & ii
   c) ii & iii d) i, ii & iii

On the basis of the following diagram answer the questions 3 and 4.



3. Which one of the following is applied to 'A' shown in the picture.

   a. Phototropism b. Geotropism
   c. Hydrotropism e. Chemotropism

4. Which one of the following is applicable in the development of part A shown in the picture.

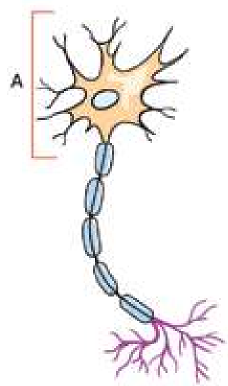
   a. Auxin b. Gibberellin
   c. Cytokinin d. Abscisic acid

Creative questions

1. During visit with her father to an agricultural farm Ohona observes different types of plants. She notices some small seedlings kept in electrical light in a cold room. She also observes that flowering is not occurring in some fruit, trees, and some fruits being immature, are falling off the trees.

a. What is biological clock?
b. What does it mean by vernalization?
c. What are the causes of the problems found in the fruit trees mentioned in the stem above?
d. Analyse the causes of keeping the seedling in the environment notices seen by Ohona.

2.



a) What is reflex action?
b) What is hormone?
c) Explain the role of part 'A' of stem to create stimulation in human body.
d) The structure and nature of the cell given in the picture is different from a normal cell- Analyse it.

Chapter Eleven

Reproduction in Organism

Reproduction is a basic characteristic of living organisms. Organisms give rise to other organisms of the same kind to continue generations. The process of the reproduction of different organism can be different. Plant and human reproduction is to be discussed in this chapter.

At the end of this chapter, we will be able to-

- explain the concept and significance of reproduction in organisms;
- describe the functions of a flower as a reproductive organ;
- explain sexual reproduction in plants with the life cycle of flowering plants;
- explain the asexual and sexual reproduction of animals;
- explain the nature of reproduction;
- make differences between external and internal reproduction;
- describe the steps of human reproduction with the help of block picture;
- explain the role of hormones in reproduction;
- explain the development of embryos;
- explain the mode of transmission, prevention and remedy of AIDS in the human body;
- explain the preventive measures of AIDS on the resistance of body;
- draw the poster and leaflet describing the prevention of AIDS;
- show sympathy towards AIDS patient.

11.1 Concept of reproduction in organism and its significance

Death is inevitable. If only death occurred, organisms would become extinct. But this does not because, on one hand, organisms are dying, on the other hand, organisms are reproducing. Reproduction is a physiological activity through which organisms continue their existence by producing offspring. The process by which the organism reproduces their offspring is called reproduction. Reproduction is of two types: asexual and sexual. In most lower organisms, sexual reproduction does not occur but some of the lower organism reproduces by sexual reproduction. Most higher plants and all higher animals produce offspring through sexual reproduction.

In sexual reproduction, two opposite reproductive cells are fused. In this case, one is called the male reproductive cell or sperm, and the other is called the female reproductive cell or ovum. In higher plants, there are two types of reproductive cells produced in the same body. These are monoecious plants. When two types of reproductive cells are produced in separate bodies, these plants are called dioecious plants.

The precondition of developing any reproductive cell is that the germinal mother cell will have to divide through meiosis. As a result, the number of chromosomes in a reproductive cell becomes half of the mother cell. The zygote develops by fusing one male gamete with one female gamete and thus the number of chromosomes becomes the same as the mother cell. Later, the zygote divideds repeatedly through mitosis to develop the new body of the newly born organism. In this way, an organism gives birth to many organisms. An organism this way also maintains the flow of its future generations.

If reproduction did not occur in organisms, they would be extinct. From a bacterium up to human beings, all organisms maintain the existence of their species by reproducing. How an organism accomplishes its reproduction depends on the characteristics of the organism. This is why a lower organism does reproduction through cell division, while an organism of a higher level accomplishes reproduction through the complex process of sexual reproduction. Though sexual reproduction is a complicated, laborious and time consuming process in comparison to asexual reproduction, it has still taken a place in evolution. Due to meiotic cell division it would is easy to get gene variation from one generation to the next. We have seen in the third chapter and will see in chapter twelve and thirteen that this variation is very helpful for the existence of any species in unfavorable environmental conditions. On the other hand through asexual reproduction the daughter cells produced are exactly the same as the mother cell, so very little variety is seen. Comparatively, in simpler living organisms such as Bacteria, Protozoa etc. reproduction is possible in large number using very little time and little energy, so asexual reproduction still exists.

11.2 Plant Reproduction

11.2.1 Reproductive organ: Flower

A flower is a special type of modified shoot for reproduction. A flower is the reproductive organ of a higher plant. We know that two (androecium and gynoecium) of the five whorls of a flower are very significant for reproduction. They directly take part in the reproduction. Though other parts or whorls of a flower do not directly take part in reproduction, they help the process. The flowers, which have five whorls, are called complete flowers, such as- China rose, datura. If a flower lacks any of the five whorls, it is called an incomplete flower, such as- bottle gourd, pumpkin. The flowers, which have pedicel, are called sessile flower, such as- China rose, pumpkin and those which have no pedicel, are called non-sessile flower, such as- Indian heliotrope. When both the androecium and the gynoecium are present in a flower, it is called a bisexual flower, such as- China rose, datura. If the androecium or gynoecium is absent, this flower is called unisexual flower, such as- bottle gourd, pumpkin. If both the androecium and gynoecium are absent in a flower, it is called a neuter flower.

Different parts of a flower

(a) Thalamus: This is usually round and is developed at the tip of a floral axis.

The other parts or whorls of a flower are arrayed consecutively on the floral axis one after the other.

(b) Calyx: The outermost whorl of a flower is called the calyx.Each of the part of calyx is called a sepal. If the sepal of the calyx are not separated, it is called gamosepalous/aposepalous. If the sepals are separated, it is called polysepalous.

The green calyx takes part in the production of food. Their main function is to save the inner parts of a flower from the sun, rain and attack of insects and pests. When the calyx is of different colours, it plays important roles in pollination, and it attracts different animals such as insects, birds etc. as the medium of accomplishing pollution.

(c) Corolla: It is the outermost but one whorl of a flower. If the corolla is segmented, each segment is then called a petal. If the petals in a corolla are separate from each other, the term polypetalous is used then. In case of having sepals wholly or partially fused, they are called gamopetalous. Corolla are usually colourful. They protect the internal parts of a flower from the sun and rain. Bright colourful corolla attract animals – birds, insects etc., and helps pollination. Sometimes insects draw nectar from the corolla of a flower. The purpose of pollination is served when the carriers complete these activities.

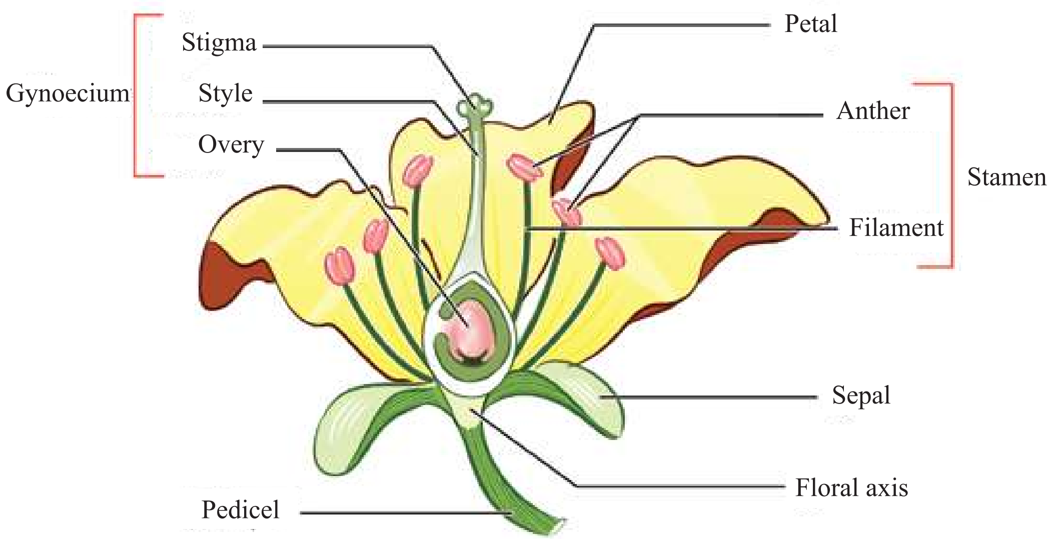


Figure: 11.01 Different parts of a flower

(d) Androecium: It is the third whorl from outside of a flower, and it is an essential whorl. Every part of an androecium is called a stamen. In an androecium, there may be one or more stamens. Each stamen has two parts. The stalk like structure of stamen is called the filament and the sac like apical structure of it is called the anther. The part of a stamen, which connects the anther to the filament, is called connective. Pollens are developed in an anther. A pollen tube is produced from a pollen after germination. The male gamete is produced in the pollen tube. The male gametes directly take part in reproduction. In some plants, the filaments may be connected to each other, and sometimes the anthers may combine with each other. When the stamens are merged together with all the filaments into a tube like group, it is called a monadelphous, such as in Chinese hibiscus. If the filaments are attached with two groups, it is called a diadelphous such as pea and when in many groups, it is called a polydelphous, such as cotton tree *(Salmalia malabarica)*. When anthers are united into a single group, it is called syngenesious. The state of being of the stamen free of attachment to corolla, the androecium, is called epipetalous, such as in Datura.

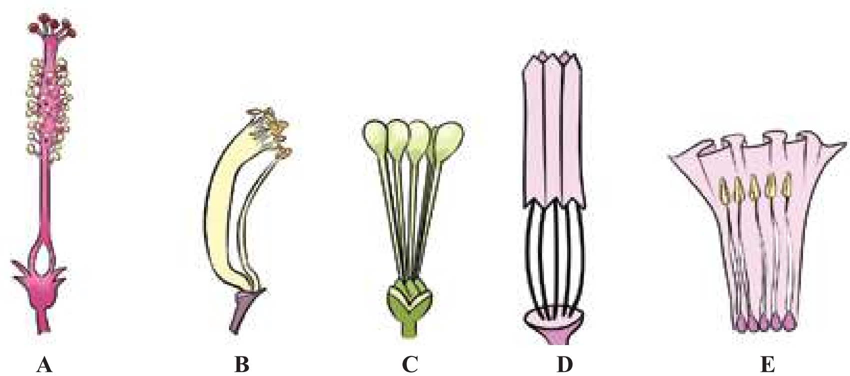


Fig: 11.02 Different types of stamen: a. Monodelphous b. Diadelphous, c. Polydelphous d. Syngenesious e. Epipetalous

(e) Gynoecium: The gynoecium is at the centre of a flower. It is another essential whorl of a flower. A gynoecium may be structured with one or more carpels. A carpel has three parts, the ovary, style and stigma. When a gynoecium is formed with many more carpels which are completely merged with each other, then it is called, syncarpous and when they are separated, it is called polycarpous.

One or more ovules are in a flower, arranged inside of the ovary. Within the ovule, the female reproductive cell (ovum) is produced. This ovum, like an androecium, is directly involved in the process of reproduction.

Individual Activity

Activity : Observation of different whorls of a flower.

Elements: a flower, blade, forceps, and blotting paper.

Procedure: Collect a flower and seperate the different parts of a flower, placing them on a blotting paper.

Individual Activity

Activity : Observation of the transverse section of ovary.

Elements: A mature flower, blade and simple microscope.

Procedure: Separate the ovary from a flower. Observe it under a simple microscope and write down what you have seen.

Inflorescence: All of you have seen inflorescence. Clusters of flowers arranged in a branch of a tree, is called inflorescence.

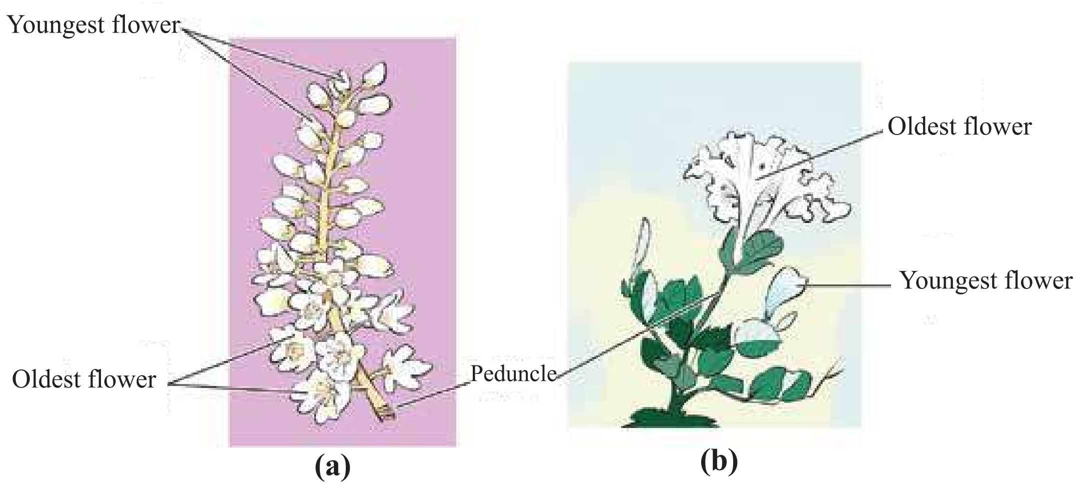


Figure: 11.03 (a) Indefinite inflorescence (Recemose) (b) Definite inflorescence (Cymose)

The axis on which flowers are orderly arranged is called peduncle. If the growth of this axis is unlimited, it is called indefinite inflorescence (recemose), and in case of limited growth of the axis it is called definite inflorescence (cymose). An inflorescence plays important roles in pollination. Two consecutive steps occur in reproduction- pollination and fertilization. Discussion regarding this are given below.

11.2.2 Pollination

Pollination is also called the linking of pollen. Pollination is a precondition for the development of fruits and seeds. The transfer of pollen from the anther to the stigma of the same flower or to the stigma of another plant of the same species is pollination. Pollination is of two types, self-pollination and cross- pollination.

(a) Self-pollination: On the same flower or on two flowers of the same plant, transfer of pollen can occur. This is called self-pollination. For example- brassica, cucumber and datura usually pollinate through this way.
Wastage of pollen is less, the process is not dependent on a carrier, and the occurrence of pollination is ensured. The plant that develops in this way cannot make changes to their characters, and so the features of the species can be maintained. This way, a species can maintain purity. No new characters appear in the new generation of plants. The newly born plants breed seeds with less vigour. The ability of adaptation in the new plant is reduced,which means this species can become extinct.

(b) Cross-pollination : When the attachment of pollen occurs in between two distinct flowers of the same species, it is called cross-pollination, such as, cotton tree *(Salmalia malabarica),* papayas *(Carica papaya)* pollinate this way.

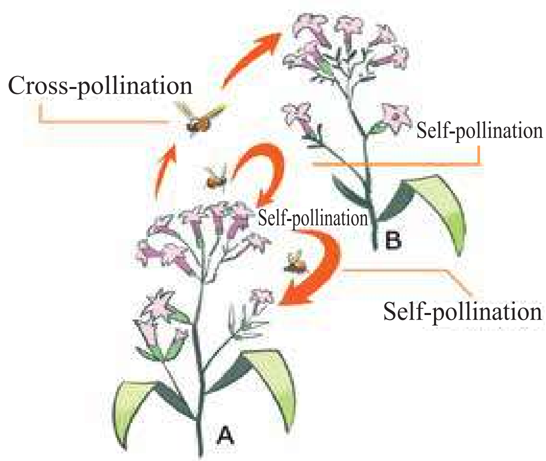


Figure: l 1.04 Self-pollination and Cross-pollination

New characters emerge through cross-pollination. The rate of germination goes up and much more vigorous seeds are produced through this way of pollination. As the pollination occurs in between two different plants, the seed produced this way is born with new characteristics. The plant, which grows from that seed, also has new characteristics. This is why new varieties of those plants emerge. As it is a carrier dependent process, pollination is not ensured and large waste of pollen is a consequence of this type of pollination. So, the purity of the species is impaired.

Medium of pollination

Figure: 11.05 Entemophillic flower

In most cases, a medium accomplishes the transfer of pollen. The carrier which carries pollen, is called the pollen carrier. Air, water, insects and flies, birds, vampires, snails and even humans may be the media of pollination. To consume nectar from a flower or after attraction to the charming colour of the flower, the carriers travel from one flower to another. When the carrier sits on the flower, the pollen attaches to it. To obtain the aid of the carrier, some plant adaptations are remarkable.

Insect pollinated flowers are big, with coloured nectar secreting glands. In these flowers, pollen and stigmas are sticky and have fragrance. For example, hibiscus, gourd, mustard etc. Air pollinated flowers are light weight and do not have nectar secreting glands. The flower has no fragrance, can easily wander in the air. Their stigmas are branched and sticky, and sometimes feathery. Branched stigmas will attain pollens from the air. For example, *Oryza sativa*.

Figure: 11 .06 zoophillic flower

Water pollinated plants are small and lightweight, so that they can float in the water. They have no fragrance. The petiole in the female flower is longer than that of the male. Mature male flowers, detached from the petioles, float in the water and after coming in contact with the female flowers, they accomplish pollination, for example, *Vallisnaria*.

Animal pollinated flowers are usually large in size. If they are small, they are arranged in the inflorescence. They have attractive colours. Fragrance may be present or absent in them. For example, Kadam, cotton tree (shimul) and taro.

Microsporogenesis

A pollen is the first cell of a gametophyte. Pollen mother cell (2n) produces four daughter pollen cells (n) by meiosis. Soon after becoming mature harbouring in the pollen sac pollen starts to germinate. The nucleus of the pollen gets divided through mitotic division and two cells, one large and another small, are formed. The large one is called the tube cell and the small one is called the generative cell. The tube cell turns into the pollen tube and two male gametes are produced. Division of the generative cell takes place in the pollen or pollen tube.

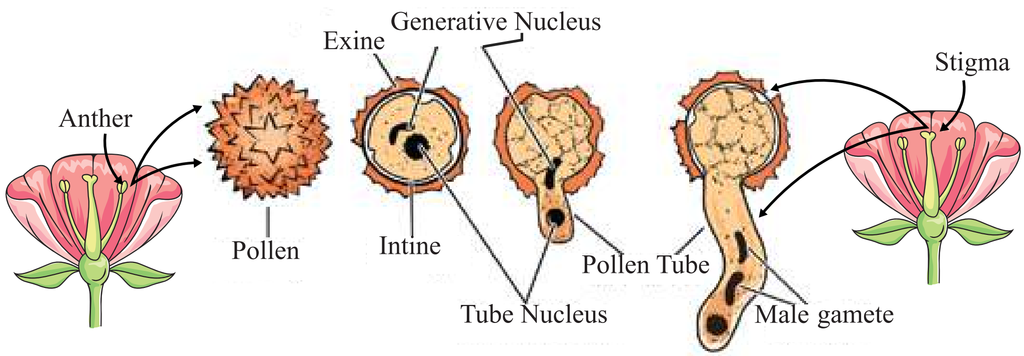


Figure: 11 .07 Different stages of the development of male gametophyte

Megasporogenesis

Near the micropyle of the nucellus tissue being nourished in the nucellus of an ovule, a cell starts to become larger. Its protoplasm is dense and the nucleus is comparatively large. The cell divides into four haploid cells through meiotic division. Every cell, except the lowest one, gets disintegrated. Growing gradually, this larger cell matures into an embryo sac. The nucleus of the cell is haploid. The nucleus divides and produces two nucleus. These two nuclei take positions in two opposing poles. Next, these two nuclei consecutively divide twice and result in four nuclei.

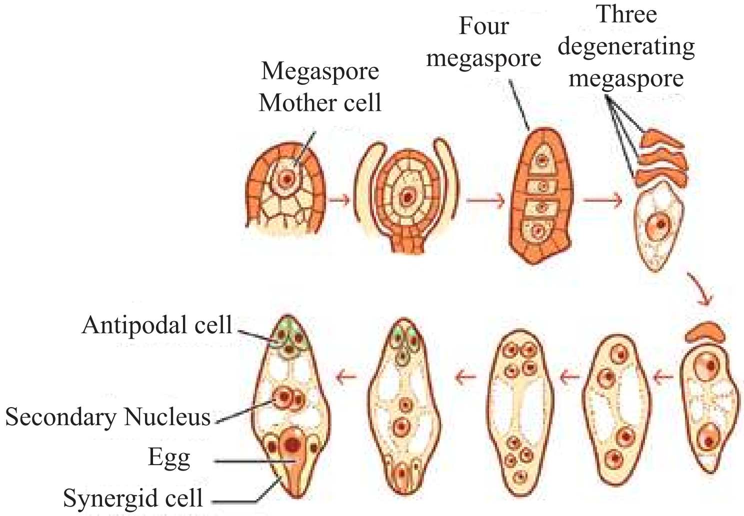


Figure: 11.08 Different stages of the development of female gametophyte

In the next stage, two nuclei from the two poles come to the middle of the cell and get fused to cause the emergence of two haploid secondary nuclei. The nuclei in the two poles turn into cells with some amount of cytoplasm. Collectively, the combined structure of the three cells near the micropyle is called the egg apparatus. In between the cells, the one occupying the middle place is the ovum, which is a little larger. This is called an egg cell and the other two are called synergid cells. The cells in the opposite pole to the egg apparatus are called antipodal cells. This is how the process of developing the embryo sac is done.

11.2.3 Fertilization

Through pollination, the mature pollen lands on stigma of a carpel. Then the pollen tube grows, penetrating the style and absorbs some liquid. Once the tips of the extended pollen tube enter the embryo, it ejects two male gametes into the embryo sac. One of them, meeting with the egg, causes the emergence of a zygote. The other male gamete, mixing with the secondary nuclei, develop triploid endosperm cells.

