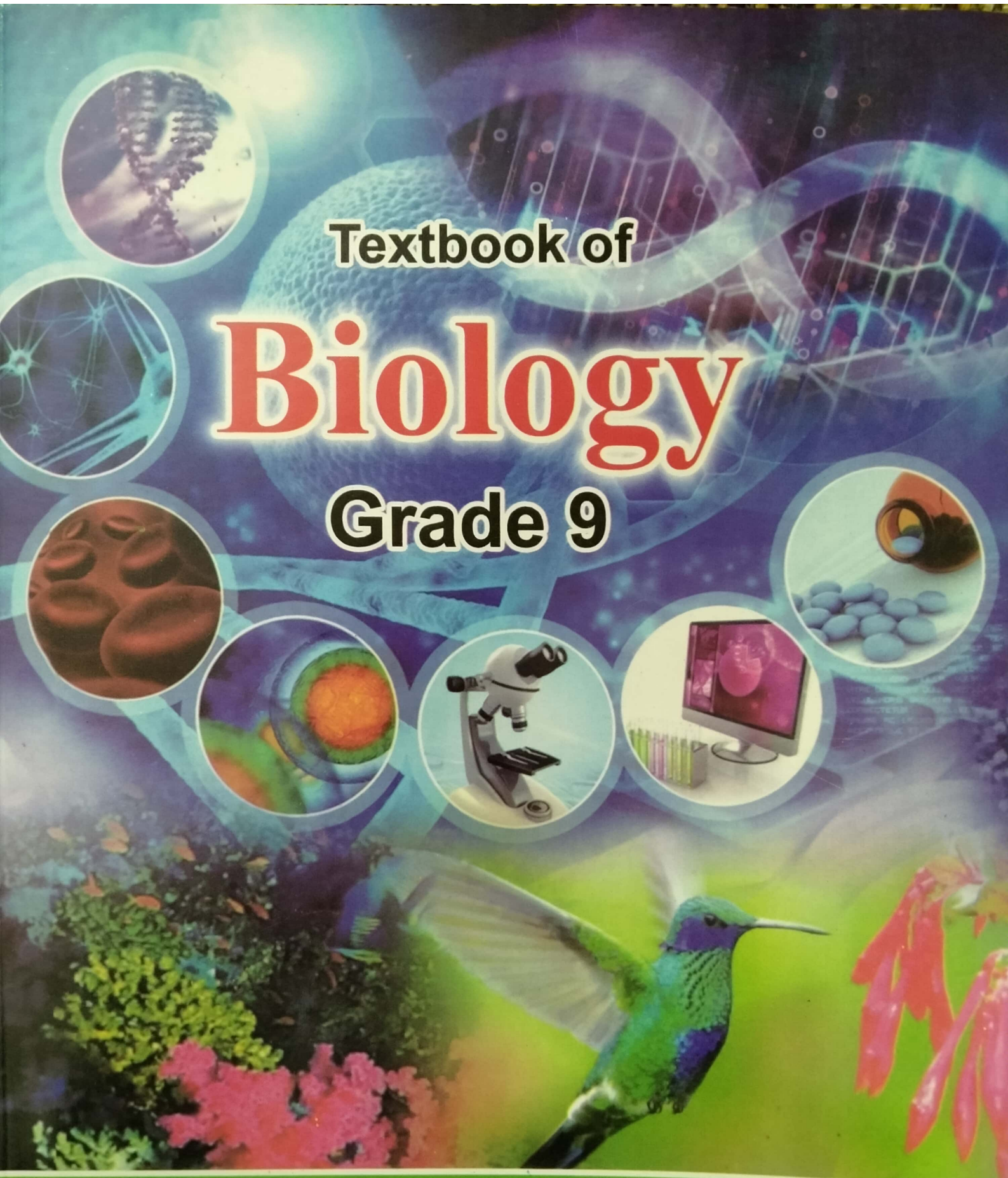


Textbook of
Biology
Grade 9

National Book Foundation
as
Federal Textbook Board
Islamabad

Textbook of

Biology

Grade

9

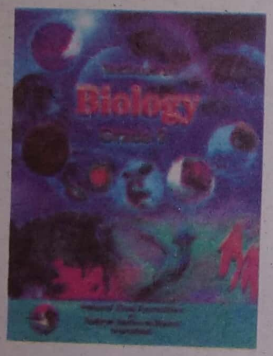
National Book Foundation
as
Federal Textbook Board
Islamabad

OUR MOTTO

• Standards • Outcomes • Access • Style

The material given in the box (Science titbits, Did you know, Critical thinking, STSC, Activity, Teacher's Point) and parenthesis, are not part of the text or SLO's.