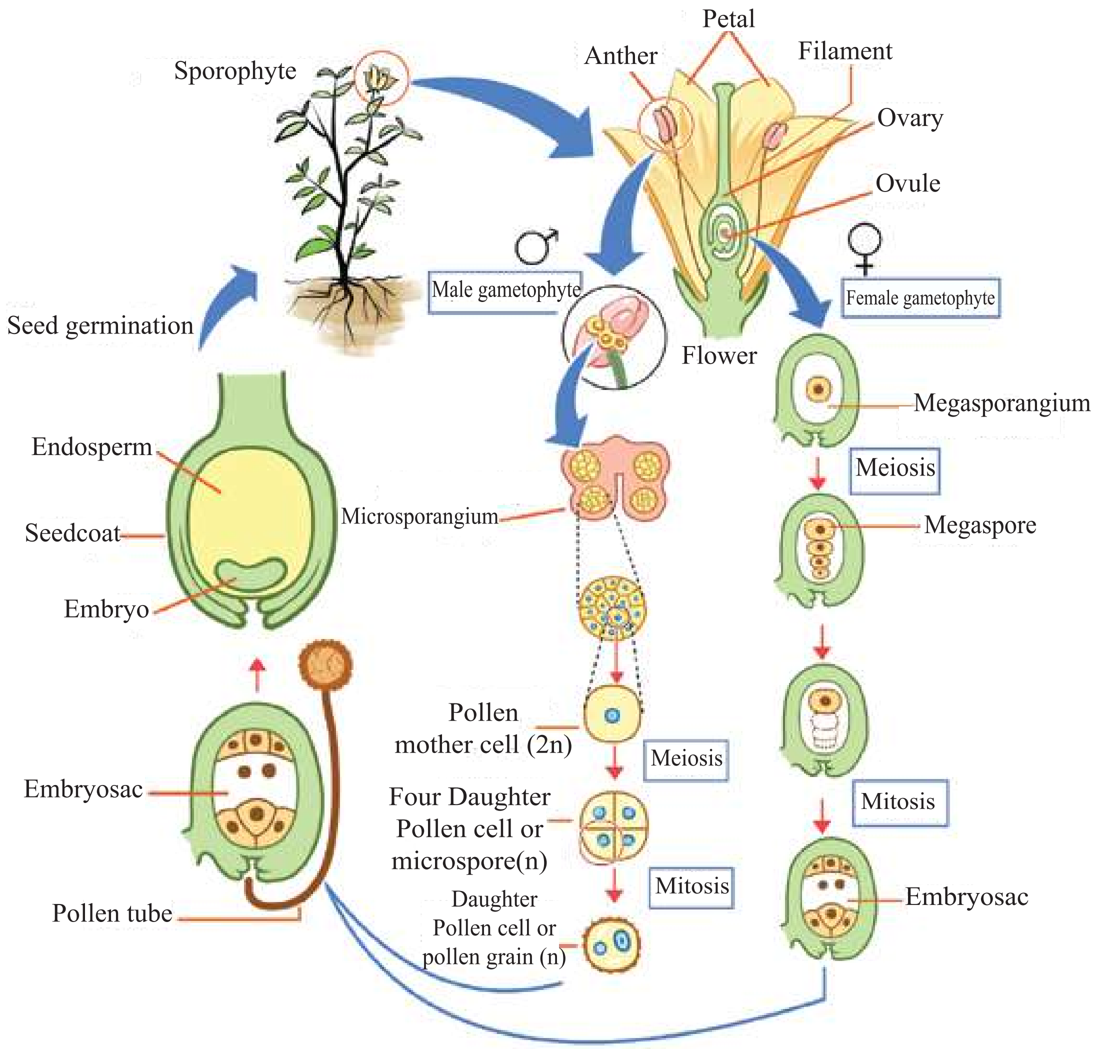


Figure: 11.09 Life cycle of flowering plant

The two fusions, mixing of a male gamete with an egg and mixing of another male gamete with secondary nuclei, take place at about the same time. This phenomenon is called double fertilization.

Development of new sporophyte

A zygote is the first cell of a sporophyte. Two cells are produced after its first division. At the same time, the flourishing of the endosperm is also initiated. A zygote divides transversely. The cell towards the micropyle is called the basal cell and the cell towards the centre of the embryo sac is called the apical cell. The division of these two cells continues simultaneously. Gradually, the apical cell turns into the embryo. The suspensor also gets developed concurrently. The cotyledon, radicle and plumule are developed one after another and the secondary nuclei start to make the endosperm. The cells in an endosperm are triploid, meaning they posses three sets of chromosomes (3n). At maturity, the ovule with the endosperm and embryo turns into a seed. As the seed germinates, a complete sporophyte is developed.

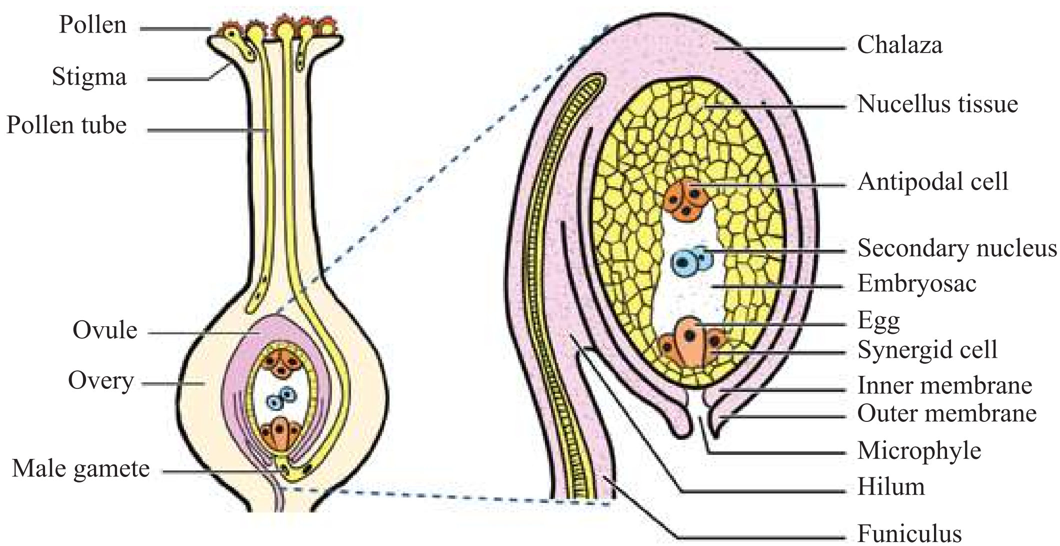


Figure: 11.10 Structure of ovule and fertilization

The sporophyte and gametophyte run in a repeating way one after another through the life cycle of a flowering plant.

Origin of fruits: When we think about fruits, the images of mango, jackfruit, lichi, banana, grape, apple, guava, sofeda etc. appear in our mind. Bottle Gourd, Gourd, Ridge Gourd, pointed gourd are also fruits, though, they are called vegetables. In fact, they are all fruits. The process of the formation of fruits begins immediately after the completion of fertilization. Fertilization initiates stimulation in the ovary to develop fruits steadily and ultimately, ovules are turned into seeds. The ovary after fertilization turns into the fruits. If only the ovary turns into a fruit, it is called a true fruit. Mango and berries are examples of true fruits. When along with the ovary, other parts of a flower get mature this type of fruit is called false fruit. Apples, Elephant Apple (Chalita) are the examples of false fruit. All the true and false fruits are grouped into three categories: fleshy fruit, aggregate fruit and compound fruit.

11.3 Animal Reproduction

Reproduction is of two types in animal kingdom. (1) Asexual reproduction and (2) Sexual reproduction.

Asexual reproduction : Asexual reproduction happens in lower animals. Asexual reproduction occurs in different ways, such as - budding, binary fission, fragmentation etc.

Sexual reproduction : The process through which two animals of opposite sex (male and female) complete their reproduction by means of producing male and female gametes, fertilizes and produce offspring is called sexual reproduction.

11.3.1 Fertilization

Fertilization is necessary for sexual reproduction. It is a universal biological process. In sexual reproduction the fusion of sperm and ovum is called fertilization. During sexual reproduction active sperm penetrates into the ovum, and the two nuclei fuse together. The cell formed by the fusion of the nuclei is the zygote. It requires some time for fertilization. Each of the sperm and ovum contains a haploid number of chromosome, and each of them carries one set of chromosome. Due to fertilization zygote is produced, which is a diploid new cell (it carries two sets of chromosomes). The maturity of sperm and ovum is a precondition of fertilization.

Fertilization is a special process. It happens only with the matured sperm and ovum of the same species. Generally fertilization is unchangeable. Once an ovum is fertilized, it will not fertilize again. On the basis of the place of occurrence, fertilization is divided into two types. (1) External reproduction and (2) Internal reproduction.

(a) External fertilization : If the fertilization takes place outside the body of male and female animals, it is known as external reproduction. This type of fertilization occurs in most aquatic animals, such as, different types of fishes. But there are exceptions, such as: sharks and some other species of fishes.

(b) Internal fertilization : The fertilization which takes place inside the reproductive organ of the female is called internal reproduction. This fertilization occurs introducing sperms of the male into the female reproductive organ. It is one of the characteristic of most of the terrestrial animals.

The basic significance of fertilization : Restoration of the number of diploid chromosomes within the embryo accumulates hereditary characters of both the male and female, and makes the ovum active for its development. Chromosomes carry the characteristics of both the father and mother. These characteristics combine, determining the sex of the embryo. The picture shows the steps of the gamete formation.

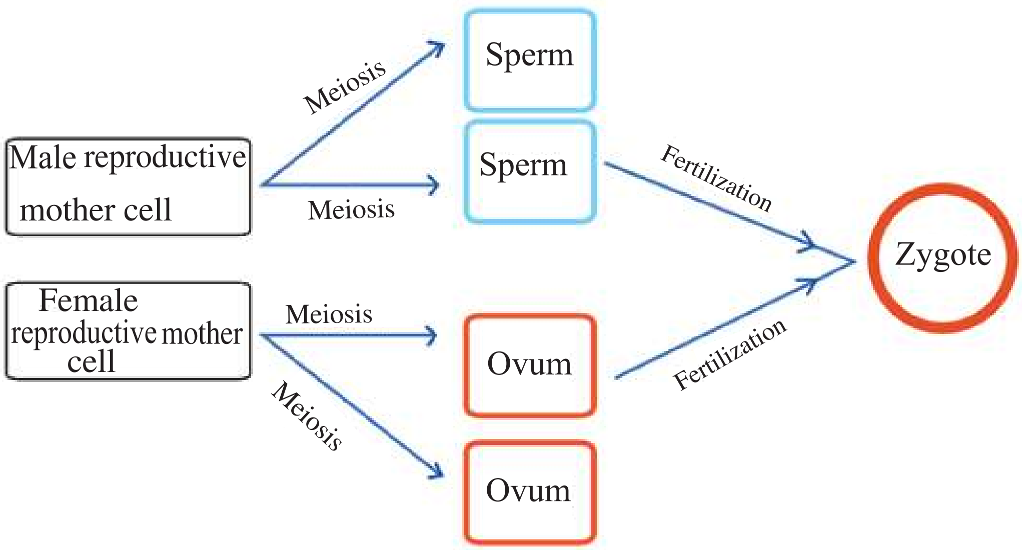


Figure 11.11 Different stages of reproduction (block Picture)

For continuity and restoration of hereditary, reproduction is essential. This process includes formation of the embryo and giving birth to offspring. Humans are unisexual, so male and female reproductive organs are present in different individuals.

11.3.2 Role of hormone in human reproduction

You have learned that a hormone is a type of organic substance, secreted from ductless glands. It acts as a chemical messenger and is transported all over the body through the blood, to help in chemical reactions and control different metabolic and physiological processes.

Specific but very small amount of hormone secrets and regulates various physiological activities. If the secretion of hormone is much more or less than the specific amount then it hampers the various activities of the body. As a result, different type of abnormality of the body arises. Reproductive hormones secreted from endocrine glands within the body are described below. (1) Pituitary gland (2) Thyroid gland (3) Adrenal gland (4) Testis (5) Ovary (6) Placenta.

The growth stimulating hormone and the producer hormone are produced by the pituitary gland. These hormones regulate growth of reproductive glands secretions and functions, and controls mammary gland and milk secretion. These hormones also regulate the contraction of uterus. The thyroid glands secrete thyroxine hormone. This regulates metabolic function, and ensures physical and mental development, and sexual characteristics. Hormones secreted from the adrenal gland regulate development of the reproductive organs, and exposition of sexual characteristics. Testosterone hormone secreted from the testis and androgen help to produce sperms and secondary sexual characteristics, such as: deepening of the voice and growth of a beard. The ovary secretes estrogen, progesterone, and relaxin hormones. These hormones cause the development of sexual characteristics, such as: menstruation, enlargement of the well of uterus for implantation of the embryo and placenta. It also has a particular role in the formation of the ovum. Gonadotropic and progesterone of placenta stimulates ductless glands of the ovary and helps in enlargement of mammary glands.

When the baby is born their reproductive system remains immature. Children pass childhood to become adolescents. The transitional period of adolescence and youth is named puberty. At that time secondary sexual characteristics develop. Organs of the reproductive system grow and develops. Hormones play an important role in this respect. Both inner and outer changes occur, such as: growth of beard on the face, deepening of the voice, widening of shoulder etc. are the external changes in males.

During puberty the changes within the girls are - softness in skin, loveliness in appearance etc. In this stage of puberty usually monthly discharge of blood or menses from the uterus begins at regular intervals. This is the menstrual cycle or menstruation. After 1-2 years of puberty girls gain the ability to reproduction. Then they begin to produce ovum from the female reproductive mother cell within the ovary. This continues up to 40-50 years. After that, cessation of the menstrual cycle occurred permanently. Then it is called menopause. The menstrual cycle remains temporarily stopped during pregnancy. Six weeks after child birth it starts again.

Marriage is a social, spiritual and family tie. A family is formed by the efforts of a husband and wife's adjustment through marriage. They become intimate with each other. A relation of love, affection and attachment develops between them. There should be a specific minimum age for getting married. Before 20 years, a female should not marry. Early marriage causes a girl to become pregnant in immature age. There is every possibility of harm for both mother and the baby.

Sexual reproduction occurs through physical relationship between husband and wife. During physical contact, the sperm of male enters the female reproductive organ. A sperm has a tail which helps it to swim into the female reproductive system. The fusion of sperm and egg nucleus occurs within the oviduct. This fusion is called fertilization. An egg (ovum) is fertilized with a single sperm only. In this way, internal fertilization occurs within the human body. Each of the sperm and ovum contains one set of chromosomes (haploid). By the fusion of these haploid sperm and ovum, a diploid zygote is formed.

11.3.3 Development of the embryo

The fertilized egg gradually passes along the oviduct to the uterus. Immediately after fertilization, cell division begins in the zygote. This is called cleavage. At the last stage of cleavage, the growing embryo arrives in the uterus. At this stage, this mass of cells of the growing embryo is called a blastocyst. The changes that happens in the uterus are very important for the development of the embryo.

For the development of next stage of blastocyst the embryo has to be embedded in the inner wall of the uterus. So the blastocyst becomes embedded with the uterine wall. This process is called implantation. Imbedded in the uterus, the embryo grows and turns into a human body. Time between implantation and child birth is called pregnancy. At that time menstruation or menstrual cycle does not occur. The embryo or fetus develops in the uterus for 38-40 weeks.

Placenta : The special organ through which the fetus in the uterus is connected to the tissue of the mother is called the placenta. Implantation is completed within 4-5 days after the embryo reaches the uterus. Some cells of the developing embryo along with the endoderm of the uterus compose an oval shaped and blood vessel enriched placenta. The placenta is formed within twelve weeks of zygote formation. In this way a temporary unseparated organ is formed between the fetus and endoderm of mother's uterus. At the time of child birth the placenta is eliminated from the body.

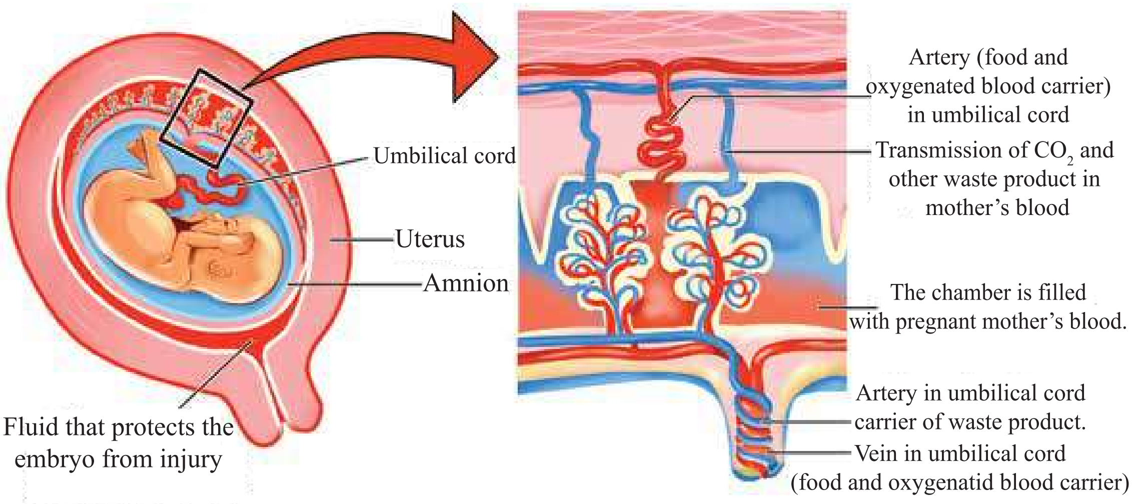


Figure 11.12 Placenta and Embryo in mother's uterus

The embryo is implanted into the uterine wall with the help of the placenta. The embryo needs food for its growth. Carbohydrate, (glucose), protein (amino acid), essential minerals, water etc. are transferred from maternal to fetal blood to nourish the developing embryo. The placenta acts more or less like a lung. The dissolved oxygen in the blood of the maternal blood diffuses into the fetal blood and exchanges carbon dioxide from the fetus to the mother. The placenta also acts as kidney; metabolic waste product is diffused from the embryonic blood capillaries into the mother's blood stream. In this way the waste products are eliminated. The placenta produces some important hormones which protect the embryo and helps in normal development.

Placenta contains a huge amount of blood capillaries. The embryo is attached to the placenta by a tube called the umbilical cord. It is a tube through which the

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exchange of different materials occur between mother and fetus. At the time of pregnancy, it secretes some hormones which helps to produce milk and facilitate child birth.

Foetal membrane : The embryos of each species have a series of embryonic membranes which are essential for easy, normal and safe development of the embryo. These help in fetus nutrition, gaseous exchange and elimination of waste products. The embryonic membrane protects the fetus (embryo) and controls other important action.

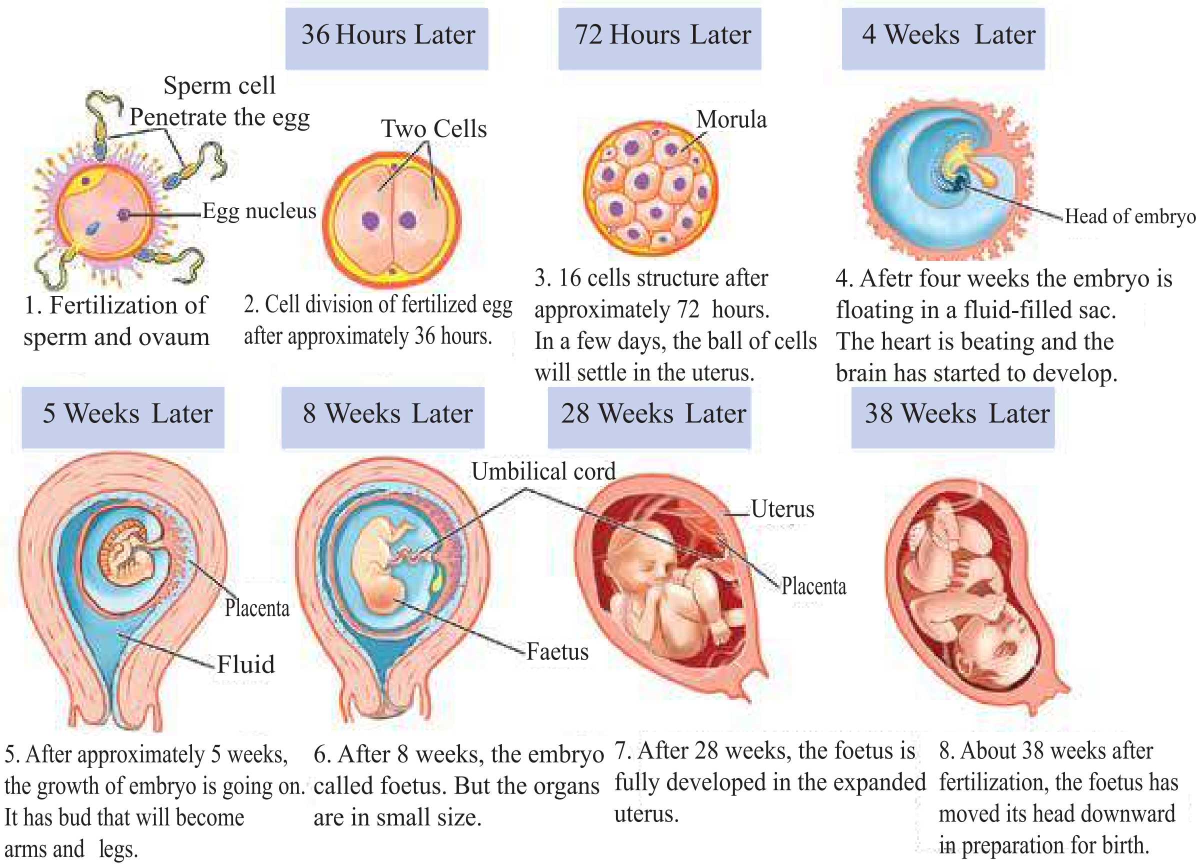


Fig. 11.13 : Embryonic Growth and development

In humans, pregnancy lasts for an average of 40 weeks. During this time the mother's anterior pituitary and placenta begins to secrete two hormones. These hormones actively promote uterine contractions at regular intervals that results in pain. This increasing pain is called labour pain. At the last stage of child birth the embroyonic membrane bursts and fluid enclosed by the membrane comes out, and the child is born.