Textbook of
Biology Grade - 9



Review Committee Members
Prof. Hamid Saeed
Prof. M. Nadeem Asghar
Prof. Dr. Zaheer-ud-Din Khan
Prof. Farrukh Shahbaz Hussain
Prof. M. Riaz Khan
Prof. Israr Ali

Authors : Jawaid Mohsin Malik, Dr. Sarwat Jawaid, Neelofar Shaheen, Ruquaya Shaikh, Nasreen Fatima, Sajid Ali Shah
Desk officer : Muhammad Hanif
Designer : Mr. Shahzad Ahmad
Management of : National Book Foundation
Incharge Textbooks : Muhammad Rafique, Assistant Director, NBF
First Edition : 2021 Qty: 50000
2nd Print : July 2021, Qty: 25000
Price : Rs. 140/-
Code : STE-605
ISBN : 978-969-37-1235-3
Printer : Ishaq Al-Fateh Printers, Lahore

Test Edition
Test Edition

For Information about other National Book Foundation Publications, visit our Web site **http://www.nbf.org.pk** or call **92-51-9261124, 9261125, 9260391** or Email us at: **nbftextbooks@gmail.com / books@nbf.org.pk**

PREFACE

Biology Grade - IX is developed according to the National Curriculum 2006 . It is presented under the new management and supervision of textbook development, principles and guidelines.

The standard includes higher thinking, deep knowledge, problem solving substantive conversation and connections to the world beyond the class room and achieve the target set by the curriculum. The special features of the textbook are:

- The textbook has coloured illustrations to capture the students' attention. Where necessary, concept mapping has also been incorporated.
- At the end of each chapter terms to know, ligating and planning, analyzing and interpreting science technoloy have been added
- The exercises include multiple choice questions, short answer questions and extensive questions.
- At the end of the book a glossary and has been annexed.

These interventions will serve as a guide for evaluating the students' skills development through the chapter knowledge and their abilities to apply knowledge to the scientific and social problems.

Quality of Standards and Actualization of Style is our motto. With these elaborations, this series of new development is presented for use. However there is always room for improvement and suggestion from the teacher and the community will be highly appreciated to make the book more valuable and to make the textbook more interesting, informative and useful for the students. After educational feedback, research report and reviewed by NCC through review committees, The book, **biology for Grade-IX for the year 2021.**

May Allah Guides and helps us. (Ameen).

Dr. Raja Mazhar Hameed

Managing Director

بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ

اللہ کے نام سے شروع جو بڑا مہربان، نہایت رحم والا ہے

Contents

SECTION 1

Study of Life and Biodiversity

1

INTRODUCTION TO BIOLOGY

Major Concepts

Of all the living organisms human beings are the most intelligent ones. With their intelligence human beings started learning. With their learning, science developed.

1.1 INTRODUCTION TO BIOLOGY

What is **science**? In ancient times science meant knowledge or learning. Today we define science as the study of the world around us. The study of science helps us to answer the how, what, where and why of our surrounding.

1.1.1 DEFINITION OF BIOLOGY

The word biology consists of two Greek words *bios* meaning life and *logos* meaning thought, reasoning and study. **Biology** is the study of living organisms. It helps us to explain how living things relate to one another and to their surroundings.