11.4 Reproduction Related diseases

11.4.1 Acquired Immune Deficiency Syndrome (AIDS): At present AIDS is well known as a killer disease of the world. This disease was discovered in 1981. Taking the first letters from 'Acquired Immune Deficiency Syndrome' the disease AIDS has been named.

According to the statistics of UNAIDS published in 2023 worldwide more than 39.9 million people are infected by AIDS. Almost 53% of the infected persons are female. According to World Health Organization this disease is spreading in about 164 countries. AIDS disease is caused in human body by the attack of a virus named HIV (Human Immune Deficiency virus). This virus destroys white blood cells, causing obstacles in antibody formation, that results in the gradual shortage of white blood cells and antibodies. In human body this virus can remain dormant for a long time. It destroys the victims immune system. There is no effective medicine discovered to regain the immune system completely, so the ultimate fate is death.

Causes of AIDS : A healthy person can be infected by this life threatening disease in the following ways:

(i). Unprotected sexual relation or physical relation with infected males and females.

(ii). Transfusion of blood because of blood loss due to accident, excessive bleeding at the time of child birth, anemia, thalassemia, cancer etc. Transfusion of blood from a HIV infected person to a healthy person may transmit the disease.

(iii). AIDS does not spread directly from the AIDS affected father. Through sexual relations mother may be affected by AIDS and the child of the affected mother may be affected. A baby may be infected from an HIV-infected mother during breast feeding.

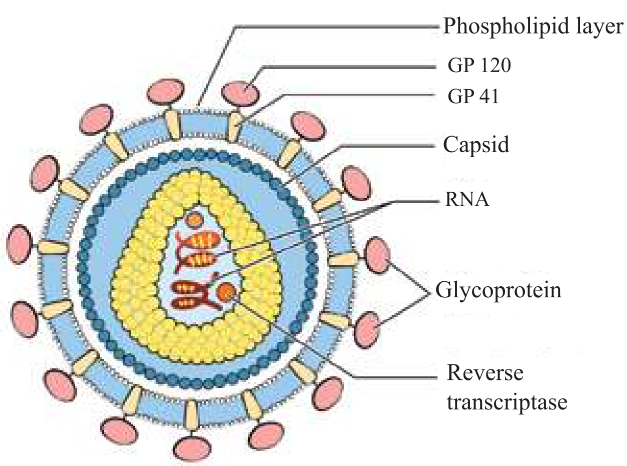


Fig. 11.14 Structure of HIV

(iv). The disease may transmit to a healthy person, through sharing of infected needles, syringe, dental and surgical operation related instruments etc. Even by using the same blade in the saloon the disease may transmit.

(v). Transplacement of HIV infected organ or tissue in the body of healthy person.

Symptoms of AIDS : Signs and symptoms of the disease are exposed 6 months after the germs of the disease enters the body of healthy person. Then symptoms are very negligible and after some days it disappears. After the entrance of HIV in human body, it may remain harmless for a few months to years and it just increases in number in the host body. When the number of HIV virus becomes enormous, then suddenly the patient is in a serious condition and there is nothing else to do for the patient. Before this, it is not easy to tell that infected person is the carrier of this disease.

The symptoms are–

- rapid loss of body weight.
- fever for more than one month for unknown reasons.
- dry cough for prolonged period.
- pain in armpit, neck and face become rough.
- puffiness and swelling of some organs, such as : face, eyelid, nose etc.
- itching in the whole body.

Prevention of AIDS : You have learned earlier about this disease. Let us see if we can remember it.

- What is the necessity to prevent AIDS?
- Is it possible to avoid the causes that spread the infection of the disease?

  Write the measures of prevention on the black board and summarize.

Individual Activity

Activity: Form a group of 5 students and draw a poster/ leaflet regarding the preventive measures of AIDS.

Exercise

Short answer questions

1. Why are humans called unisexual animals?
2. What is the uterus? What is its necessity?
3. What is the placenta? What are the functions of the placenta?
4. What measures should be taken to prevent AIDS?
5. Explain the functions of hormones in reproduction.

Essay type questions

1. Why is a flower called the reproductive organ? Describe it.
2. Describe the causes, symptoms and remedies of AIDS.

Multiple choice questions

1. In which flower, are the stamens diadelphous?

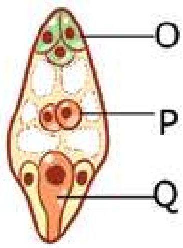
   a. Chinese hibiscus b. Pea
   c. Cotton tree or shimul d. Sunflower

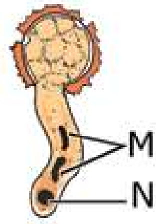
2. The air pollinated flower is-
   i. large in size.
   ii. with undivided stigma.
   iii. without nectar glands.

Which one is correct?

a. i & ii b. i & iii
c. ii & iii d. i, ii & iii

Look at the stem and answer the questions 3 and 4:





3. Which part of the stem turns into a seed?

   a. N　　b. O

   c. P　　d. Q

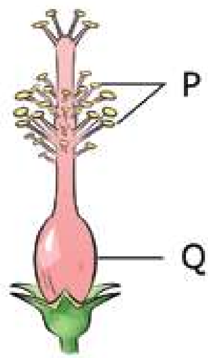
4. Which one does play a role in producing endosperm?

   a. M & Q　　b. M & P

   c. M & N　　d. N & P

Creative questions

1.



a. What is an embryo sac?

b. What does it mean by indefinite inflorescence?

c. Explain the problems there will be in pollination if the part P is absent.

d. Express your opinion how part Q protects its species.

2. 12 years old Ridoy sings with a melodious voice. Recently with some physical and mental changes, his voice becomes deep. So, his mother consulted with a doctor, who said, this change is normal for children.

a) What is the placenta?

b) Why is AIDS called a fatal disease?

c) Explain the causes of the events happened in Ridoy's body.

d) Explain the role of the elders towards Ridoy at that time.

Chapter Twelve

Heredity in Organisms and Biological Evolution

A picture showing comparison among the skulls of human, orangoutang and macaque monkey.

Structural and behavioural traits from both the parents, mother and father, are passed to the offspring generation after generation. We will learn in this chapter how traits from both the parents are transmitted to the offspring. We will also learn about the existing classes in the living world, which emerge from their ancestors through evolution, and express their visible form of present existence.

At the end of this chapter, we will be able to-

- explain the concept of heredity;
- describe the components containing the behavioural materials obtained through generations;
- explain the transmission of behavioural characteristics from generation to generation;
- explain the replication of DNA;
- explain the role of DNA in transferring heredity materials;
- explain the necessity of DNA tests;
- explain the role of a male in determining the gender of an offspring;
- explain the causes and results of genetic disorders;
- explain the conception of the biological evolution;
- describe the natural selection theory of biological evolution;
- explain the significance of biological evolution in the survival of species;
- determine the differences between the similar and dissimilar features of the mother and father;
- conceive the roles of DNA test in our life.

12.1 Heredity in organism

All the organisms in the world are characterized with their own unique features. Features of individual organisms pass to the next generations and evolve in them. This natural principle is applied to all organisms in the world. This is why rice plant grows from rice seed, mangoes from their seeds, jute does also this the same way. This way the characteristics of species are maintained in offspring through generations. Heredity is the passing of traits from father and mother to their offspring through generations. In depth discussions and research concerning heredity are done in the special branch of biology called genetics.

Individual Activity

Activity: Identify the similar and dissimilar traits from your parents and place them in a chart with a nice presentation.

12.1.1 Components carrying (heredity materials) behavioural features to the offspring from generation to generation

The features of parents are transferred to their offspring through heredity materials. These are chromosomes, genes, DNA and RNA. These are discussed below:

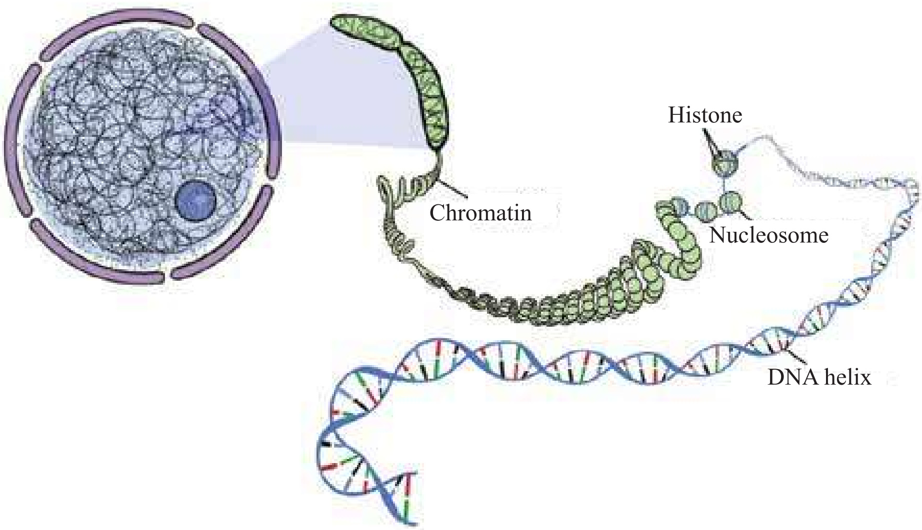


Figure: 12.01 Location of Chromosome in Nucleus

(a) Chromosome: The main heredity material is the chromosome. It is spread in the nucleoplasm of a nucleus as a thread like structure named the chromatin. The scientist Strasburger first discovered the chromosome in 1875. Across species, the number of diploid set of chromosomes (two sets chromosome, one set from the father and the other set from the mother) may be 2 to 1600. In length a chromosome may be from 3.5- 30.00 microns (l micron =l/l00 mm) and in width 0.2 to 2.0 microns. The function of chromosomes is to carry genes (which control the characteristics of organisms) to the offspring from the parents. Colours of human eyes, nature of hair, compositions of skin etc. continue intact through the flow of heredity carried by chromosomes. This is why chromosomes are designated as the physical basis of heredity.

(b) DNA : The main component of a chromosome is deoxyribonucleic acid (DNA). It is usually a double stranded spiral structure of polynucleotides. One strand is complementary to the other. In it there are five carbon sugars, nitrogen bases (adenine, guanine, cytosine, thymine) and inorganic phosphate.

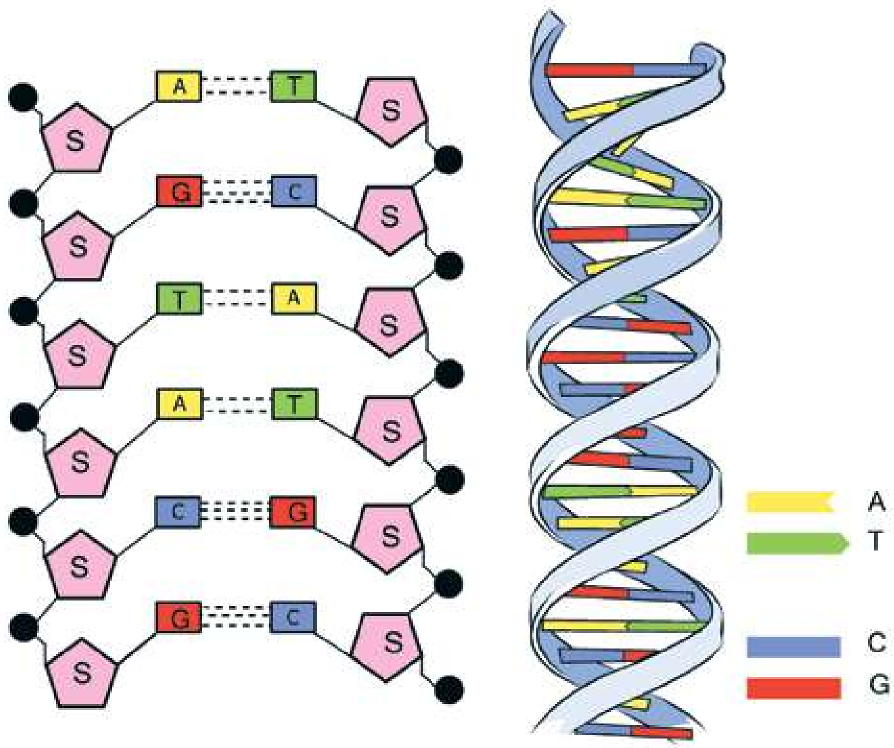


Figure : 12.02 DNA

These three components collectively are called a nucleotide. DNA is a stable substance in a chromosome. In 1953 American scientist Watson and British scientist Crick first described the double helical structure of DNA and for this contribution both of them won the Nobel Prize. Nitrogen bases are of two types, a purine and a pyrimidine. Adenine (A), guanine (G) are purines and cytosine (C) and thymine (T) are pyrimidines. The Adenine of one strand bonds with the thymine of another strand by two hydrogen bonds, and guanine of a helix connects with a cytosine of another helix by three hydrogen bonds. This bond is always developed between a purine and pyrimidine. So, a strand of DNA is complementary to another strand but not identical to it. A complete twist in a helix is $34A^0$ long and in a complete twist, there are ten nucleotides. So,the length between the two adjacent nucleotides is $3.4A^0$ (from top to bottom). The two strands of polynucleotides in DNA are positioned antiparallelly. It looks like rungs in a twisted ladder. The bases are connected flatly and horizontally in position from the main axis. The external two strands or two axes of DNA are composed of consecutive arrangements of sugar and phosphate, and internal nitrogen bases are plainly aligned. In fact, DNA is a precise thread, but in a prokaryotic cell DNA is usually circular and the surface area would be a few microns to centimeters. It is composed of thousands of nucleotides and the diameter of the twisted helical structure everywhere is $20A^0$. DNA is the main component and chemical carrier of heredity. DNA is the true structure and carrier of the behavioural characters of organisms, and it directly carries the characteristics of parents to their offspring from generation to generation.

Group Activity

Activity : To develop a DNA model.

Required equipment: Iron wire - 1 meter, 2 used ball point pen,40 beads of 1.5 cm diameter, 7-8 drinking straw, Coloured paper (Red, blue, yellow and green), Glue, Scissors, One (empty) shoe box.

Procedure

1. To build this model, 40 beads of 1.5 cm diameter are needed. If beads are not available they can be made from dough. Dough can be prepared by mixing of 1 cup of flour, ½ cup of salt and little amount of water. Small balls with holes can be made from dough and used as beads. These beads will represent phosphate.

2. Each straw is to be cut into three equal pieces. Each piece will be nearly 8-9 cm long. 20-25 pieces are necessary which will represent nucleotides.

3. In each piece of straw, make holes in parallel, at both terminal end of the straw.

4. Cut coloured papers in ribbon like shape with 2 cm width.

5. Now from these ribbons cut down 3 cm long green paper and wrap it up around 2 cm part of the straw starting from center to one end. In the same way, wrap up the other side of the straw with yellow ribbon. In this way 10-12 pieces of straw are to be wrapped up with yellow and green ribbons. The green part will represent A (adenine) while the yellow portion will represent T (Thymine) of nucleotide. Thus each piece of straw will represent one base pair.

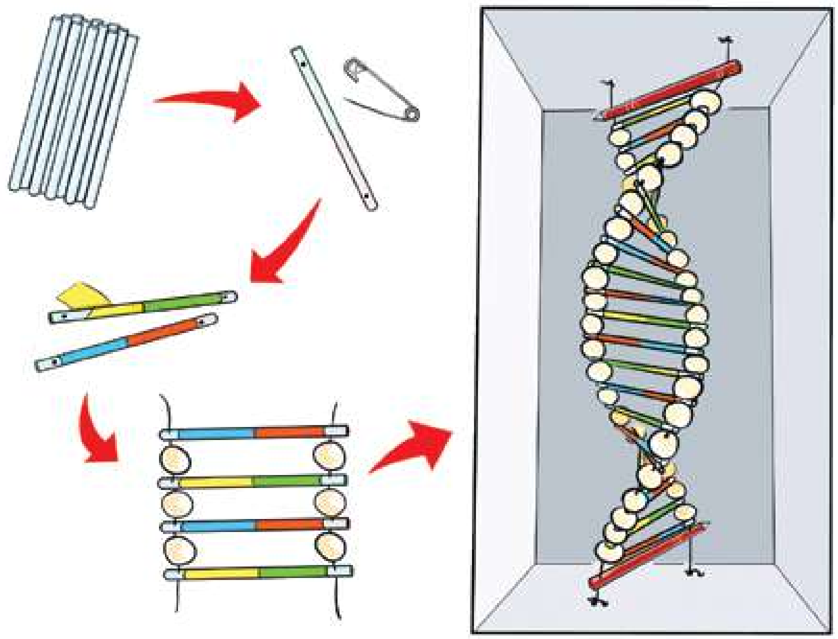


Figure : 12.03 Different stages of the preparation of DNA Model

6. In the same way the remaining pieces of straw will be wrapped up by blue and red ribbons of paper. Here the blue will represent C (Cytosine) and the red portion will represent G(guanine) The pieces of straw with red and blue represent one base pair CG.
It should be remembered that yellow would be paired with green and blue with red.

7. 1 meter long iron wire is to be cut into two pieces and tied at two ends of the ball point pen, keeping a gap of 7-8 cm space.

8. Now insert the wires through the holes made at both ends of each piece of straw.

9. Now pull up the straw to the pen and then insert both ends of the wire through two beads.

10. Thus insert one piece of straw and then two beads at both end alternatively. Try to make a nice combination of base pairs while continuing the process.

11. After finishing the arrangement of straw and beads through the wire, tie the remaining ends of the wire with another ball point pen. Cut off any extra wire, if there is any.

12. In real DNA the rotation of strands occur after every 10 base pairs. As there are 20 base pairs, it will give two rotations. So twist the two pens to make two full rotations along with the base pairs. This will show the model of DNA structure (double helix).

13. Now imagine the yellow colour band as A and the green as T, in the same way blue as C and red as G. Beads represent phosphate and the part of straw between two beads is carbohydrate.

14. To keep the model safe, keep it in the empty shoe box by twisting the ball pens and tying it with the side of the shoe box.

Remarks

The DNA model built in this way has 20-22 base pairs. Ovserve it from different angles. Focus a torch on it and observe the shadow it makes. This is important because Rosalind Franklin (1920 – 1958) took pictures from different angles by focusing X Ray. By analyzing the X-Ray photo, James

Wilson (1928 – till now) and Fancies Greek (1916 – 2004) discovered the DNA structure and won the Nobel prize for it in 1962.

Limitation

This model looks like real DNA but here the structural ratio between the different molecules and chemical groups is not accurate.

(c) RNA

RNA stands for ribonucleic acid. Most RNA has contained single polypeptide strand. It is composed of 5 carbon ribose sugar, inorganic phosphate and nitrogen bases (adenine, guanine, cytosine and uracil). In the genome of RNA virus, RNA is found as a permanent component or the inherited component. In some viruses (i.e. tobacco mosaic virus) DNA is absent. The viruses which are not composed of DNA possess RNA as their nucleic acid. In this situation, the RNA serves itself as the hereditary material.

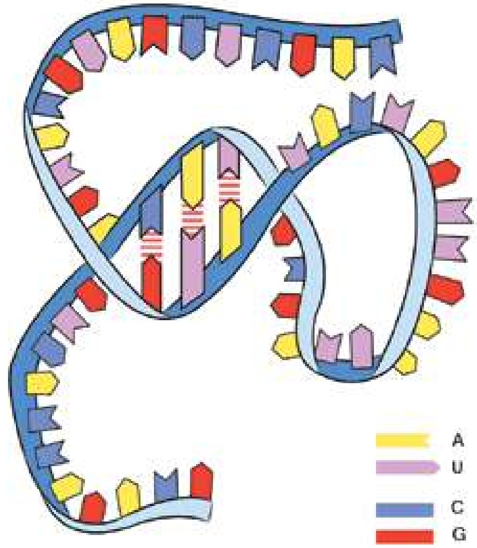


Figure : 12.04 RNA

(d) Gene

The unit of controlling all the visible and invisible signs and characters of organisms is called the gene. Genes are positioned throughout the chromosomes of organisms. The location of a gene throughout a chromosome is called the locus. For a specific characteristic, a gene is responsible. In some cases, a characteristic is expressed through cooperative action of several genes. In other cases, one gene controls more than one characteristic. From different research, it is clear that a gene is the perfect master of heredity. By taking necessary signals from DNA, RNA enters into the ribosome of the cytoplasm and according to that signal, protein is synthesised. In the case of a eukaryotic cell this protein (synthesised) is first deposited in the endoplasmic reticulum and then it passes through the glogi body and vesicle. Meanwhile the protein undergoes many changes and is carried to necessary places. In the prokaryotic cell protein directly reaches the destination. This protein determines the nature and speed of biochemical reactions and from that, the characteristics of living organisms are determined with respect to the environment. These characteristics include everything from structure to the behavior of any living organism. It can be expressed as: DNA → RNA → Protein → Characteristics.

The number of genes in different organisms is not the same. In organisms of the same nature, the number of genes is more or less same. Genes are arranged in common principle along side from one end to another end. Chromosomes are separately spread from each other in a linear form.

Different replicas (edition) of the same genes can express the same characteristic in different levels. For example in a pea, for tallness, the height determination gene is 'T' and for shortness the height determination gene is 't'. When Tt is combined, it expresses its tallness. So 'T' with respect to 't' is called the dominant gene and 't' with respect to 'T' is called the recessive gene. When in an organism two genes are recessive, only then does the recessive gene express the recessive characteristic. e.g., only pea plant with 'tt' is short in height. Different version of the same gene are called alleles of that gene. Here, T and t indicate two alleles of the gene that determine the height of peas.

To see how the characteristics or traits of parents are expressed in the next generation (offspring) scientist Gregor Johan Mendel did some experiments with pea plants in 1866 and discovered a valuable theory of genetics. The factor takes the presently glamorous form known as the gene. Gregor Johan Mendel is called the Father of genetics.

Mandel took a tall and a short pea plant and transferred pollen grain of a tall plant into the stigma of a short plant. In the same way, he transferred the pollen grain of a short plant into the stigma of a tall plant. This resulted in reproduction. He made sure that the other pollen grain would not appear. The reproduced seeds were sowed and it was found that all the plants were tall in size and no plants were short. Out of these plants, one was taken into reproduction through self-pollination and the seeds were sowed. It was found that there were both tall and short plants. Among them, ¾ were tall and ¼ was short.

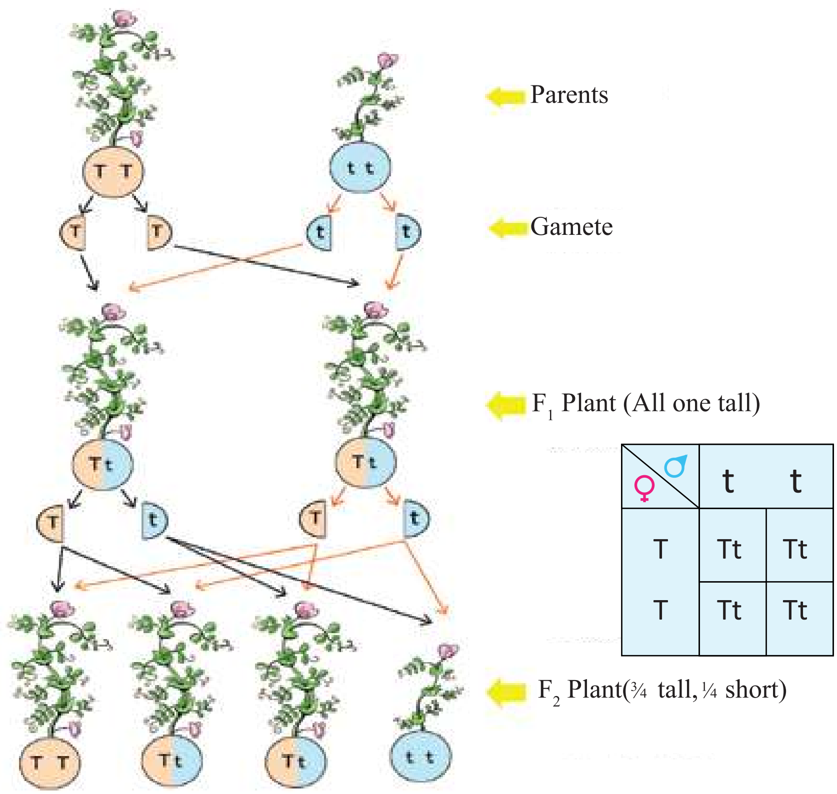


Figure : 12.05 Experiment of Mendal's law

This theory of Mandel is applied in breeding of plants and animals. The controlled sexual reproduction is done in plants and animals to bring about desired characteristics. As a result, a generation with various characteristics are produced. From this generation, desired characteristics are selected for breeding to get plants and animals that have desired characteristics. At present, this theory is applied largely for the production of improved variety of crops.

DNA replication

Through the process, a new DNA molecule is synthesized from an existing molecule of DNA. DNA replicates in a half-conservative way. Through this process, the double stranded DNA becomes single stranded by breaking hydrogen bonds.

Then the floating nucleotide in a cell creates new complimentary strands by combining "A" (adenine) with 'T'(Thymine) 'T' with A 'C' with 'G' and 'G' with 'C'. Thus one of the old strands remains and combines with a new strand to make a complete DNA. At the end, a new strand, combining with another old strand, forms the structure of a molecule of DNA. As the new DNA emerges, it has a new and an old strand. This principle is known as the semiconservative method. In 1956 Watson and Crick first successfully proposed the replication process of DNA.

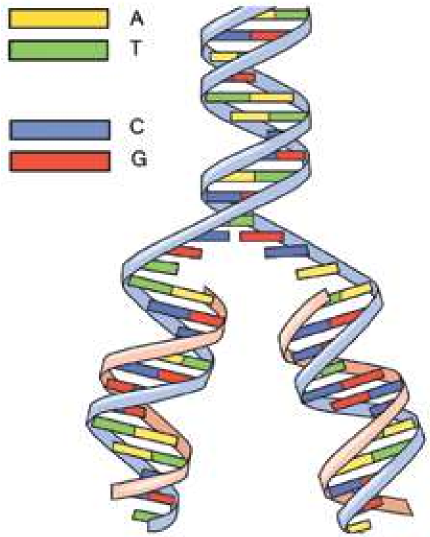


Figure: 12.06 DNA Replication

Individual Activity

Activity: The teacher will ask the students to demonstrate a diagram of a DNA after drawing it in a big piece of paper with a pencil.

12.1.2 DNA Test

Throughout the present century, DNA technology and the significance of it in the field of medical science, agriculture, fish and animal resources and in the industry of medicine have introduced a new chapter on creation. In Bangladesh, along with evidence, witness, eyewitness dependent judiciary system, DNA has opened a new window of ensuring true justice.

A scientific and practical method of DNA test is called DNA fingerprinting. The name DNA typing or DNA testing is also used. To perform the DNA test, the first requirement is an organic specimen. Bone, teeth, hair, blood, saliva, semen of a person can serve as valuable organic specimens. The profile from the place of occurrence of crime or the profile from the specimen of the victim of a crime is compared with the profile obtained from the blood or organic specimen of a suspect.

In this method DNA is isolated from the sample by a chemical process and then DNA are cut into pieces by one or more restricted enzymes. Then, through a special method (electrophoresis by egarose or polyacrylamide gel) the pieces of

DNA are sorted according to the length of different bands. Then, radioactive isotope DNA prob is hybridized, keeping it on a special nitro cellulose paper and then putting it on an x-ray film to determine different visible bands by autoradiograph method. After that, the sample is compared with DNA band (DNA map) of the victim or suspected person. This method is termed as finger print method. Currently by using polymerase chain reaction (PCR) method DNA test is done with even a small sample for identification without any error.

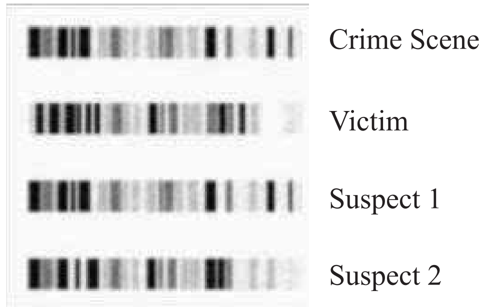


Figure 12.07: Here the band pattern obtained from the DNA sample collected from the crime scene exactly matched that of the suspect 1, therefore he/she must have been present at the spot.

12.2 Determination of human sex

In human and other mammals sex is determined in the same way. In the cells of the human body, the number of chromosomes is 46, i.e. 23 pairs. Among them 22 pairs (total number 44) are autosomes and the remaining pair is the sex chromosome. Autosomes play roles in physiological, and embryonic development and the formation of the body of organisms which have no part in determining sex. The two sex chromosomes are marked with X and Y. They play a significant role in determining sex. In females, in the diploid cells both sex chromosomes are X i.e. XX. In males the two chromosomes one is X and the other is Y. Both the chromosomes are long in structure, and rod shaped but Y chromosome is shorter than the X chromosome. At the time of the development of the egg, meiosis occurs, and every egg possesses an X chromosome along with other chromosomes. But in case of a male at the time of the formation of sperms, half

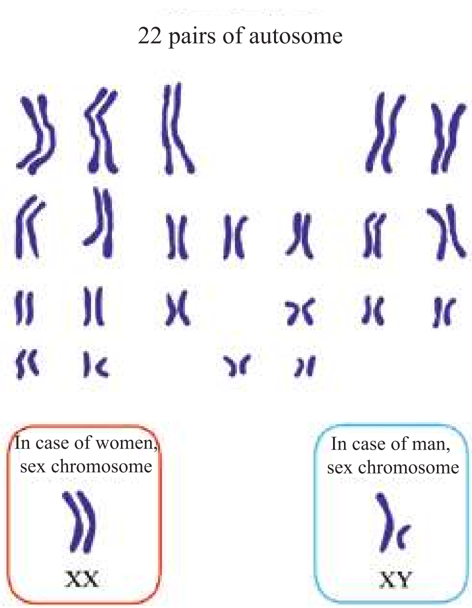


Figure 12.08: 22 pairs of autosome and one pair of sex chromosome

the number of sperms contain an X chromosome and other half number of sperms contain a Y chromosome. An egg can be fertilized with either type X or Y. Only one sperm (X or Y) of father's successfully fertilized with the mother's X bearing egg during gestation. So the sex of the future child depends on which sperm fertilized with egg. So, a zygote can have both the chromosomes as type X, or can have one X and the other Y. The baby, which is born having both the chromosomes as X i.e. XX, will be a baby girl and the baby, who is born with one chromosome of type X and the other one of Y, will be a baby boy. In determining sex, a mother plays no role because the mother always produces eggs containing only an X chromosome. On the other hand, the father produces sperms having both the type X and Y.

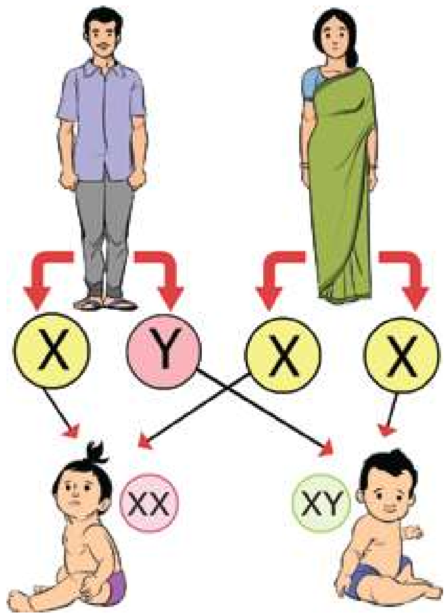


Figure 12.09 : Sex determination process of human child by sex chromosome

Individual Activity

Activity: Determine whether a son or a daughter will be born following the following chart.

Mother and Father	X	Y
X		
X		

Individual Activity

Activity: Sex determination of bird, cricket (insect) and crocodile are different from that of human. Investigate the sex determination process of these animals and prepare a report on it.

12.3 Genetic disorder

In some genetic diseases, a mutation occurs in gene of sex chromosomes. These types of diseases are called sex-linked disorder. As the size of Y chromosome is comparatively short and there are less genes on it. In most cases sex-linked disorders occur due to the mutation of the X chromosome. In female, there are two X chromosomes. Even if one X chromosome is affected by mutation, symptoms of genetic disorders are never expressed as the other X chromosome remains normal. Two X chromosomes in a female are unlikely to have the same type of mutation. So a female is not usually affected by sex-linked disorder, but merely acts as a carrier (the person who is not affected by sex-linked disorder but carries the mutant gene of the sex-linked disorder is called a carrier).

In genes of male, there is only one X chromosome. So they do not act as carrier, rather they show the symptom of sex-linked disorders directly if only the X chromosome is affected.

(a) Colour blind or colour blindness

Colour blindness is a condition when someone cannot properly identify colours. To identify colours, we have pigments in our optical nerve cells. If colour blind, the patient is deficient of colour identifying pigments in their optical nerve. If someone lacks a single pigment then he would not be able to differentiate red and green. This is the universal problem of colour blindness. If lacking more than one pigment besides red and green, the patient cannot differentiate the colours blue and yellow. One man out of ten is colour blind. In comparison, a very few number of women suffer from this problem.

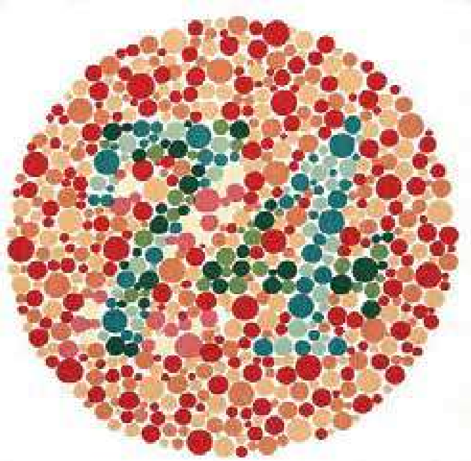


Figure 12.10 : A picture taken from Ishihara chart used to indentify red-green colour blindnes. It is designed in such a way that a colour blind man will see the number 21 whereas a healthy man will see it 74.

Along with heredity, some medicines such as taking hydroxy chloroquinine for the treatment of rheumatism triggers a side effect causing colour blindness by disintegrating the colour pigment in the eyes. Advice from a registered ophthalmologist can be a solution to cope with the colour blindness.

Individual Activity

Activity: In Picture 10.12 X′ represents a mutant of X chromosome, carrier mother (XX′) and sex linked disorder father (X′Y) produce the offspring that may have the probability of ratio, such as:
sex linked disorder daughter baby (X′X′) : carrier daughter (XX′) : sex linked disorder son (X′Y) : Normal son (XY) = 1:1:1:1
This ratio does not mean that if such a couple has four children, they will definitely have one sick girl, another carrier girl, another sick boy and another normal boy! The ratio only indicates the probability, where each of the four possibilities can occur 25% of the time. It is similar to the scenario where a 1:1 probability ratio of heads to tails when tossing a coin does not mean that every two tosses there will always be a head and a tail; rather, every time there is a 50% chance of getting a head and a 50% chance of getting a tail.

Mother

Father	X'	X	
X'	X'X'	X'X	baby daughter
Y	X'Y	XY	baby son

Figure : 12.11 How sex-linked disorders (such as: red, green colour blindness) are transmitted has been shown in panet square.

In this same way find the ratio of offspring:

(a) Ailing father (X′Y) and healthy mother (XX)

(b) Ailing father (X′Y) and ailing mother (X′X′)

(c) Healthy father (XY) and carrier mother (X′X′)

(d) Healthy father (XY) and ailing mother (X′X′)

(b) Thalassemia

Thalassemia is a disease of abnormal state of red blood cells. Because of this disease, red blood cells disintegrate. The patient suffers from anemia. This disease genetically passes from generation to generation. In Bangladeshi context, thalassemia is an important hereditary blood problem. It is guessed that every year 7000 babies are born with thalassemia and at present the number of patients may be one lakh. It is an autosomal recessive disorder. i.e., when both father and mother are the carrier or both are the patient of thalassemia, only then does it dominate in the offspring. When the marriage is held between maternal and paternal cousins or between close (blood related) relatives there is a higher probability of giving birth to a child with thalassemia. Red blood cell consists of two types of protein α globulin and β globulin. If the gene of these two types of protein in red blood cell are defective then defective red blood cell produces, for which thalassemia occur.

There are two types of thalassemia due to two types of gene disintegration i.e., α thalassemia and β thalassemia.

α thalassemia is caused when α globulin production is absent or defective. This type of disease is prevalent in South Asia, the Middle East, China and Africa. In the same way, β thalassemia is caused when the gene for the production of the protein β globulin is disintegrated. β thalassemia is also called kulir thalassemia. This type of disease is found in the people of the Mediterranean region. Some people having African, American or Chinese origin may also suffer from this disease.

On the basis of the inherited gene, thalassemia is grouped into two categories: thalassemia major and thalassemia minor. In case of major thalassemia, the victim baby obtains genes from both the parents and in case of minor thalassemia a baby obtains genes either from the father or from the mother. This type of body does not express any sign of thalassemia but functions as a carrier of thalassemia genes.

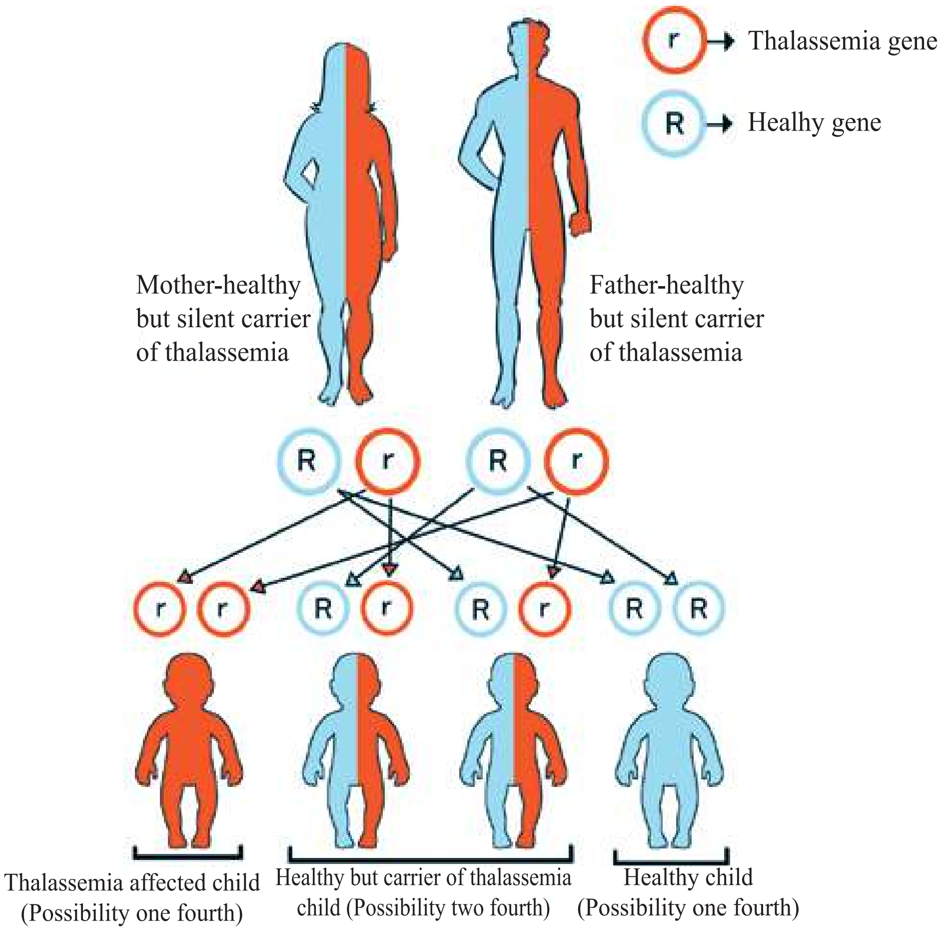


Figure 12.12 : The possibility of inheriting thalassemia from carrier father and carrier mother is one fourth.

Symptom: Due to severe thalassemia, the baby may die in the womb. Babies born with major thalassemia may suffer from anemia just after birth, up to one year of age.

Treatment: Thalassemia is treated by transfusing blood at regular intervals and by providing the patient with required medicines. The patient must not eat iron enriched fruits and medicine, as they may be accumulated and cause harm to other body organs. If the liver is badly affected, other diseases or jaundice can be initiated. The patient suffering from major thalassemia faces threats of life from age 20 to 30.

12.4 Theories of biological evolution

In this world of diversity, we are familiar with many living organisms, among which only 1.3 million are animals. Besides this, four hundred thousand species of plants are identified. Once man had an idea that the world is unchangeable i.e., the shape, the volume of earth remained unchanged from its inception. They thought that there was no difference between the primitive and current (present) living kingdom. But in 500 BC a scientist named Xenophanes first discovered fossils.

He proved that the living organisms are not unchangeable i.e., there are many changes happening between the past and the present.

In 400 BC Aristotle proved that in the living kingdom there are some species which are more developed in comparison to other species. These developed species adapted with changes of the environment, and came to their present form through evolution. Generally biological evolution is a slow and continuous process, and through this process from the structural view complex organisms originate from simple organisms. There are also very few examples of abrupt evolution.

According to the latest scientific data, 4.5 billion years ago, the earth was a heated gas mass evolved from the sun. This gas mass radiated heat and gradually became denser to a liquid state. Then the mass solidified from outer side to the inner side and released vapour, creating cloud surrounding the mass. Rain produced from that cloud created the sea on the solid level of the earth. In the course of time, life originated in the sea. These lives underwent gradual changes and resulted in today's diverse world.

After many hypothetical and research based experiments, modern people have attained the concept that evolution is the basis of the origin of life.

Evolution comes from the Greek world “Evolveri”. The English philosopher and educationist Herbert Spencer first used the world evolution. Once it was thought that through slow and continuous changes a complicated and developed species was developed from a simple and unicellular organism. This process is known as evolution. But evolution does not always occur slowly, sometimes it occurrs fast with environmental changes. Not only that, sometimes complex organisms turns into simpler ones due to evolution. The Mexican catfish lost its eyesight when it shifted from surface water to dark caves of deep water. So, now the definition of evolution is given by gene alleles. (One specific gene can remain in more than one form. Then each and every form of that gene is called its allele.) According to Curtis-Bums (1939) the modern definition of evolution is the change of the gene allele frequency from generation to generation within the species more or less similar in nature.