1.1.2 DIVISION AND BRANCHES OF BIOLOGY

Biology has three main divisions: Botany, Zoology and Microbiology. **Botany** is the study of plants. Zoology is the study of animals. **Microbiology** (*micro*: tiny) is the study of micro-organisms e.g., viruses, bacteria etc. By dividing biology into a number of branches it is convenient to study it. Some of the major branches of biology are:

1. **Morphology**: The study of the form and external structure of the organisms is called morphology.
2. **Anatomy:** The study of the internal structure of the organisms is called anatomy. Anatomy is also called **internal morphology.**
3. **Physiology:** The study of the functions of various organs of the organisms is called physiology.
4. **Histology:** The microscopic study of tissues of organisms is called histology.

5. **Cell Biology:** The study of the structure and functions of the cell is called cell biology
6. **Genetics:** The study of genes, and heredity in organisms is called genetics.
7. **Embryology:** The study of the developmental stages of an organism from egg to the formation of a new organism is called embryology.
8. **Palaeontology**: The study of fossils is called palaeontology.
9. **Taxonomy:** The classification and naming of organism is called taxonomy.

Fossils are remains of the living things preserved by natural process. Fossils help the study of life in the past and process of evolution.

10. **Environmental Biology:** The study of the interrelationship of organisms and their environment is called environmental biology. It is also known as ecology
11. **Socio-biology:** The study of social behaviour of the insects/animals that make societies e.g., ants, honey bee is called socio-biology.
12. **Parasitology:** The study of parasites is known as parasitology.

The parasites derive its nutrients and shelter from the host, and does harm to its host.

13. **Immunology:** The ability of the body to protect itself from foreign substances and cells including infectious microbes is called immunity and the study of immunity is called immunology.
14. **Entomology:** The study of insects is called entomology.
15. **Pharmacology:** The science that deals with the study of drugs is called pharmacology.
16. **Biotechnology**: The study of use of different techniques to manipulate the living organisms for the benefit of mankind is called biotechnology.

1.1.3 RELATIONSHIP OF BIOLOGY WITH OTHER SCIENCES

Biology in one way or other is integrated with other disciplines of science. The animals move, walk or run on the principles of physics. There is a similarity between working principle of lever in physics and human limbs. The behaviour of atoms and molecules underline and explain the behaviour of living cell. The physical structure of atoms and molecules determine their chemical properties and the roles they play in cells. To understand biology, basic knowledge of chemistry is necessary. The biology is not an isolated science. It is associated with other branches of science.

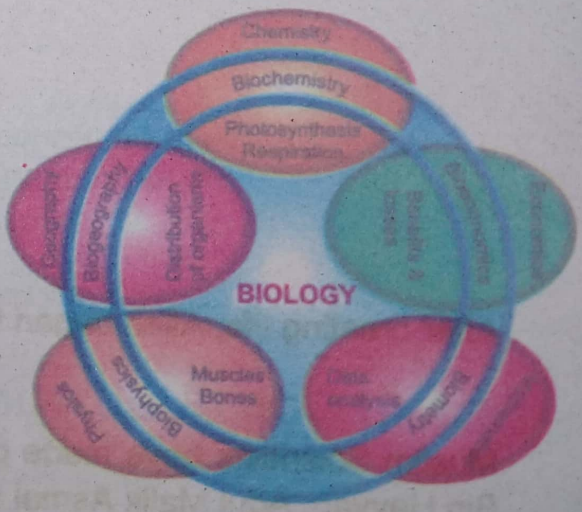


Fig. 1.1: Relationship of biology with other sciences

1. **Biophysics:** Biological organisms work on the principles of physics e.g., movement of muscles and bones. The study of biological phenomena on the principles and laws of physics is called biophysics.
2. **Biochemistry:** The study of chemical constituents found in an organism and chemical reactions taking place in the living organism is called biochemistry. Living organisms consist

1.1.4 QURANIC INSTRUCTIONS TO REVEAL THE STUDY OF LIFE

What science is finding today, the Holy Quran has already hinted several hundred years ago. The Holy Quran is a book for all times to come. It gives us spiritual, moral and practical knowledge. There are many verses in Quran which tell us about the origin of life. Few are here;

1. Origin of Life in Water

وَجَعَلْنَا مِنَ الْمَآءِ كُلَّ شَىْءٍ حَيٍّ

"We made every living thing from water"

(Sura Ambia 21, Ayat-30)

As we know that living things consists of 85 to 90 percent of water. So all living things have come out of water and thus they have a common origin.