For example, a list was made after determining the genes of all the tigers of the Sundarbans. At the same time, the number of alleles of the genes was also counted. After some years, another list will be made by determining genes of the next generation of tigers along with determining the alleles.

When comparing the two lists, if it is found that there is a significant change in the alleles then one can say that biological evolution occurs in the tiger population.

12.4.1 Origin of life

There are many opinions about how life originated on earth. But there is no controversy about life originating from sea water or other water bodies. In this regard scientists put forward logic in different ways. First, the presence of different mineral salts in most living cells, blood and other liquid of body are similar to that of sea water minerals. Second, there are still simple and unicellular organisms found in sea water.

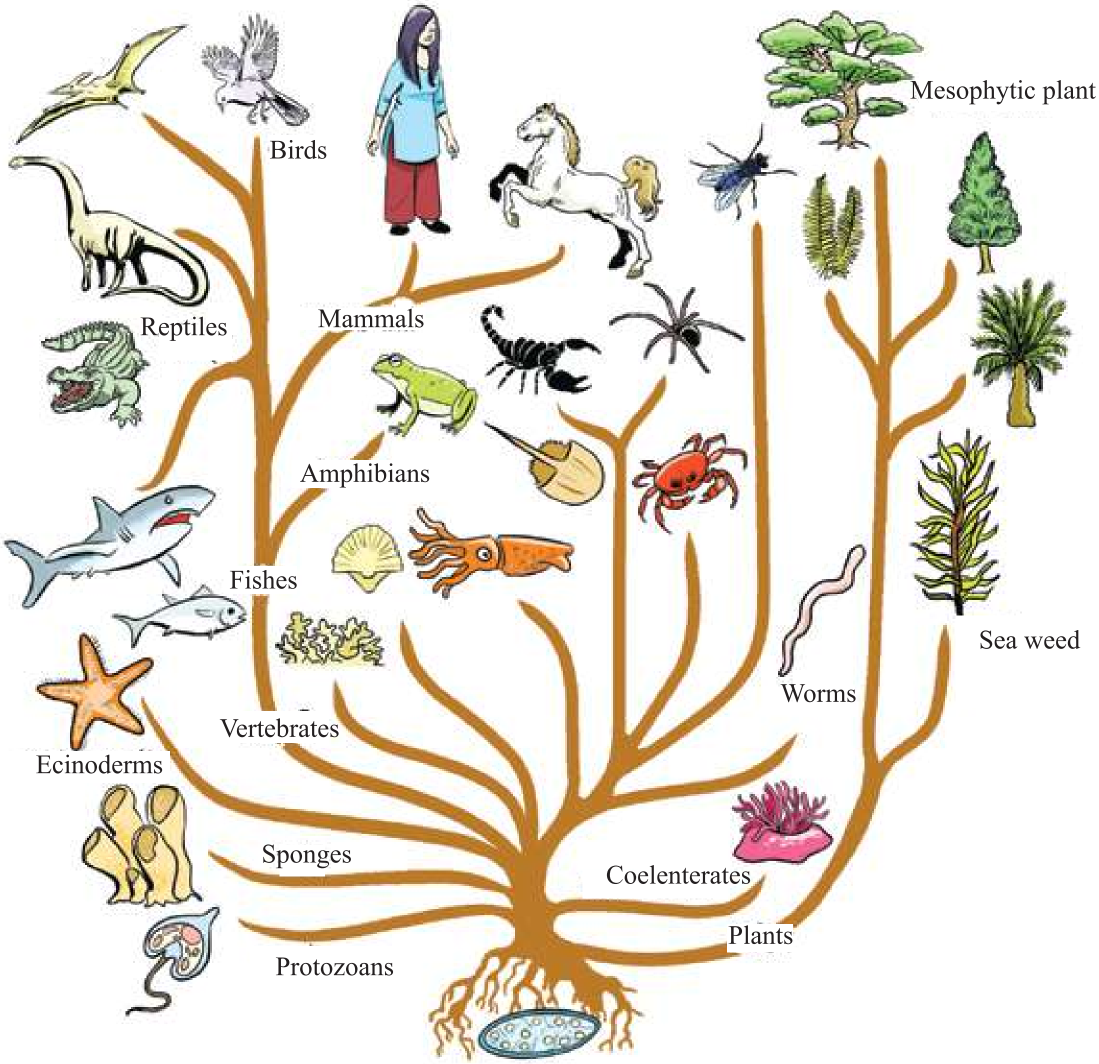


Figure :12.13 Biological evolution is a complex network of numerous changes occurring simultaneously in various branches.

The scientific hypothesis regarding how life originated on earth is like this: 260 years ago the air of the earth was filled with a large amount of methane, ammonia, hydrogen sulphide, water vapour, nitrogen and carbon dioxide. There was no trace of oxygen. Due to frequent eruptions of volcanos, and the effect of ultra violet rays and lightening the atmospheric temperature increased and the organic materials combined to produce amino acid and nucleic acid.

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The above process was proved by doing an experiment in the laboratory. Nucleoprotein is produced from the combination of amino acid and nucleic acid. Gradually the nucleoprotein attains the power of replication and thus a life starts. The origin of earth and its consequent evolution of life is called chemical evolution.

It is assumed that the nucleoprotein is produced by the chemical combination of protein and nucleic acid. A protovirus is evolved from the nucleoprotein and from it, a virus evolved. A virus is a state between living and non-living. After that, bacteria were produced and later on protozoa was originated. The nucleus of bacteria is primitive in nature, it is called a prokaryotic cell.

Later on, true nucleus appears in Protozoa. In some unicellular organisms, chlorophyll is formed and as a result synthesis of food became possible and oxygen is produced as a by product. Then the aerobic organisms increase in number. Initiation of multicellular organisms appear from the unicellular organisms.

After that more complex organisms began to evolve. There are many other explanations about chemical evolution and the origin of living organisms but the explanation given above is the most commonly accepted one.

Evolution never happens in a linear way. It has always been happening in a complicated way in different branches. This is shown in figure 12.12.

12.4.2 Theory of Darwin or Darwinism

Charles Darwin, the British naturalist, brought a revolutionary idea to the history of biology and science. Scientist Charles Robert Darwin (1809-1882) was born in Shrewsbury, England. During his voyage to the Galapagos Island in the Pacific ocean he was attracted to the amazing diversity of plants and animals of that region and he came back to England in 1837 with a vast collection of data and samples. Twenty years after his return i.e., in 1859, he expressed his opinions in a book named the 'Origin of Species by means of Natural Selection.'

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It is mentionable that Darwin is not the founder of evolution but his theory is known as the theory of evolution.

According to the discussion in this chapter, we have seen that scientists living before Christ knew that biological evolution occurred on earth.
The success of Darwin was that he developed a mechanism based on scientific data and proof which could explain all matters related to evolution.

Alfred Russell Wallace, (1823-1913), a contemporary British naturalist and scientist who independently developed a theory on natural selection, also mentioned natural selection as a cause of biological evolution. Due to some historical reasons, Darwin's name was more popular than his.

According to Darwin, general facts about natural events

(a) Increase of generation in excessive rate: According to Darwin a general characteristic of living beings is to reproduce its species in an excessive rate. Due to this the number of species increases both geometrically and mathematically. For example, one mustard plant produces 7,30,000 seeds in a year. It is possible to get 730,000 plant from those seeds. A female salmon fish lays thirty million eggs in one breeding season.
According to Darwin, if all the elephants born from a pair of elephants would survive, the number of elephants would be 1,90,000 (one hundred ninety thousand) in 750 years.

(b) Limited food and shelter: As the area is limited on earth, shelter and food for living organisms is limited.

(c) Struggle for survival: As the number of living organisms increases both geometrically and mathematically, having limited food and shelter, living organisms have to face hard competition for survival. Darwin called this the struggle for existence. Darwin noticed that living organisms had to struggle in three stages. These are:

(i) Interspecific Struggle: For example, a frog eats an insect and a snake eats a frog. A peacock eats both snake and frog. Thus only due to physical needs (hunger), a cruel relationship develops among different species, where each species plays the role of food or consumer.

(ii) Intraspecific struggle: As the same species has the same habitat and the same food habits, when their number increases, they compete among themselves for survival. For example, when in an island the number of herbivorous animal increases, they fight for food and shelter among themselves. The stronger animal (herbivorous) beat the weaker ones and take the command of that area. As a result, the weaker animals die after a certain period from starvation.

(iii) Struggle with Environment: Normal life of living organisms is interrupted by unfavourable conditions like flood, drought, cyclone and tornado, earthquake, volcano eruption etc. So living beings always have to fight with these unfavourable environment to survive. Those who won the struggle can survive, while others become extinct. For example, the koel bird of Mid and North America became extinct due to severe cold and snowfall.

(d) Variation: According to Darwin, two animals (or group of animals) are never exactly the same. There are always some differences, even if in a very small scale. The difference between the two specimens of the same species is called variation or mutation. Variation helps living organisms to survive.

(e) Natural selection: The process through which organisms develop through adaptation, gain more success in struggling in comparison to others, and enjoys more advantages in competition, is called natural selection.

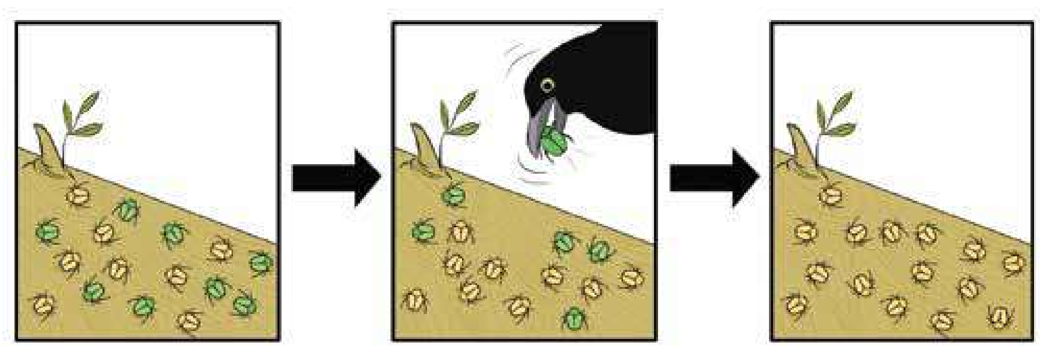

Figure :12.14 The chronological picture of struggle for survival between two living organisms. Green beetles could not adjust with the environment and were easily marked and later on consumed by birds. But brown beetles survived.

The organisms which win the competition in struggling through adaptation are selected by nature and reproduce at a greater rate. On the other hand, organisms which cannot adjust to the new changes cannot survive and gradually become extinct.

According to Darwin, the organism which can survive in unfavorable conditions by adaptation should be addressed as the fittest. Thus it can be easily said that the fittest organism survive by winning the competition through adaptation (Survival of the fittest).

(f) Origin of new species: Nature selects plants and animals and nourishes them. Plants and animals that survive can cope with the changes of the environment and are able to reproduce more than those who are unfit for survival. The characteristics of variation are transferred generation after generation. The generation which has the quality of environmental friendly variation are again selected by nature. Over the years through natural selection, plants and animals are selected and thus new varieties of species are produced. It is not always the case that the original species is lost when a new species arises from that ancestral species.

At present geneticists, cytologists and taxonomists following the theory on genetics and evolution, believe that new varieties could be produced in three different ways, such as :

(a) Being isolated from original species population

(b) Hybridization

(c) In hybridized species the accidental increase of chromosomes (due to polygamy) occurs during cell division and as a result, a new variety produced can adapt with the environment and is selected by nature for survival.

Conditions for natural selection

The idea that a massive or great change must always occur for biological evolution to occur is wrong. Just as arising of new species from ancestral species is regarded as evolution, change in allele frequencies from generation to generation is also evolution by definition. The first is macroevolution and the second is microevolution. After many generations of microevolution, macroevolution can occur, just as tiny grains of sand combine to form long sand dunes or miniscule droplets of water accumulate to give rise of large oceans.

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We may understand the principles of the Darwinian evolution only by understanding the conditions, each of which must be met in order for Darwinian evolution to happen.

First Condition – Variation: Even if all the members of a population are of the same species, each of them will have some individualistic characteristics that differs. All cows are not the same, all jackfruit trees are not the same, all humans are members of the same species, yet look how different people are, even bacteria of the same species are not exactly the same.

Second Condition – Selection: The variation or diversity of traits that contribute in favour of its reproduction in an environment, some of those traits are transmitted to the next generation. All variable features can be roughly divided into three categories.

- **Fit:** characteristics in favour of environmental tolerance or adaptation.
- **Unfit:** characteristics associated with death or failure of reproduction or extinction due to environmental conditions.
- **Neutral:** characteristics unrelated to the given environment.

It is easily understood that organisms with fit traits have a higher chance of survival than organisms with unfit traits.

Third Condition – Heredity: Some, but not all, fit and unfit traits will be passed down to the next generation by the rules of heredity. That is, the frequency of fit and unfit trait-determining alleles in one generation's gene pool will not match the frequency of fit and unfit trait-determining alleles in the next generation's gene pool.

This is biological evolution. Note that mutation and selection occur at the level of individuals or individual members of a population, but evolution occurs in the population as a whole. A member of a population does not suddenly change into another organism in the same generation. Instead, the entire population changes from generation to generation.

No environment or population can be found in nature where the above conditions are completely absent. So, every population in the universe has some degree of Darwinian evolution going on.

Non-Darwinian evolution

Natural selection or Darwinian evolution plays a major role as the cause of evolution as a whole. But biological evolution can occur in other ways besides the theory developed by Darwin and Wallace. Those ways are collectively called non-Darwinian evolution. Under special conditions, evolution can often occur by mutation alone, without the aid of selection. Again, when a significant part of a population moves from one place to another through migration, large changes in the allele frequencies of that population can occur in a very short period of time. So, migration can also result in non-Darwinian evolution. This non-Darwinian evolution is also responsible for the emergence of new strains of flu virus almost every year. Our genome contains many non-coding segments of DNA that are of no known use to the body. Perhaps these too have accumulated as a result of non-Darwinian evolution. Darwinian and non-Darwinian evolution usually coexist in a population. The DNA we now find in our genomes is actually the combined result of Darwinian and non-Darwinian evolution over millions of years.

Evidence of biological evolution

A bird's wing, a bat's wing, a whale's flipper, a seal's foreleg, a horse's forefoot, a human hand – all are homologous organs. Despite their apparent morphological differences, the basic nature of their skeleton is similar. Both bats and moths evolved flight aids as a means of survival under the same environmental influences, albeit in different ways. Such analogous organs are also evidence of biological evolution. Organs (such as third eyelid, tail bone, etc.) are present in an organism's early ancestors but are absent or of no use in organism evolved from those ancestors later on. Such extinct or atavistic organs have been modified in those animals by natural selection. In the biosphere there are many organisms (such as platypus, mudskipper, gnetum etc.) that have intermediate characteristics of several organisms. Before they were found, they were called missing links. Many missing links are no longer missing. They are now the connecting organisms or connecting links of evolution. Fish, amphibians, reptiles, birds and mammals all have gills and tails at some point in their embryos and look similar. It cannot be explained without evolution. A fossil is a complete or partial petrified body or imprint of an organism buried in the underground rock layer. For example, Darwin predicted that fossils of animals with characteristics intermediate between reptiles and birds would be found in a certain rock layer. About a year and a half later, a similar fossil was found, named Archeopteryx. Not all fossils are dead. Several organisms originated in the distant past and still survive without much change are called living fossils, such as, *Limulus, Ginkgo biloba* etc. At present, it has been possible to unravel the genome sequence or mystery of life of many organisms. Therefore, matching the nucleotide sequences of DNA or RNA or amino acid sequences of proteins of one organism's DNA or RNA or proteins with the similar sequence of another organism has become easy. This can be done using appropriate software if you have a computer connected to the internet. This method determines how closely or distantly an organism is genetically related to another organism. This shows how consistent the picture of biological evolution is with other methods, including fossils. As it turns out, it proves evolution so strongly that it has been said that if no fossils were found, it would be no problem to determine the history of evolution using only genetic information of life.

Application of the principles of biological evolution

Inventing new varieties

New species have naturally evolved from old species through biological evolution, and are occurring, and may continue to occur in the future. On the other hand, using the principles of natural selection, humans have been inventing new breeds of animals and plants according to their needs for thousands of years. In the early days of agriculture, without knowing anything about natural selection, mutation, or genetics, people knew from experience that by setting aside seeds from crops that produced good quality crops in the field and replanting them the following year, more good crops were produced. It is actually just an imitation of natural selection, where members of a crop population with particular genotypes are given extra advantage to reproduce. In this way, if the selection process is carried out for many generations, one day it will be seen that new species of crops have emerged. Almost all of the grains we grow today originated in this process.

Control of insects such as mosquitoes

Not only are our health and environment at risk as a side effect of using toxic chemicals to control mosquitoes. Over time, mosquito populations are becoming resistant to these chemicals, just as bacterial populations are becoming antibiotic-resistant. Therefore, more and more toxic chemicals are constantly being used to keep up with the biological evolution of mosquitoes. Scientists are trying to use the principles of natural selection as a way to get rid of this vicious cycle. They have genetically engineered male mosquitoes that female mosquitoes will be interested in mating with but will not produce any baby mosquitoes. If these engineered mosquitoes are released in sufficient numbers in an area, the fitness of the mosquito population in that area will drop to zero within a few generations. That is, mosquito breeding will stop. Without using any toxic chemicals. In this method, since the environment will not be changed by applying any chemicals on them, no immunity will evolve in the mosquitoes.

Significance of biological evolution in surviving of species

During emergence of a new species through biological evolution, many species are lost in the passage of time. For example, dinosaurs. The species which possess a greater ability to adapt through biological evolution can go far. So the species which can attain more ability to adapt with the environment, flow of life and demography will survive for a longer period of time. This process is called adaptation.

It is not that evolution occurs only in nature. Evolution can also be done by experiment in the laboratory. This is also evidence of realistic evolution. There is no scientific evidence found against evolution till today. The more knowledge we gain about the biological kingdom, the more difficult it becomes to deny evolution.

Exercise

Short answer questions

1. What is RNA?
2. What is a gene?
3. Why is a chromosome called the physical basis of heredity?
4. What is an autosome?
5. What does Thalassemia mean?

Essay type questions

1. Describe with diagrams, how DNA replicates itself.

Multiple choice questions

1. Where is uracil found?

   a. DNA　　b. RNA
   c. Gene　　d. Locus

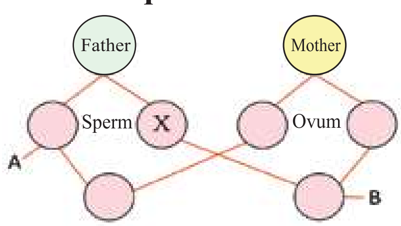
2. Which one does RNA contain?

   i. ribose sugar
   ii. inorganic phosphate
   iii. nitrogenous bases

Which one of the following is correct?

a. i　　b. i & ii
c. ii & iii　　d. i, ii, iii

Answer the questions 3 & 4 using the figure given below –



3. What is the number of chromosomes in the state of X, in stem?
   a. 46 b. 44
   c. 23 d. 22
4. What type of chromosome are there in A and B of stem?
   a. X, XY b. X, XX
   c. Y, XX d. Y, XY

Creative questions

1. Sifat is a farmer. He has two daughters. The older daughter looks like her father. While the younger daughter's hair and complexion are like her father, she looks like her mother. As the mother has given birth to a female child recently, Sifat became aggrieved with his wife. One day he learned from the health workers of his village that he is responsible in determining the sex of his offspring.

a. What is heredity?
b. What does it mean by replication?
c. What are the causes of physical development differences found in the offspring of Sifat?
d. It is irrational that Sifat got aggrieved with his wife. Explain why.

2. Sohel has seen on television that an exhibition of pet cats is going on in a town of Brazil. He saw that in spite of their belonging to the same species, they look different in size and colour. Some days later, he watched a film about growing up of wild cats. His father explained to him the concept of evolution and adaptation when he became interested to know more about it.

a. What is locus?
b. What do you understand by the term adaptation?
c. Explain the causes of difference with the animals seen by Sohel.
d. What will happen if the organisms in first group of the stem are left in the environment where the animals of the second group were found?

Chapter Thirteen

Environment of life

The environment of an organism is all the living and non-living components around it. Light, air, rain, storm, soil, water are important in the life of organisms. The living world around it also plays significant roles in the life of the organism. The steps that the organisms take in different stages of life, also have effects on the lives of the other organisms living in the same environment. In the living world the food chain and food web are very important issues without which the existence of life cannot be imagined.

At the end of this chapter, we will be able to-

- explain ecosystem;
- explain the interrelationship between the elements of an ecosystem;
- explain food chain and food web;
- draw the comparisons between the energy flow and the nutrient elements of an ecosystem;
- compare the relationship between energy performances in between trophic levels;
- explain the concept of an energy pyramid;
- explain the concept of an ecological pyramid in limiting the food chains;
- explain biodiversity and types of biodiversity;
- evaluate the role of biodiversity in sustaining the stability of an ecosystem;
- explain the interactions and interdependence in between different organisms in maintaining balance in environment;
- explain the methods used for the conservation of the environment;
- analyse the importance of the conservation of the environment in maintaining the balance in it;
- determine the reciprocal interrelationship between the producers, consumers and transformers in a given locality;
- identify the causes of pollution of all the elements of a specific environment;
- draw a flowchart showing the flow of energy, food chain and food web in an ecosystem;
- perceive the contribution of the components of an ecosystem to the maintenance of balance of the environment and will be cautious for its preservation.

13.1 Ecosystem

Our environment consists of all the organisms, and non-living substances in the world. Organisms actively collect components from the non-living world and carry on their life, and after death become waste substances and mix with the environment again, sending back all the elements to the environment. Green plants collect carbon dioxide from the air and water from the soil through photosynthesis, and produce carbohydrates, releasing oxygen into the air. For the whole living world (plants and animals) the oxygen, required for respiration, comes from the oxygen produced through photosynthesis. Both green and non-green plants absorb mineral salts from the soil as food. Herbivorous animals survive by eating different parts of plants in different ways. Carnivorous animals consume herbivorous animals and other small carnivorous creatures. Waste materials from all animals become mixed with the environment again. After death, all plant and animal bodies go back to the environment and are disintegrated. Bacteria and microorganisms do this disintegration process. This way, the balance in the natural environment is maintained.

In natural environment the exchange of energy and materials, between plants and animals and the living and non-living substances, is called interaction. Interrelations are developed through these interactions. An ecosystem is any unit of landscape where there are non-living substances, food producing green plants, animals dependent on plants and microorganisms for the disintegration of the dead bodies of organisms, and a proper interrelation between these elements. For the different elements for nutrition and other physiological activities, soil, air and water are required.

13.1.1 Components of an ecosystem

The living community, inanimate components of the environment and the physical conditions collectively develop an ecosystem. Each of these main components is composed of some other small components. The living components are greatly diverse.

(a) Non-living matter: Non-living matter harbors the habitats of living organisms, provide them with oxygen for respiration and can supply some nutrient components as well. The components of all inanimate materials can be divided into two groups, such as, inorganic matter and organic matter.

i) Inorganic matter: Water, air and mineral substances in the soil, which have not evolved from any living body, but existed before the emergence of organisms are the inorganic components of an ecosystem, such as calcium, potassium, iron, nitrogen, oxygen and carbon dioxide etc.

ii) Organic matter: The waste materials of plants and animals or the dead bodies of organisms or substances derived from them are called the organic matter of an ecosystem. They are generally termed as humus. Some of the components of humus are urea, cells, tissue and organs of plants and animals. This organic matter is nutritious for plants. This is why compost should be applied for the cultivation of plants. Most animals also like soil composed of rich humus.

(b) Physical components: The amount of sunlight, temperature, presence of water vapour in the air, air pressure and wind, depth and height from the surface of the earth (under the ground or under the water) all influence the ecosystem. These element collectively create the wheather and climate of any region. These are all the physiological components of an ecosystem.

(c) Living components: The living world is the active component of ecosystem. They cause changes in the environment through their activities. The living components of the environment are of three types: 1. Producers 2. Consumers 3.Transformers.

i) Producers: Green plants, in the presence of sunlight, obtaining carbon dioxide from the air and absorbing water from the soil, produce their food carbohydrates. At this time, oxygen is produced as a by-product. This is why photosynthesis is the production process of an ecosystem. The producers are the green plants. These green plants are also called autotrophs because they can produce their food themselves, they do not depend on others for their food.

ii) Consumers: No animal can produce food from non-living substances in the environment. They directly or indirectly depend on plants for their food. This is why they are called heterotrophic animals. The animals which directly consume plants as food, are called herbivorous. They are the consumers of the first line. Grasshoppers, chickens, cow, goats and deer are examples of herbivorous animals.

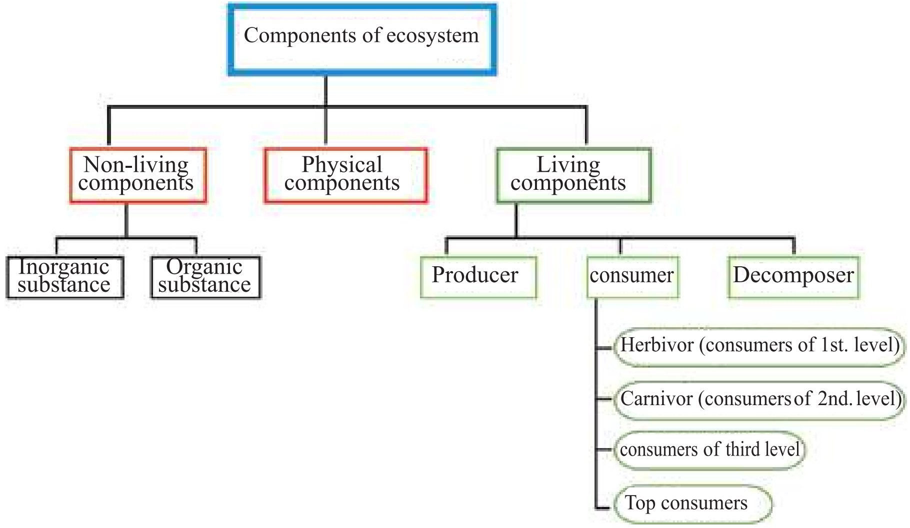


Figure: 13.01 Components of an ecosystem (in a chart)

The animals, which depend on herbivorous animals for their food, are called secondary consumers or consumers of the second line. They are carnivorous animals. Toad, fox, tiger are examples of carnivorous animals.

The animals, which eat secondary consumers, are also carnivorous. They may be called tertiary consumers or top consumers, such as peacock, snake, tiger etc. There are also animals who like to eat dead bodies of other organisms than the living body, for instance, vulture, crow, fox, hyena etc. They are called scavengers because they keep the environment clean by eating the dead bodies of different organisms. Sometimes in the ecosystem, some animals play a double role as a consumer in two different levels of the food chain, such as man. Man is at a time herbivorous and omnivorous.

iii) Decomposers: Some microorganisms, like bacteria and fungus, get their food from the waste of plants and animals and their dead bodies, and as a consequence, they are mixed with the soil and water by being decomposed. These mixed components can be again consumed as food components. This is why these microorganisms are called decomposers or transformers.

13.2 Ecosystem of a pond

To take a closer look at an ecosystem, a pond can be thought of. The deeper relationships, between the organisms living in the ponds and the non-living substances there, can be conceived. The non-living components are the different types of organic and inorganic components water, sunlight, carbon dioxide, oxygen, calcium, phosphorus etc. The living components are the producers, consumers of the first level, the consumers of secondary and tertiary levels and the different types of decomposers.

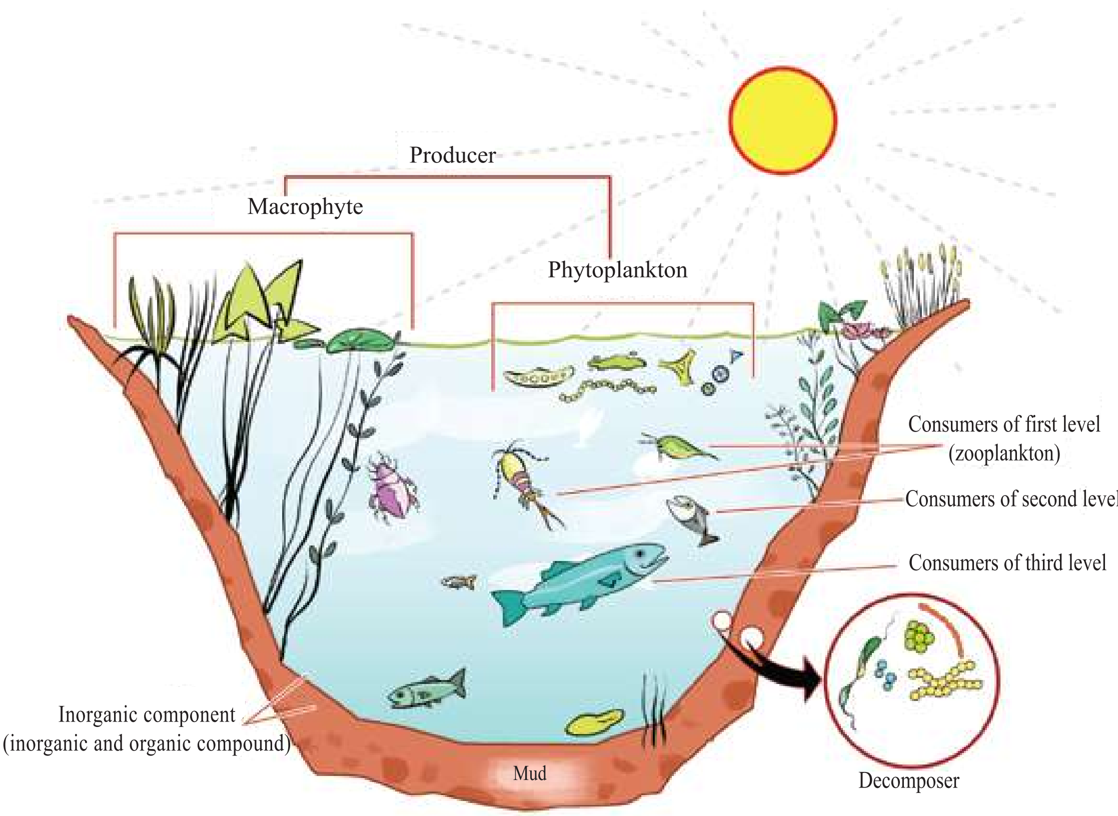


Figure: 13.02 A pond ecosystem

(a) Producers: The producers are the photosynthetic algae and plants of shallow water. The free-floating microscopic organisms are called plankton. Phytoplankton, green algae and other aquatic plants, which produce food through photosynthesis are called primary producers.

(b) Consumer of primary level: Different types of floating insects, larva of mosquito, very small animals, zooplankton , Rui and catla fish etc. are the consumers of the first level. Free-floating small animals are called zooplankton. These consumers cannot produce their food themselves. So, they live by directly consuming the primary producers.

(c) Consumers of secondary level: Small fishes, some aquatic insects, toad etc. are the consumers of the second level. They cannot produce their food themselves and cannot directly consume the primary producers. They eat the consumers of the first level as their food.

(d) Consumers of tertiary level: The consumer which eats secondary consumers such as small fishes, prawns etc. is called the tertiary consumer. Shoul, bhetki, boal like big fishes and stork are consumers of the tertiary level.

(e) Decomposers: Many fungi and bacteria live in the pond as saprophytes, and they are decomposers. They live floating in the water or at the bottom in the muddy habitat. They attack living and non-living organisms and help them to be degraded, and as a result organic and inorganic chemical components required by the producers are produced again for them. The producers in the pond can again consume the substances created by the decomposers.

13.3 Food Chain

Among the living components of any ecosystem, first the green plants start their activities. If they do not produce food, herbivorous animals and other carnivorous animals may die in want of food. When the food energy is flown from the primary producers through different trophic levels, then this flow is called the food chain.

For instance, the green grass on a field is the primary producer and grasshoppers live on of the grass. The toad eats the grasshoppers and the snake eats the whole toad as its food. If the snake is small and there is a large gui snake around it, a reptile of lizard family, it will definitely eat the snake. In this case, a food chain may be formed as shown in the flowchart.

Grass →	grasshopper →	toad →	snake →	gui snake
Producer	consumer of primary level	consumer of secondary level	consumer of tertiary level	consumer of top level

In different ecosystems food chains may be different, such as predator food chain, parasitic food chain and saprophytic food chain.

(a) Predator Food Chain: The food chain, where organisms of the primary level are of the smallest size and consecutively consumers of the higher levels prey the organisms of the lower levels and eat them, is called a predator food chain. The food chain mentioned above is an example of a predator food chain.

(b) Parasitic Food Chain: Parasitic plants and animals in most of the cases derive their food from a host much larger in size than they are. In some cases other smaller parasites are dependent on all the parasites for their food. In this type of food chain, the primary producers may not be always at the beginning level. The chain remains incomplete.

Man → mosquito → Dengu Virus

Remarkably, the blood sucked by a female Aedes mosquito does not provide any nutrients to the mosquito but helps to develop its egg inside the body.

(c) Saprophytic food chain: If a food chain is stretched from the dead organisms to the different trophic levels, then it is called a saprophytic food chain.

Dead body → fungi → earthworm

Needless to say, this kind of food chain is incomplete and the food chain describes only part of the total interaction or interrelations of an ecosystem. Parasitic and saprophytic food chains are always incomplete since there is no producer in them. Both types of food chains, to maintain their activities, depend on one or more levels of the predatory food chain. The food chains of an ecosystem are all based on the activities of the photosynthesis of the producers green plants.

13.4 Food web

In most cases, the same consumer can be placed in different trophic levels. This way some food chains collectively may form a net or web like structure. This is called a food web. This is a phenomenon for both the terrestrial and aquatic ecosystem. This concept can be made clearer by thinking of a pond ecosystem.

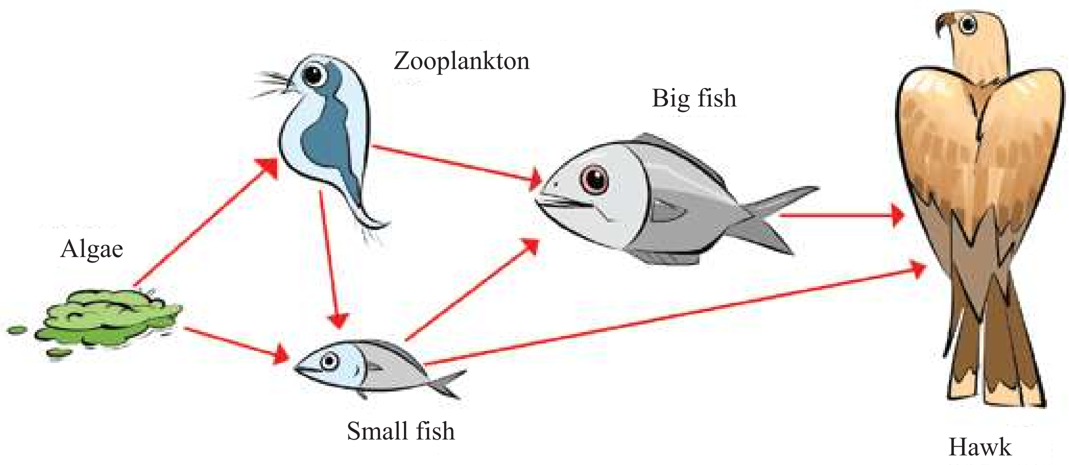


Figure: 13.03 Food web

In the diagram above, it is found that primary producers (algae) directly provide zooplanktons and small fishes with their food. Both the small and big fishes eat zooplanktons as their food. This big fish also eats the small fishes. A hawk eats small fishes and some other small members of the big fish belonging to the same species. Here five organisms have developed food chains in different ways. This way, more complex food webs can be developed in different ecosystems than the food web developed here.

Five food chains are found in the food web mentioned above.

1. algae → small fish → hawk
2. algae → zooplankton → big fish → hawk
3. algae → small fish → big fish → hawk
4. algae → zooplankton → small fish → big fish → hawk
5. algae → zooplankton → small fish → hawk

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A food web in a forest ecosystem may be the following:

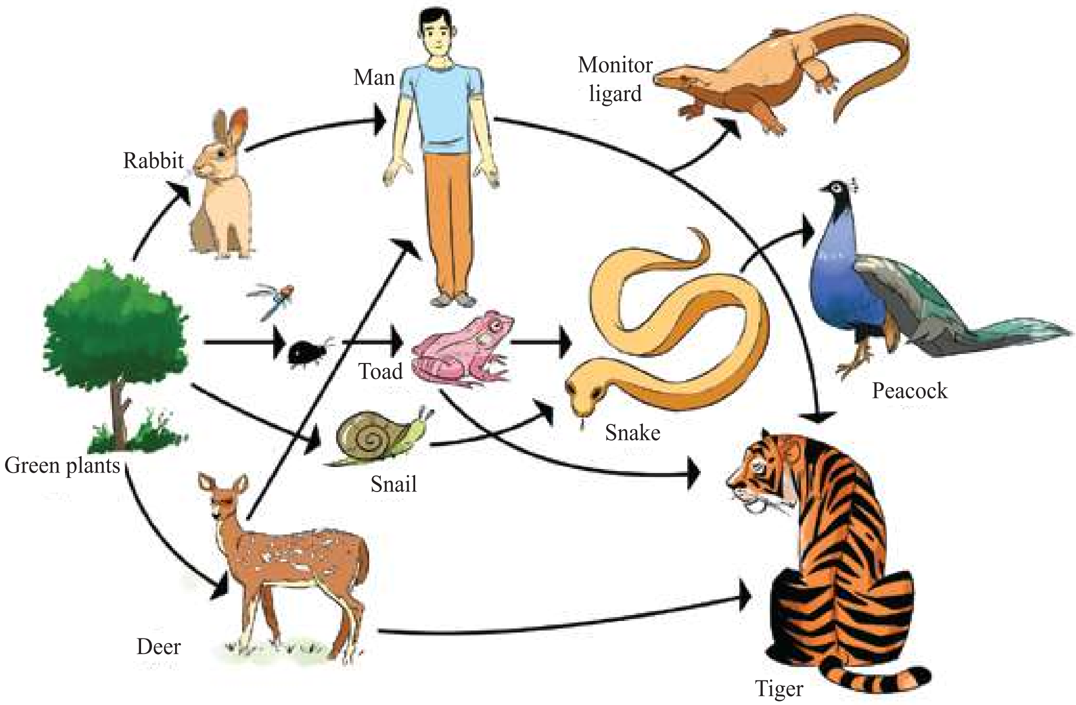


Figure: 13.04 A food web of forest

Individual Activity

Activity : Write down the food chains in the food web mentioned in the figure 13.04.

Nutrition flow in ecosystem

Plants produce food through the photosynthesis process after obtaining necessary inorganic substances. A plant uses a part from the food it produces itself, and the remaining food is stored in the plant body. Herbivorous animals eat these plants and carnivorous animals eat the herbivorous. After the death of these plants and animals, decomposers transform them into inorganic substances by using them as their food and the decomposers return the substance to the states from where they are taken. Green plants obtain these substances and again use them in producing food. The cyclic movement of nutrition materials is called the nutrition flow. The flow of nutrition materials through food chains is a unique character of ecosystems.

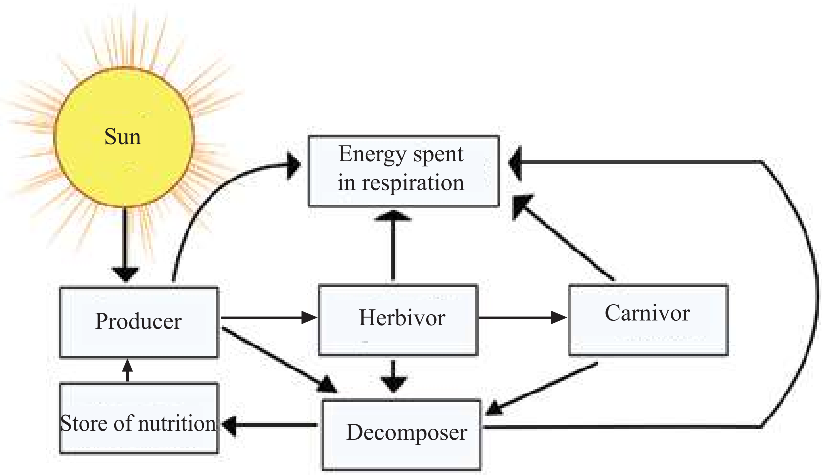


Figure: 13.05 Brief chart of the flow of nutrition and energy

Energy flow in the ecosystem

The sun is the main source of energy in any ecosystem. From the amount of light and heat energy that reaches the planet earth, the green plants store only 2% of the received energy through photosynthesis. Heat and chemical energy produced by photosynthesis are primarily stored as carbohydrate for the requirements of the next stages of ecosystem. This energy, stored in plants, reaches different trophic levels through different kinds of food chains. The energy again comes back to the environment through the terminal acts of the decomposers.

The herbivorous animals, consumers of first level, maintain life by eating leaves, stems, flowers, fruits, seeds or roots of green plants. This way the chemical energy produced in green plants reaches herbivorous animals. The carnivorous animals, who live by eating the consumers of first level (herbivorous animals) are the consumers of the second level. The chemical energy, from the consumers of the first level, is transferred this way to the bodies of consumers of the second level. The chemical energy from the consumers of second level reaches the consumers of third level in the form of food. If any other superior consumers eat the consumers of the third level as their food, the energy reaches the consumers of the top level.

After death, procurement of energy is stopped in all the organisms. Then the chemical energy stored in the dead bodies comes back to the environment in the form of inanimate substances and energy after being broken down by the activities of decomposers. The energy stored in different inanimate substances of the environment becomes suitable for the plants to use again. And this way the flow of natural energy in ecosystem is continued.

Some energy gets wasted in every level of all types of food chain. The herbivorous consumer does not store the exact amount of energy, which it procures from the producers of green plants. The amount of nutrition that a consumer of the second level obtains from the herbivorous consumers does not even reach its own body, as some of the energy is released into the inanimate environment. This way, at the time of transferring food from one organism to another, much energy goes out of the system in accordance with the principles of the ecosystem. This is why, if in an ecosystem the number of trophic level is low, energy waste decreases accordingly.

Relation of energy between trophic levels: Every step of a food chain is called a trophic level. Each of all the levels, (primary producers, primary consumers of the first level, consumers of the second level and the consumers of the top most level) is a trophic level. The producers represent the first or the lowest level in an ecosystem. The herbivorous consumers, consumers of first level are the representatives of second trophic level. This way carnivorous animals of both the higher and lower levels represent third and top most trophic levels respectively. Some of the energy collected from the sun in the producers or in the lowest trophic level of any food chain goes out in every consecutive step as heat energy. As a result, it is found that the energy the producers collect from the sun is reduced when reaching the second trophic level. The amount of energy is reduced again when reaching the top most trophic level. Generally in any ecosystem 10% of the stored energy is transferred from one trophic level to another and the remaining 90% energy is released as heat in the atmosphere or remains unused.