2. Creation of Man

خَلَقَ الْإِنْسَانَ مِنْ صَلْصَالٍ كَالْفَخَّارِ

"He made man from clay like the potter"

(Sura Rehman, Ayat 14)

Creation of man consisted of two steps. The first step was the creation from water. The second step was to mix clay with water to create man. It can be said for all animals as man shares all characteristics of life with other animals.

3. Reproduction

ثُمَّ خَلَقْنَا النُّطْفَةَ عَلَقَةً فَخَلَقْنَا الْعَلَقَةَ مُضْغَةً فَخَلَقْنَا الْمُضْغَةَ عِظٰمًا

فَكَسَوْنَا الْعِظٰمَ لَحْمًا

"Then fashioned we the drop a clot, then fashioned we the clot a little lump, then fashioned we the little lump bones, then clotted the bones with flesh,"

(Sura Al-mominoon, Ayat 14)

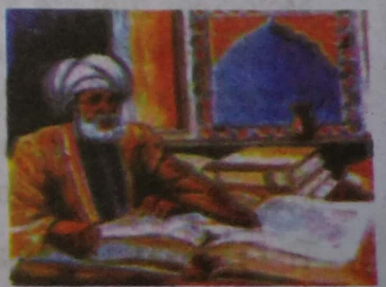
After creating life, Allah began the process of reproduction for the continuity of life.

1.1.4.1 CONTRIBUTION OF MUSLIM SCIENTISTS

Muslim Scientists have made great contribution in the field of biology. The knowledge of Jabir Bin Hayyan, Adul Malik Asmai and Bu Ali Sina have contributed much in the development of present-day knowledge of plants and animals.

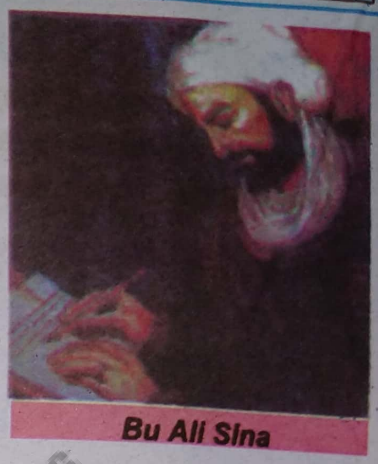
1. Jabir Bin Hayyan

He introduced experimental investigation in chemistry. He wrote number of books on plants and animals. His famous books are "Al-Nabatat" and "Al- Haywan".



Jabir Bin Hayyan

2. Bu Ali Sina


Bu Ali Sina

Bu Ali Sina is known as the founder of medicine. He was a physician, philosopher, scientist, astronomer and a poet. His famous books are "The Book of Healing" and "The Canon of Medicine".

3. Abdul Malik Asmai

Al-Asmai is considered as the first Muslim scientist who contributed to Zoology, Botany and Animal husbandry. His famous book is "Kitab Khalaq-al- Insan".

1.2 THE LEVELS OF ORGANIZATION

Whether we study an individual organism or the world as whole, we can identify a pattern of increasing complexity.

Bioelements

About 16 of the 92 natural elements are essential to life. These are called **bio-elements**.

Out of these bioelements:

- Only six (O, C, H, N, Ca and P) make 99% of the total mass.
- Other ten (K, S, Cl, Na, Mg, Fe, Cu, Mn, Zn and I) collectively make 01% of the total mass.