Concept of energy pyramid: The narrow apex of the three-dimensional structure based on its triangular base is called a pyramid. The structure of trophic levels in an ecosystem is shown with the structure of a pyramid. The chart, describing the arrangement of energy storage and transfer of every nutrition level, connected to food chain, is called the energy pyramid. The amount of energy is much higher in the level of producers than in the next trophic levels. The organisms of higher trophic levels than those of lower trophic level lose more energy for respiration and other activities. This is why the producers and the top most consumers are placed on the base and at the top of the pyramid respectively.

Effects of energy pyramid to keep food chain in limit.

The flow of energy is always unidirectional. This energy flow can never be turned around. About 90% energy is reduced in every stage. The ever-increasing loss of energy limits the size of a food chain to 4 or 5 stages. The longer a food chain is, the more energy is reduced in the higher trophic levels and at one stage there would be no energy left.

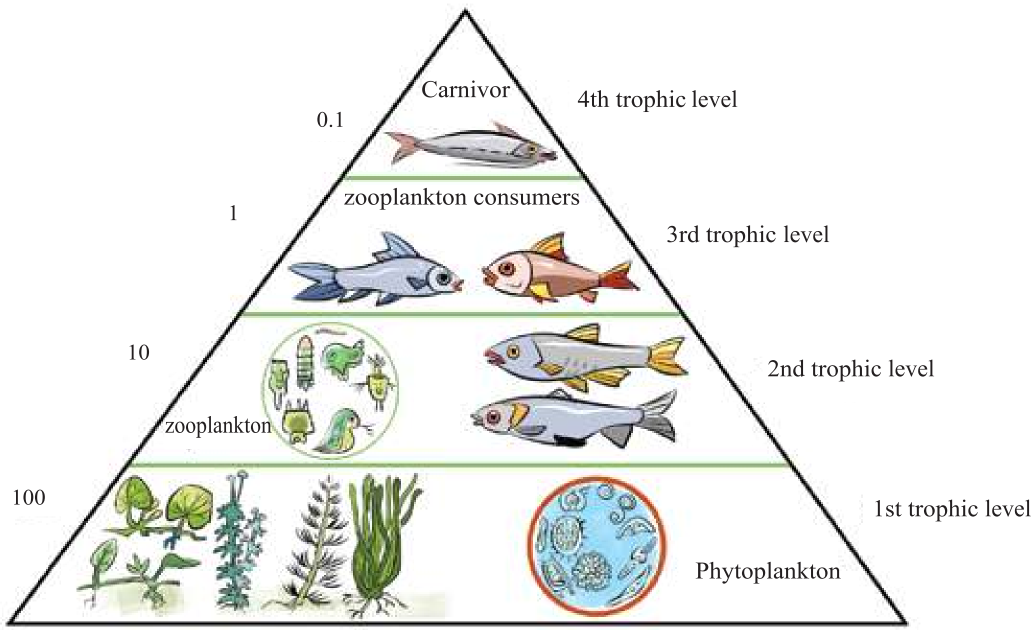


Figure: 13.06 Energy pyramid

13.5 Biodiversity

The environment is composed of animate and inanimate substances. It is the assemblage of many types of organisms and innumerable kinds of inanimate substances. How many types of organisms are there in the world? It is difficult to give the exact figure of it but on account of species (who are similar to each other in physical and reproductive characters and originate from the same ancestor) it is easier to present. Until now, it has been possible to know the description and nomenclature of 13 lacs of animals and 4 lacs of plants. Every species is characterized with its own unique features and is different and identifiable from all other species. For instance, jackfruit is a species, and it is possible to separate it from other species by its special characteristics. It has become possible to group the living world into millions of species because of the existing diversity in organisms. The human being is a species. At present about seven hundred crores of human beings live on the earth. They are all not exactly the same and are different from each other in some characteristics. So, diversity is there even among the members of the same species. Briefly, it can be said that biodiversity is the abundance and variability among organisms existing on the earth.

13.5.1 Types of biodiversity

Biodiversity can be divided into three categories: (1) species diversity, (2) genetic diversity and (3) ecosystem diversity.

Species diversity: Species diversity generally means the total number of organisms existing on the earth. A species is different from other species by its distinctive characteristics, such as, a deer is distinct from a tiger in size, habits, ferocity, number, mode of reproduction etc. The difference in different issues of a species from other species is species diversity.

Genetic diversity: Differences in many issues are found in the members of the same species. Though they belong to the same species, their structure, size, and ability to resist diseases and to endure environmental adversities are different. These differences emerge because of the small diversity in the composition of their genes. Hereditary characters of organisms are transmitted through generations by genes. There is a gene for every characteristic. Changes in characteristic in organisms occur because of the changes in the structure and arrangement of genes, and new species may evolve. Through this process, the diversity introduced within organisms of the same species is called genetic diversity.

Ecosystem diversity: If any changes occur with the physical, chemical and organic components of a ecosystem, the balance of the ecosystem is hampered. These changes are, of course, slow and steady. To adapt with these changes, changes also occur in the organisms living there. As a result the biodiversity developed there is called the ecosystem diversity. In a small pond ecosystem, the habitats, for the plants and animals are different than those in a river ecosystem. In the ecosystem of a forest, grassland, lake, river, water reservoir, hill, sea, or desert the living communities are developed with their own distinct characteristics.

Effect of biodiversity on the maintenance of stability in an ecosystem

The components of the environment are deeply interrelated with each other. To maintain balance in the environment, this complex relationship has developed. With the activities of a large number of organisms, the balance is maintained in the environment. The extinction of a species in an environment can cause a large catastrophe. So, for the stability of the environment, biodiversity is especially important.

Some organisms and animals were once considered unnecessary and undesired. With the passage of time, it has been found that these organisms are continuously playing a necessary role for the conservation of the environment. Once there were innumerable oysters in the coast of Chesapeake in the United States of America. They could purify the water of the whole locality in only three days. But now 99% of those oysters have been extinct. As a result, the remaining oysters cannot purify the water of that total locality even by a year. This is why, the water of that coast is gradually becoming muddy, and the level of dissolved oxygen in the water locality is being reduced. A mature toad in a day can eat the amount of worms and insects equal to its body weight. These worms and insects cause harm to our cultivated harvest. Because of pesticides, toads are being killed. Worms and insects are the main food of birds. Among them, the number of the pests, which cause harm to humans and cultivated harvest, is high. Besides that, birds play a significant role in pollination. We know that owl, eagle, vulture, and raptor are

Figure 13.07: Vulture, kite and crow regularly cleans the garbage of nature

predatory birds. By eating rats, they keep the number of rats under control. If a pair of rats, living at a house of a human without any trouble could reproduce freely, the number of rats would be 880 at the end of a year. But an owl can eat three rats in a day. If vultures, raptors and crows would not clear the dead and decaying organic matters, the world would be covered with them. This is why no organism can be considered unnecessary. If any organism is extinct from the environment, the stability of an ecosystem is destroyed. So, for the sustainability of ecosystem the role of biodiversity is unquestionable.

13.5.2 Interaction and interdependence among different organisms and the balance of environment

Green plants are generally called self-dependent because they are autotrophic. But considered from environmental point of view, no organism is self-dependent, not even the green plants. Plants, birds and animals, worms and insects and other organisms influence each other.

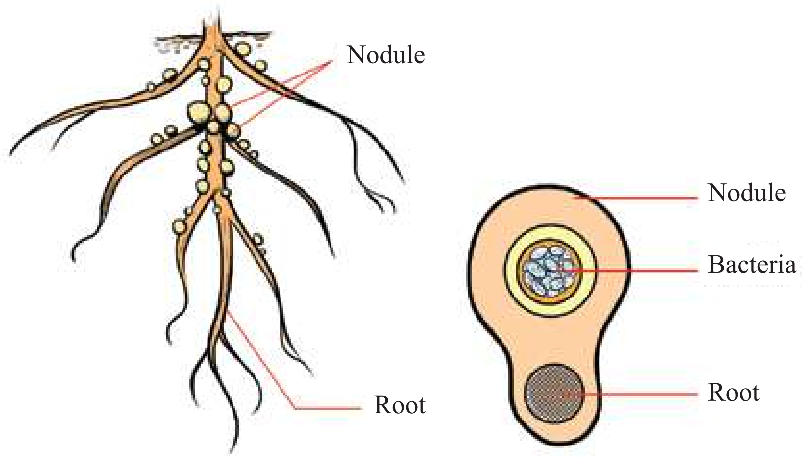
A flowering plant depends on worms and insects for its cross-pollination and on others birds and animals for the dispersal of seeds. For photosynthesis, green plants use carbon dioxide that is released by animals during respiration. Conversely, animals use oxygen released by plants in the daytime. Bacteria, fungi and different microorganisms in different ways affect plants, animals and worms and insects. It can briefly be said that mutual assembly and dependence are the key to the regulation of the activities of life. In the living world existing organic relationships between plants and animals can be designated with the term symbiosis. In symbiosis, the related organisms are called symbionts. The action-reaction, that occurs in between symbiotic organisms, is called interaction. It has also been clear from the discussion made above that the organism participating in interactions, are interdependent and none is self-sustaining. Environmental scientist Odum says that this interdependent relationship can occur in two ways:

(a) positive interaction and

(b) negative interaction.

(a) Positive interaction: The interrelationship, in which two organisms help each other, is called positive interaction. Of these symbiotic organisms, one or both may be benefited. This beneficial interaction can be grouped further into two categories named mutualism and commensalisms.

(i) Mutualism: The relationship is mutualism when in the association both the organisms are benefited. For example, a bee, or fly, etc. flies around from flower to flower to attain the nectar and as a result, the pollination is accomplished. Many birds and bats live on eating fruits, and they release seeds with their stools.



(A) Nodules in leguminous plant

(B) Longitudinal section of root and nodule

Figure: 13.08 Mutualism

In this way seeds are transferred and the distribution of plants is done. This seed helps to develop a new plant. The association of an algae and a fungus forms lichen. The fungus collects water vapour from the air and mineral salts to use for both of them. On the other side, the algae produces carbohydrates for itself and for the fungus. The rhizobium bacteria residing at the roots of leguminous plants form nodules, fix atmospheric nitrogen in them. They supply this fixed nitrogen to the host leguminous plant, and in return collect their carbohydrates from it.

(ii) Commensalisms: In this association only one organism gets benefited. Though the other associate is not benefited, it does not lose anything. For example, a creeper plant with its root is anchored in the soil and creeps up round a big tree. This way it collects a sufficient amount of light by spreading on other

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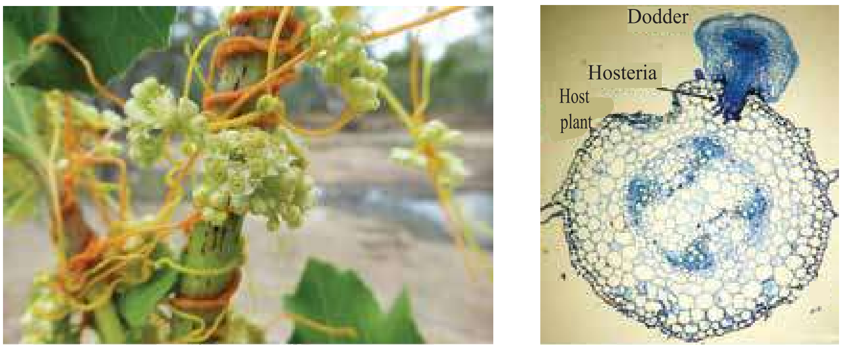
plant. Woody creeper does not depend on the plant that is providing shelter for it for food, and does not do any harm to it. Epiphytic plants collect food from the air but do not do any harm to the plant providing shelter. Some algae dwell in bodies of other plants, but do not do any harm to them.

(a) Epiphytic Plant **(b) Creeper plant**

Figure: 13.09 Commensalism

(b) Negative interaction: In this case the relationship is detrimental to one or to the both. Negative interaction can be grouped into three categories, such as-

(i) Exploitation: In this case one organism enjoys its rights by exploiting directly or indirectly another organism from its rights, for example, dodder. A dodder with the help of the absorbing structure hosteria collects food from the plant, which has provided it with shelter. A cuckoo is never able to build a nest. It lays its egg in the nest of a crow, and the crow hatches its egg for it.



(A) Dodder and host plant. (B) Host- parasite relationship through longitudinal section

Figure : 13.10 Exploitation

(ii) Competition: There may be tough competition between organisms for light, air, water and food. In this competition, the stronger organism survives and the weaker one is abandoned. This is a good example of inter and intra-species struggle of Darwinism.

(iii) Antibiosis: If the growth and development of any organism is partly or wholly interrupted by the biochemical substance produced by another organism, then this process is called antibiosis. This type of relationship is mainly found in micro-organisms. The reason behind the discovery of penicillium by Alexander Flemming was keeping antibiosis along with penicilium.

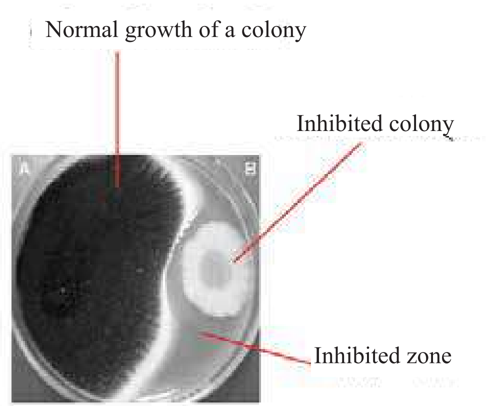


Figure: 13.10 Antibiosis

It becomes clear from the discussion made above those actions and reactions are continuously occurring in between the organisms existing in an environment, and every component is interrelated to each other. By this relationship, some are becoming benefited and some are harmed. This way, they are maintaining the balance of the environment.

13.6 Significance and method of conserving environment

It is essential to conserve the environment to maintain habitable conditions for the organisms living on our planet, the Earth. There are innumerable organisms on the earth, and for their survival, there are different substances, such as, soil, water and air etc. All these natural components are being damaged to meet the different types of human demands, such as, food, clothes, dwelling place, and health care for the excessive population of the present world. In this catastrophic situation, if people do not become more conscious disaster will occur. In our environment from the smallest plants, worms and insects to the large animals and plants, none is valueless. In the realm of nature all the organisms and the inanimate substances are each other tied closer. The biodiversity is formed with millions of species of plants, worms and insects, birds, animals and humans etc. and the existence and well being of human race are based on it. Forests, hills, water reservoirs, sea are the very essential harbours of biodiversity. So, biodiversity will be sustained if the environment is well conserved. It is to be remembered that biodiversity can sustain without human but human cannot be sustained without diversity.

If the environment especially the forests are degraded, the rate of rainfall is reduced, and the cultivation of crops is hampered. The temperature is raised for the increasing amount of greenhouse gases (CO_2, CO_4, N_2O etc.) and it is called enhanced greenhouse effect. For the enhanced greenhouse effect sea level will rise and consequently, vast coastal areas will be inundated, weather will be changed, forest will be damaged, crops will be destroyed by different pests and the severity of storm and tornado will rise. If the environment is well conserved, it will be possible to be safe from enhanced greenhouse effect. This is why from now on all the best measures should be taken to conserve the environment.

Nowadays man has raised his voice for the conservation of environment because of his own existence. The whole world has to come forward for the maintenance of a healthy environment. It is also essential to organise people for the protection of environment. Plantation should not be limited only in a weekly or monthly programme. For cutting a tree, two trees should immediately be planted. Tree should not be planted in unplanned way. It should be planted with accordance to the suitability of surrounding ecosystem. Before setting any industry and mills in any locality, their adverse effects on the environment should be first taken into consideration and safe disposal of industrial waste should also be ensured. Urbanisation should be well planned. Massive plantation should be carried out side by side with the rapid urbanisation. Instead of wood, solar energy should be used as fuel. Excessive use of chemical fertilizers and pesticides damage the normal quality of soil and degrades beneficial microorganisms, terrestrial worms and insects, aquatic and terrestrial ecosystems. So, the use of bio-fertilizers should be increased. Use of chemical fertilizers and pesticides should be minimized.

Excessive population in different ways causes serious desolation on the environment. Population should be controlled and communities of well-educated people should be developed. Public awareness should be raised about negative impacts of environment and to control the environmental pollution. Mass media should play a prime role in this regard. The emission of greenhouse gases, carbon dioxide, methane, nitrous oxide should immediately be reduced. To control the soil erosion in coastal areas, massive plantation must be accomplished. This way soil erosion will be controlled and the tornado and cyclone will be resisted as well. Normal flow of water should be conserved by dredging river and water bodies. This way salinity and water logging will be removed and the aquatic ecosystems will remain in a normal state.

It is essential to conserve the biodiversity for the sustenance of healthy environment and with this view all the plant and animal species, which are on the verge of extinction from nature, should be conserved by special processes. Measures should be taken to control the pollution of air, water, soil and sound. International and national principles and guidelines should strictly be followed.

Individual Activity

Activity: Find out what are the causes of polluting the environmental components in your locality and prepare a report on it.

Exercise

Short answer questions

1. What is symbiosis? Explain it.
2. What do you understand by plankton?
3. What is a parasitic food chain?
4. What is antibiosis?
5. What is mutualism?

Essay type questions

1. The balance of environment is restored through the interaction and interdependence of different organisms. Explain.

Multiple choice questions

1. Which one is a saprophytic food chain?

   a. grass → deer → tiger b. saprophyte → decomposer → *Amoeba*

   c. zooplankton → fish → *hydra* d. green plants → bird → fox

2. Among the animals through commensalisms-

   i. one is benefited from the associates.

   ii. though none of the associates is benefited but none is also harmed.

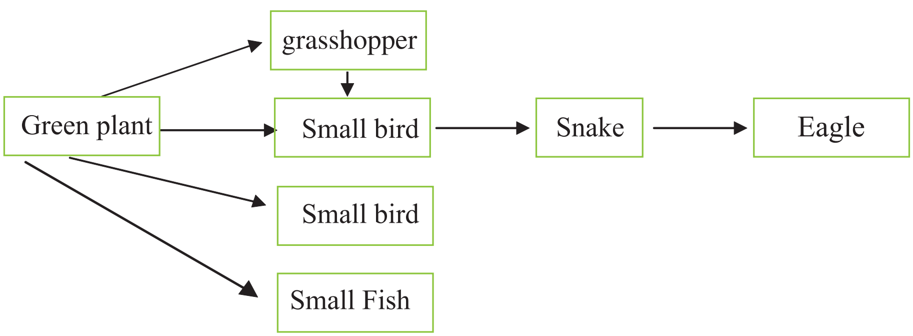
   iii. both of the associates become benefited.

Which one of the following is correct?

a. i b. i & ii

c. ii & iii d. i, ii & iii

Answer to the questions 3 and 4 in the light of the figure given below-



3. How many food chains are there in the diagram mentioned above?

   a. 1 b. 2

   c. 3 d. 4

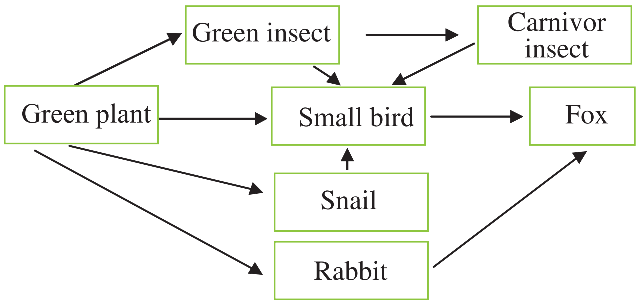
4. In the light of the stem which one is the consumer of second level?

   a. Small fish b. Snake

   c. Rabbit d. Grasshopper

Creative questions

1.



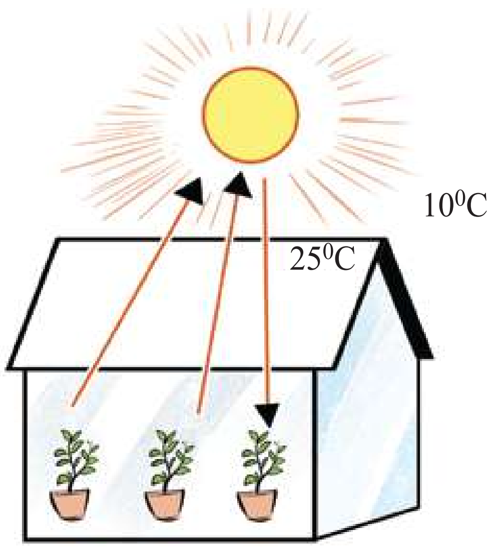
a. What are decomposers?

b. What is a food web? Write in detail.

c. In which food chain in the food web mentioned above is the most energy spent?

d. Analyse what the consequences will be occurred in the ecosystem if the bird in the food chain mentioned above is extinct.

2.



a. What is biodiversity?

b. Write in detail what you understand by commensalisms.

c. Explain the causes of difference in temperature in the figure mentioned above.

d. Analyse the impacts of the reactions caused by the process mentioned in the diagram above.

Chapter Fourteen

Biotechnology

The Bangladesh Jute Genome Project has unraveled the mysteries of jute life (genome sequence).

Biotechnology is an applied branch of biology. At the very beginning of 20th century genetics developed in different ways and genetics enriched with different information. After the discovery of genetic unit or the nature, chemical, molecular structure of gene and regulating process of biological phenomena, biologist should started research on how the gene can transplant from one living cell to another. A new branch of biology named Biotechnology has been established.

It has opened new horizons in solving many real problems in different branches of science. To improve human health care, to develop advanced type of crops, to increase the quality and amount of crops, to protect the environment, this technology has opened up doors of immense potentials. In this chapter, we will try to know the facts about this technology briefly.