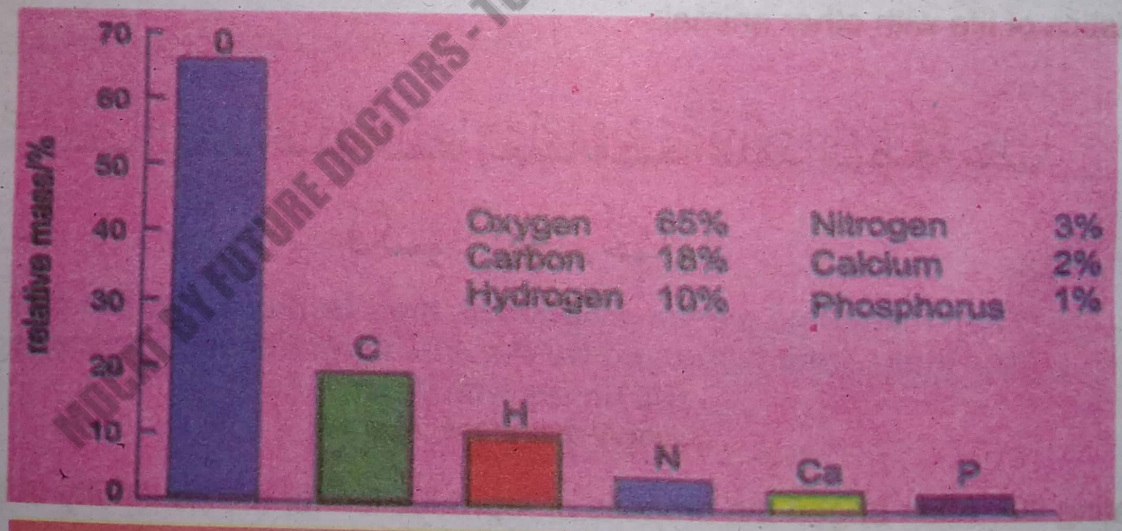


Fig. 1.2: Percentage composition of six bio-elements, by mass of a human being.

Biomolecules

Molecules that are found only in living organisms are called **biomolecules.** The four fundamental kinds of biological molecules are carbohydrates, proteins, lipids and nucleic acids. The small bio-molecules in living things are called **micromolecules.** These are sugars, fatty acids, amino acids and nucleotides. Each of the small molecules can be a unit of large bio-molecules. The large organic molecules are called **macromolecules.** For example, starch, protein, DNA etc.

The Level of Organization, its explanation and example are given in the following table.

Table 1.1: The Level of Organization and its explanation

Level of Organization	Explanation	Example
 Atomic Level	Atoms are defined as the smallest unit of an element that still maintains the property of that element.	Carbon, Hydrogen, Oxygen
 Molecular Level	Atoms combine to form molecules which can have entirely different properties than the atoms they contain.	Water, DNA, Carbohydrates
 Organelle Level	Biomolecules assemble in a specific way to form organelle. Organelles are sub-cellular structure.	Nucleus, ribosomes
 Cellular Level	Cells are the smallest unit of life. Cells are enclosed by a membrane or cell wall and in multicellular organisms often perform specific functions	Muscle cell, Skin cell, Neuron
 Tissue Level	Tissues are groups of cells with similar functions	Muscle, Epithelial, Connective
 Organ Level	Organs are two or more types of tissues that work together to complete a specific task.	Heart, Liver, Stomach
 Organ System Level	An organ system is group of organs that perform related functions.	Digestive System, Circulatory System
 Organism Level	An organism has several organ systems that function together.	Human

Cellular organization

The organizations of organisms on the basis of cells are: (1) Unicellular organization (2) Colonial organization (3) Multicellular organization

Unicellular Organization

The organisms that consist of only one cell are called unicellular organisms. All life activities are carried out by single cell. The most familiar example of unicellular organisms is *Amoeba proteus*. Amoeba shows all the features of life e.g., nutrition, respiration, locomotion, reproduction etc.

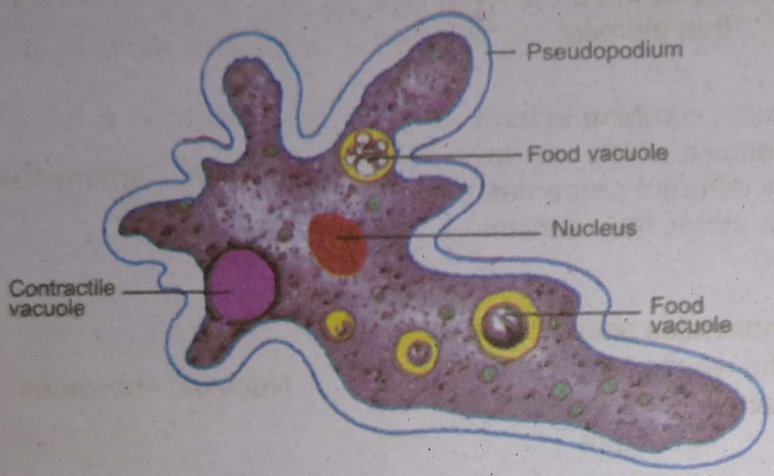


Fig. 1.3: Amoeba proteus

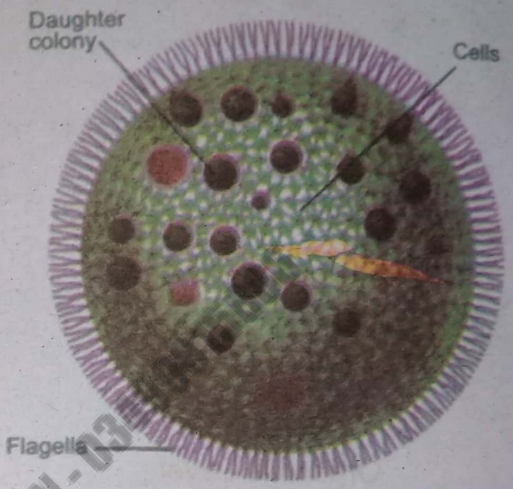


Fig. 1.4: Volvox colony

Colonial Organization

The organization in which many cells live together as independent organisms e.g., Volvox. Volvox is a colony of cells i.e., there is loose association of cells. There is no division of labour among them so tissues and organs are not formed.

Multicellular Organization

The organisms that consist of many cells are called multicellular organisms. e.g., frog, man, mustard plant etc. The different functions performed by different cells and tissues are called **division of labour**. As a cell or tissue becomes more specialized, it becomes increasingly more and more dependent on its fellow cells. For example, a muscle cell depends on blood cells for its need of oxygen.

Mustard plant

The botanical name of mustard plant is *Brassica campestris*. It can be divided into two parts on the basis of functions. Vegetative part consists of root, stem, branches and leaves, which do not take part in sexual reproduction. Reproductive part consists of flowers, which directly take part in sexual reproduction, forming seeds and fruits.

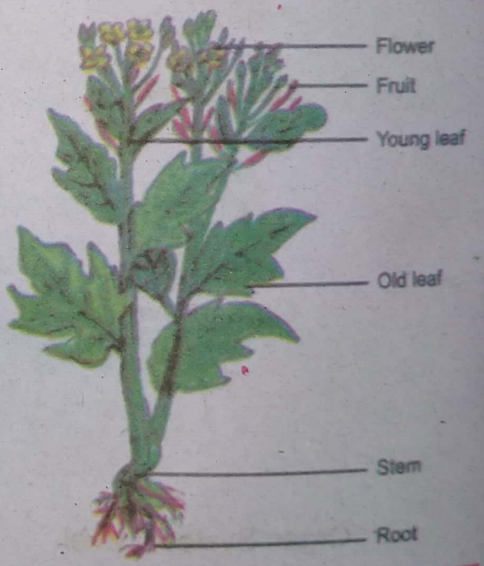


Fig. 1.5: Mustard plant

Frog

The biological name of frog is *Rana tigrina*. It is an amphibian. The body of a frog consists of head, trunk, and limbs.

Fig. 1.6: Frog

PRACTICAL WORK

Identification of organs and organ system in a dissected frog

(Dissected by the teacher)

The following is the organ system of frog.

Systems	Organs
Digestive System	Oesophagus, Liver, Gallbladder, Pancreas, Stomach, Duodenum, Ileum, Rectum
Respiratory System	Nostril, Buccal cavity, Lungs, Skin
Circulatory System	Heart, Arteries, Veins, Capillaries, Blood, lymph
Excretory System	Kidneys, Urinogenital duct, Urinary bladder, Cloaca
Nervous System	Brain, Spinal cord, Nerves

Materials required: Preserved frog, dissecting tray, dissecting kit.