At the end of this chapter, we will be able to-

- explain the concept and significance of biotechnology;
- explain tissue culture;
- describe the use of tissue culture in developing crops;
- explain the objectives of genetic engineering;
- describe the use of genetic engineering in producing crops;
- describe the use of genetic engineering in producing insulin and hormones;
- evaluate the efficacy of biotechnology;
- describe the use of biotechnology in curing diseases of animals;
- draw posters about the use of biotechnology and genetic engineering;
- understand the contribution of biotechnology in our everyday life.

14.1 Biotechnology

The word biotechnology is derived from two words biology and technology. The word biology means special knowledge about organisms and technology means a manner of accomplishing a task specially using technical processes, methods or knowledge. The interrelation between biology and technology is biotechnology. In 1919 Hungarian engineer Karl Ereky first coined the word biotechnology. Through the application of this technology, from a cell of an organism, microorganism or a part of it, any new organism (plant or animal or microorganism) with new characters is developed or any processed or by product substance is produced from this organism.

In the advancement of science, biotechnology is not only a new addition. From the dawn of human civilization, man started to apply biotechnology. Man acquired the knowledge of fermentation and brewing about 8000 years ago. In 1863 after the discovery of Gregor Johan Mendel's laws of heredity in the field of genetics, biotechnology started its new advancement. With the continuity of the invention of double helix model of DNA by Watson and Crick in 1953, today's biotechnology has emerged.

Now a days, tissue culture and genetic engineering from many methods of biotechnology are being used in multidimensional aspects in agriculture and other fields.

14.2 Tissue culture

Due to the presence of totipotent stem in different parts of plant, it is possible to grow exactly the same type of plant from any part of a plant. It is the principle of tissue culture. Generally one or more than one type of a group of cell is called tissue. This group of cells having the same origin and performing same activity collectively.

The process of separating a tissue from a plant and allowing it to grow in a nutrient medium is called tissue culture. Tissue culture is comparatively a new branch of botany. In plant tissue culture, any detached part of a plant or any part (pollen grain, terminal or lateral bud, part of root) is cultured in any nourishing and sterilized medium. All the elements for the nutrition and growth of tissue are supplied with the sterilized medium. The part of a plant being separated for tissue culture is called 'explants'.

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14.2.1 Steps of tissue culture

(a) Selection of mother plant: The healthy, disease resistant plant with high quality is selected for plant tissue culture.

(b) Preparation of culture medium: For the growth of the plant culture, culture media are made by mixing proper amount of essential mineral nutrients, vitamins, phytohormones, sucrose and condensing substance agar to bring the medium to a semisolid state.

(c) Establishment of sterilized medium: Taking the culture medium in a glass container (test tube or conical flask), its opening is usually closed with a cotton plaque. Later in an autoclave machine, keeping it at the temperature of 121° C under 15 lb/sq. inch pressure for 20 minutes, the medium is sterilized. Then again after closing the mouth or opening the glass container, it is kept in a room with the controlling of light and temperature (25±2° C) for the growth of the explants. After the turning of the medium into a cold and semisolid state, explants are inoculated on it. In this stage, the tissue placed on the medium through repeated cell division turns directly into a plantlet or callus or a cluster of cells without differentiation.

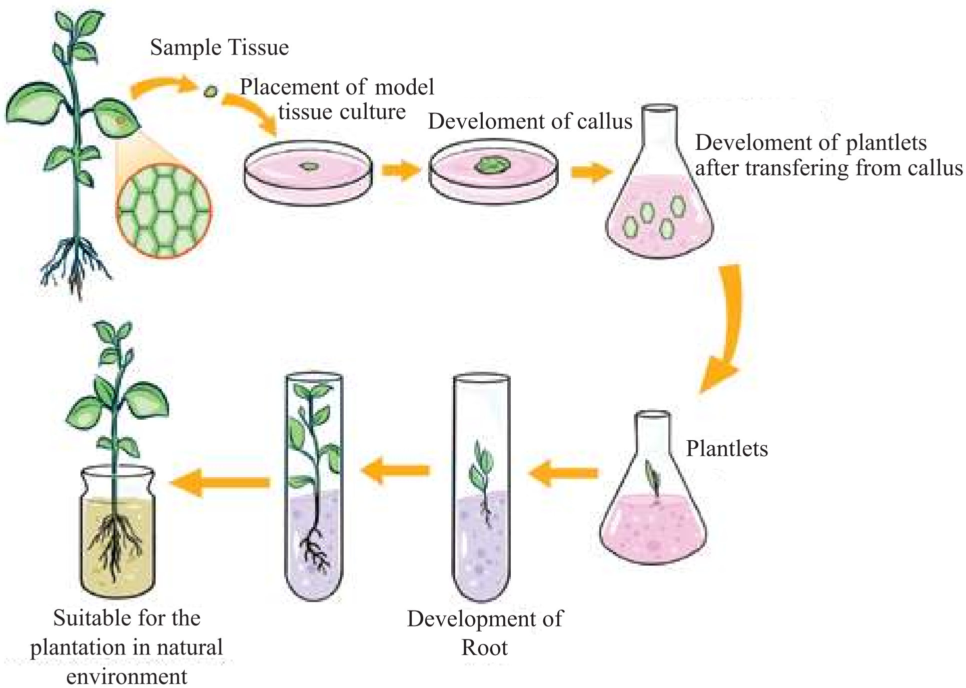

Figure: 14.01 Consecutive steps of tissue culture

(d) Transfer in root developing medium: If no root is developed in the plantlets by this time, then after attaining a definite height, shoots are cut and again placed in the root developing medium.

(e) Transfer to natural environment or to field level: After washing with water and putting them outside the room on the tubs, the plantlets are allowed to adapt with the external environment. When the grown up plantlets become fresh and strong, they are once planted in soil in natural environment.

14.2.2 Use of tissue culture

By utilizing the tissue culture, now a days in the reproduction of plants and in the field of developing new variety, much achievement has been obtained and new horizons have evolved with the vast hopes. From the plant part in a short period of time, innumerable plantlets can be produced with the same characters. Easily disease free and especially free from viruses, plantlets can be produced. It can be free from the limitation of producing plantlets in the specific season. As the facility of producing plantlets in a short period of time in a very conspicuous place, sufficient number of plantlets can be produced and the problem of storing of seeds can be avoided. The attainment of plantlets of those plants which do not reproduce by seeds and they can be speedily transferred in a short period of time in fresh condition. Tissue culture technology is well accredited for the production and conservation of the species about to be extinct. The plants, which do not produce endosperm, can be developed directly by culturing their embryo. The rapid multiplication of the plants, which do not reproduce through sexual reproduction or of which rate of natural reproduction is low, can be done by culturing their embryo. Tissue culture technology is being used for the development of the plants of new characters. French scientist George Morel (1964) proved that it is possible to obtain 40 thousand plantlets from a meristem of the orchid plant named *Cymbidium* in a year. In natural way, only a limited number of *Cymbidium* plantlets are produced in a year. In Thailand 50 million plantlets, which are mostly orchids, are produced through tissue culture method in a year. By exporting flowers, the countries like Thailand, Singapore, Malaysia etc. earn every year crores of foreign currency. In 1952 the scientist named Martin obtained disease free Dalia and Potato plant by culturing meristems of them. Meristems is the growing part of the plants where such types of undifferentiated cells are found which can produce a variety of organs or tissue (such as branch, leave, root etc.) subject to appropriate situation.

Nowadays, it has become a regular practice to make some plants free from viral diseases by culturing their meristems, such as potato tubers. In Malaysia the reproduction of Oil Palm is done through tissue culture. It is possible to obtain 44 crores of plantlets of Garland Chrysanthemum from a vegetative part of it through tissue culture. Commercially the perfume atar is being produced from the suspension of *Jasminum* using this technology in many different countries. For the operation of heavy engine such as airplane, rocket etc. a kind of oil from sperm whale is required. This sperm whale is gradually becoming extinct. In an alternative way, this oil is being derived only from a plant named jojoba but this plant does not grow anywhere except in a special desert environment (such as, in Arizona, California), and their reproduction is also time consuming. Through tissue culture, not only the reproduction of this plant has become possible but also it has been changed to a level to adapt to the climate of India.

In Bangladesh by this time much more successes have been made through tissue culture, such as it has become possible to produce the plantlets of different orchids grown in the country and in other countries. Disease resistant and high yielding plantlets of banana, wood apple, jackfruit have been produced. Garland chrysanthemum, gladiolus, lily, gerbera, garden carnation etc. flower producing plantlets also have been produced. Plantlets of different types of pulses, groundnut, mustard, brinjal, jute have also been produced. It has become possible to produce disease free plantlets and seed microtuber (by sowing it is possible to produce potatoes from naturally produced i,e smaller size than tuber) of potato applying tissue culture. Apart from this in Bangladesh, tissue culture of various medicinal plants (such as Ashwagandha, Sarpagandha etc.) is being done.

14.3 Genetic engineering

Genetic engineering is the technique of transferring a DNA with a specific gene from an organism to a desired organism. In a simpler way it can be said that changing DNA of any organism to develop new characters, is called genetic engineering. All the techniques through which gene is being transferred is combined called recombinant DNA technique. Following this technique the transfer of the desired part of DNA is cut from an organism and set it into a DNA of another organism to develop a new character, the later DNA is called recombinant DNA. The process of developing recombinant DNA is called DNA technology or gene cloning.

With this technology, the transfer of the desired part of DNA from a bacteria to human being, from plant to animal and from animal to plant have become possible. The organism with the new characteristics is called GMO (Genetically modified organism) or GE (Genetically Engineered) or transgenic.

GMO and transgenic organism are not the same. Any change that occurs in a gene through mutation or in any other way is called genetic modification. For thousands of years before the discovery of genetic method, man developed genetically modified desired character by artificial selection of nature. The process happening in nature for millions of years is called biological evolution. By the blessings of the genetic technology, organic evolution occurs in a very controlled way and in a very short time. Organism grows in this method is also a GMO. Transgenic organism refers to those organisms where one or more than one gene which has been taken from different types of species or varieties have been inserted into genome.

14.3.1 Stages of the Preparation of GMO or DNA recombinant

In human dietary canal, there lives a type of bacteria called *Escherichia coli.* Researching on this bacteria, most of the techniques of genetic engineering has been developed. Genetic engineering or recombinant DNA technique is accomplished by the steps mentioned below (Figure 14.2):

(a) DNA with the desired gene is separated from donor organism. Then plasmid DNA is separated from a bacteria to use it as a carrier of the gene. Plasmid is an individual DNA besides the chromosome in bacteria cell, which is able to divide or able in self-division.

(b) In this step plasmid DNA and donor DNA are divided by a special enzyme. Desired gene is present in any of the part (location) of the donor DNA.

(c) Then donor DNA is placed in between the two terminal parts of a plasmid by lipase enzyme. Lipase here act as adhesive. As a result DNA recombinant forms with the specific desired gene. This recombinant plasmid now carries the desired part of donor DNA.

(d) In this stage the bacteria recombinant DNA emerges into receiver bacteria. The method of emergence of donor's chopped DNA part into bacteria is called transgenic organism. A new species of bacteria or organism created due to transformation is called transgenic organism.

(e) In this stage bacteria with recombinant plasmid are identified and then separated. Bacteria with desired genes are then made reproduce rapidly. Now each of these reproduced bacteria contain the desired gene. The process by which gene is reproduced is called gene cloning. To use the gene, plasmid is separated again.

It is noted here that genetically modified organisms (GMO) through biotechnology possess the potential risk of exerting harmful effects on the environment and human health. In order to assess these possible adverse effects and successful application of biotechnologies, internationally determined biosafety guidelines are followed throughout the world including Bangladesh.

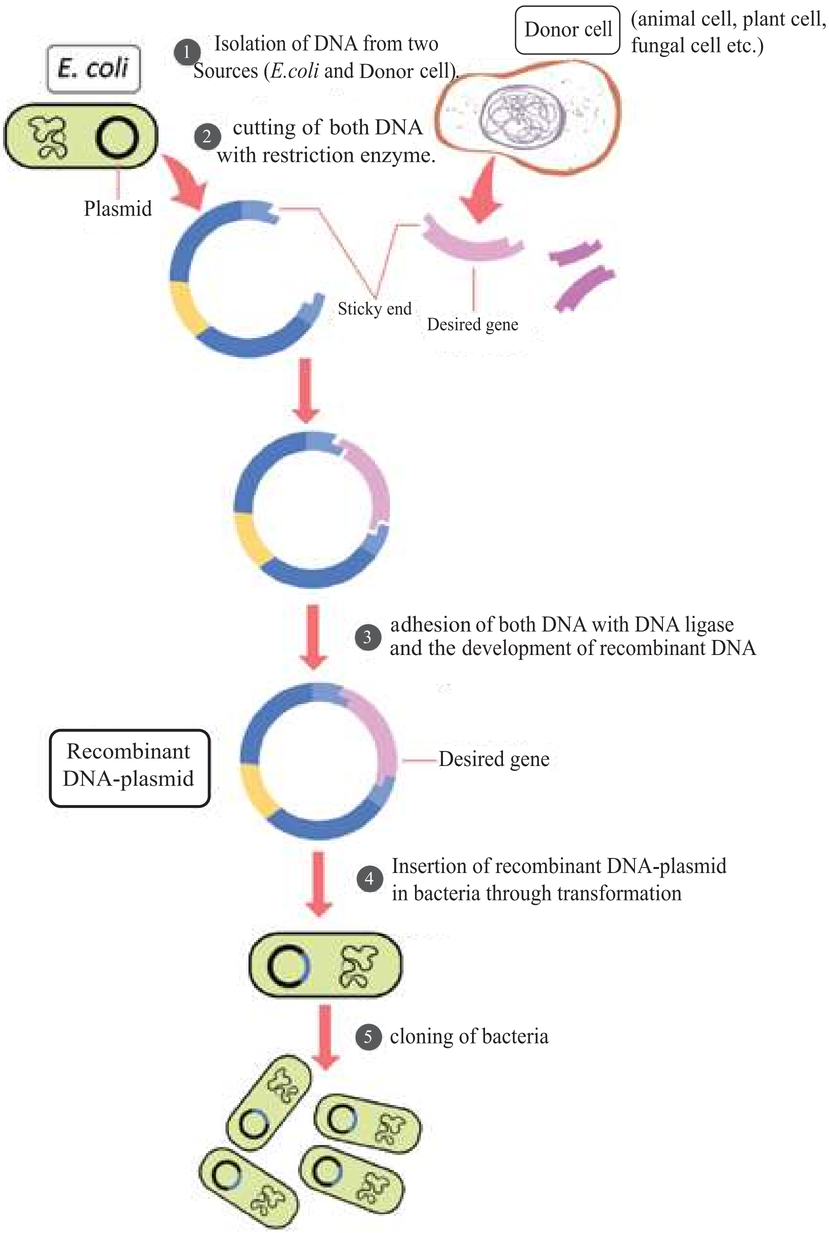

Figure 14.02: Recombinant DNA Technology

This technology is being significantly used by innovators or investors because in a short period of time very accurately desired characteristics can be transferred by transferring genes. Genetic engineering is effective for the development of new crops in comparison with traditional ways of reproduction, because the transfer of gene is similar or limited to the nearest species through traditional reproduction. But it is possible to directly transfer one or more genes to nearer or distant species through genetic engineering. Moreover, it requires a long time to achieve desired results through the traditional way of reproduction. It is possible to obtain plants or animals or microorganisms with desired characteristics in a very short period of time with genetic engineering. In case of traditional reproduction, unexpected genes may be transferred with the desired gene and the successful transfer of the desired gene remains uncertain. In genetic engineering, there is no possibility of transferring unexpected genes and the chances of transferring desired gene will be much higher. Traditional reproduction is not controlled by any rules or methods of bio-safety, but in the case of genetic engineering it is controlled by internationally accredited rules and methods of bio-safety. Toxicity is not tested in traditional reproduction but is done in genetic engineering.

14.3.2 Genetic engineering in use

Genetic engineering or recombinant DNA technology is the most modern biotechnology. The main objective of the technology is to develop organisms with new and advanced characteristics and by which human beings can be benefited. By this time, notable successes have already been achieved through this technology.

(a) In developing crops : Insect resistant varieties of crops have been developed by this technology. Through the entrance of the gene of Bacillus thuringiensis bacteria, genetically modified crops like Bt corn, Bt cotton has been developed. In the same way Bt rice (China) produced. Bt cotton and Bt brinjal are currently being cultivated in Bangladesh. These crops are resistant to harmful insects under Moth like Lepidoptera and Beetles like Coleoptera orders. Using this technology, virus resistant varieties of crop have been developed, for instance by transferring the genes, tomato mosaic virus (ToMV), tobacco mosaic virus (TMV) and tobacco mild green mosaic virus (TMGMV), resistant varieties of crop have been developed. The variety of papaya that is resistant to ring spot virus (PRSV) has also been developed. Research is being carried out for the development of late blight resistant variety of potato by transferring late blight fungus resistant gene.

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Varieties of corn and cotton tolerant to herbicides have been produced by genetic modification.

Scientists have become able to develop herbicide tolerant tomatoes by transferring herbicide tolerant genes into the tomato from bacteria.

This way herbicide tolerant varieties of soyabean, corn, cotton, canola etc. have been produced.

Through genetic engineering more than one trait can be inserted into the same plant. Nowadays, this type of transgenic plants is commercially available. For instance, side by side both herbicide tolerant and insect-resistant characteristics have been inserted in corn and cotton.

Through genetic change, the nutrition value of some crops has been improved. For example, vitamin A i.e. beta-carotene gene has been transferred into rice. If this kind of rice is taken as food then no need to take vitamin A separately. Efforts to add iron to rice are being continued. Attempts are also made to develop salinity and drought resistant varieties of crops through genetic modification.

(b) In animals: In livestock, for example, transfer of the protein C gene has been done to increase the protein in cow-milk, though this is still at research level. Through genetic modification, genetic changes have been accomplished with sheep by transferring the growth hormone producing gene from human beings to it with the view of increasing its size and meat production. To improve the amount and quality of the sheep's fur, two bacterial genes, CysE and CysM, have been transferred to the genomes of sheep.

(c) In improvement of fishing: Transfer of the growth hormone gene of Salmon fish, through genetic modification, to catfish, common carp, loitta fish, nilotica can increase the size of the fishes by near about 60 percent.

(d) In healthcare: Hepatitis b-virus vaccine interferone is being produced from yeast through genetic modification. From genetically modified E.coli bacteria and yeast, insulin is being commercially produced for the treatment of diabetes by using the gene, which produces insulin in the human body. The human growth hormone and components of the stimulant for accelerated growth of granulocytes macrophage stimulating factor (GM-CSF) or colony are being produced from genetically modified *E.coli* bacteria and yeast, and these are being used for dwarfism, viral disease, cancer, AIDS etc.

(e) For environment protection: The areas of petroleum industry and refinery and coal mining are being made free from pollution because this technology is being used to make the environmental management easy and fast, such as management of industrial wastes and sewage. Dr. M.K. Chakraborty, by performing research on genetic engineering, has developed a variety of *Pseudomonas* bacteria which is able to disintegrate oil and hydrocarbon in any environment.

Individual Activity

Activity: Draw a poster on the use of biotechnology and genetic engineering, and present it to the class.

Individual Activity

Activity: Prepare a report on the scope of biotechnology and genetic engineering in Bangladesh.

Exercise

Short answer questions

1. How is culture medium prepared?
2. What do you mean by tissue culture?
3. What is explant?
4. What is genetic engineering?
5. What is transgenic?

Essay type questions

1. Mention the roles of tissue culture in plant reproduction and developing improved varieties of plants.
2. Discuss the roles of genetic engineering in improving crops.

Multiple choice questions

1. Which one is a special enzyme to cut DNA?
   a. Ligase b. Restriction
   c. Lactase d. Lipase

2. Biotechnology is applied to-
   i. fermentation
   ii. tissue culture
   iii. develop transgenic organism

Which one of the following is corect?

a. i & ii
b. i & iii
c. ii & iii
d. i, ii & iii

Read following stem and answer the questions 3 and 4.

Imtiaz found a very good variety of woodapple visiting his friend's house. To produce the plantlets with the same characteristics, he brought some lateral buds of the plant, and produced them in the university lab of the Botany department.

3. What is the process that Imtiaz followed in the lab?

a. transfer of gene
b. application of hormone
c. use of enzyme
d. tissue culture

4. Which one shows the consecutive steps of Imtiaz's activities?

a. preparation of culture media → inoculation of explant → development of plantlets → development of roots → transfer to natural environment
b. preparation of culture media → development of plantlets → development of roots → inoculation of explant → transfer to natural environment
c. selection of mother plant → preparation of culture media → inoculation of explant → development of plantlets → transfer to natural environment
d. selection of mother plant → preparation of culture media → development of callus → inoculation of explant → transfer to natural environment

Creative questions

1. In the garden belonging to a genetic engineer Dr. Hayder, the lemon plants are dying rapidly from disease though the lemon harvest is high. He finds that there are some lemon trees of the same species, which live for long time although they do not produce high yield. From these two varieties of lemon, he developed a new, high yielding and disease resistant variety. He produced the plantlets not using a traditional process but by a special process in his lab.

a. What is biotechnology?
b. What do you mean by GMO?
c. Explain the technique followed by Dr. Hayder for the development of lemon variety.
d. Explain the reasons for developing plantlets through the special process by Dr. Hayder.

The End

2025 Academic Year

Nine and Ten : Biology

শিক্ষার শেকড়ের স্বাদ তেতো হলেও এর ফল মিষ্টি।

–অ্যারিস্টটল