Procedure: The teacher will dissect an unconscious frog on a dissecting tray. First the teacher will demonstrate the various organ and organ system to the students then will ask the students to study in groups or individually

Use the above diagram to:

1. Locate and identify the organs of the digestive system.
2. Identify the parts of the circulatory and respiratory system that are in the chest cavity.
3. Use a probe and scissors to lift and remove the intestines and liver. Identify the parts of urinary and reproductive systems.
4. Remove the kidneys and look for threadlike spinal nerves that extend from the spinal cord.

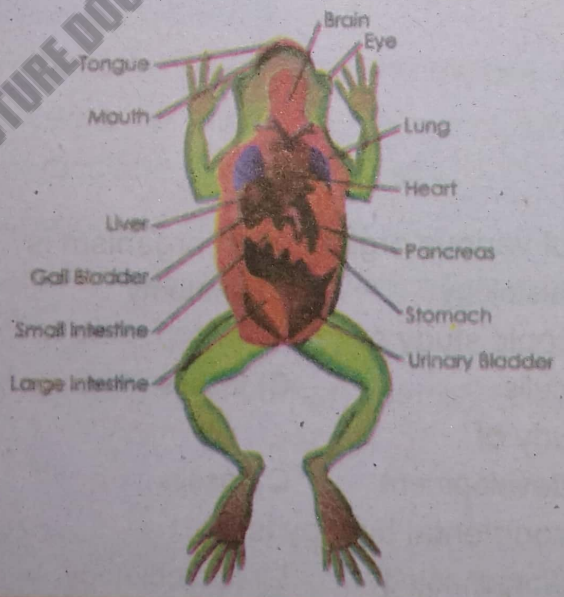


Fig. 1.7: Anatomy of a dissected frog

Observation: After identifying the organ and organ systems, draw the diagrams of your observation.

SUMMARY

1. Biology is the study of living organisms.
2. Biology has many divisions and branches. Biology is related to physics, chemistry, statistics, geography, psychology and economics.
3. Medicine, surgery, fisheries, agriculture, animal husbandry, biotechnology, horticulture and forestry are dependent directly or indirectly on the study of biology.
4. The Holy Quran instructs to reveal the study of life.
5. Muslim scientists have made great contributions in the field of biology, e.g. Jabir Bin Hayyan, Abdul Malik Asmai and Bu Ali Sina etc.
6. Organisms are made up of small, simple, inorganic compounds as well as large complex, carbon-containing organic compounds.
7. Four elements i.e., carbon, hydrogen, oxygen and nitrogen make up 96% of an organisms mass.
8. The sixteen natural elements that are essential to life are called bioelements.
9. Molecules that are found only in living organisms are called biomolecules.
10. Levels of organization of life comprises of cell tissue, organ system and organisms.
11. The cellular organization of organisms are unicellular, multicellular and colonial.

Exercise

MCQs

Select the correct answer:

1. The study of functions of various organs of an organism is
   A) morphology B) histology C) anatomy D) physiology
2. Histology is the microscopic study of
   A) tissues B) cells C) fossils D) plants
3. Palaeontology is the study of
   A) environment B) development C) fossils D) animals
4. The other name of environmental biology is
   A) ecology B) biotechnology C) microbiology D) cell biology
5. Microbiology is the study of
   A) fungi B) animals C) plants D) microorganism
6. Which Muslim scientist is known as founder of medicine
   A) Bu Ali Sina B) Abdul Malik Asmi C) Jabir Bin Hayan D) Ibne-Nafees

7. Which one of these bio-elements is highest percentage in the human body?
   A) Hydrogen B) Oxygen C) Carbon D) Nitrogen
8. Which of the following contains unicellular organization?
   A) mustard B) human C) euglena D) frog
9. Which of these major bio-elements is present in lowest percentage in human body?
   A) oxygen B) phosphorous C) calcium D) nitrogen
10. If a scientist is studying the methods of inserting human insulin gene in bacteria, which branch of biology may this be?
    A) anatomy B) physiology C) biotechnology D) pharmacy

Short Questions

1. Why are the following scientists famous for?
   a) Jabir Bin Hayyan b) Abdul Malik Asmai c) Bu Ali Sina.
2. Can you distinguish between? (a)Anatomy and Morphology (b) Micromolecules and Macromolecules (c) Biotechnology and Immunology (d) Genetics and Socio-biology (e)Organ and Organelles.
3. How biology is linked with other sciences?
4. How colonial organisms are different from multicellular organisms?
5. What is the importance of horticulture?
6. What is meant by division of labour among multicellular organisms?

Extensive Questions

1. How biology is related with other sciences? Show and explain the link.
2. How biology can lead to career of medicine, surgery, fisheries, agriculture animal husbandry, biotechnology, horticulture, farming, forestry.
3. Give an account of levels of biological organization.
4. Compare unicellular, colonial and multicellular organization in organisms.
5. How is biotechnology useful for society?
6. Why is biology important for the welfare of human beings? Give reasons.

THE TERMS TO KNOW

• Agriculture	• Biophysics	• Forestry	• Organ
• Animal husbandry	• Botany	• Fossil	• Organ system
• Biochemistry	• Cell	• Horticulture	• Parasite
• Bioeconomics	• Colony	• Inheritance	• Population

• Bioelement	• Embryology	• Macromolecule	• Surgery
• Biogeography	• Farming	• Micromolecule	• Volvox
• Biomolecule	• Fisheries	• Microorganism	

INITIATING AND PLANNING

1. Draw a linkage chart connecting different organs forming systems.

ANALYZING AND INTERPRETING

1. Identify different tissues in photomicrographs of different organs.

ACTIVITIES

1. Identify different organs systems in a dissected frog.

SCIENCE TECHNLOGY AND SOCIETY

1. Identify and evaluate the impact of scientific ideas and or advancements in technology on society.
2. List organs of human body which are damaged by the notorious diseases of today and which can be transplanted.

USEFUL WEBSITES

1) wordnet.princeton.edu/perl/webwn
2) www.tallpoppies.net.au/florey/glossary/main-content.html
3) www.ipcb.org/publications/policy/files/glossary.html
4) map.mapwise.com/safmc/LinkClick.aspx

2

SOLVING A BIOLOGICAL PROBLEM

Major Concepts

Biology is concerned not only with learning about organisms but its main purpose is to solve the biological problems faced by human beings. For example, biology has helped us to know the cause and cure of many diseases.

2.1 BIOLOGICAL METHOD

There is nothing magical about science. You already have some of the qualities of a scientist. You are curious. You like to do new and different things. You like to explore new places. These are the natural talents or skills of a scientist. Let us look more closely at the skills of a scientist.

Scientists, including biologists, employ an approach for solving scientific problem that is known as the **scientific method**.

Biological method: It has the following steps:

1. Recognition of a biological problem
2. Observation and identification
3. Building up hypothesis
4. Drawing deductions
5. Devising experiment
6. Inferring result

2.1.1SCIENTIFIC PROBLEM, HYPOTHESIS, DEDUCTION AND EXPERIMENTS

Malaria has killed more people than any other disease. The malaria is an example of a biological problem and how such problems can be solved.

STUDY OF MALARIA AN EXAMPLE OF BIOLOGICAL METHOD

Biological problems are solved by a series of steps of biological method.

1. Recognition of the biological problem: Biological problem is a question related to living organisms. This question is either asked by someone or comes in mind of researcher.

2. Observations: Observations are very important step in solving a biological problem. Observations are made by five senses of vision, hearing, smell, taste and touch. Observations are of two types;

Qualitative observations; which are based on some quality or characteristic. Quantitative observations; which are based on measurable value. Quantitative observations being measurable are invariable and can be expressed in terms of numbers, so are more accurate.

3. Formulation of Hypothesis: Hypothesis is a statement that may prove to be the answer of the biological problem under study. Hypothesis is a tentative explanation of the observations that might be true. A hypothesis should have following characteristics;

a. It should be a general statement.
b. It should be tentative idea.
c. It should agree with the available observations.
d. It should be testable and potentially falsifiable.

4. Deductions: Deductions are the logical consequences of the hypothesis. To draw deductions hypothesis is taken as true. Deductions involve "if" and "then" logic.

5. Experimentation: It is the most important step of biological method. Experiments are performed to prove if hypothesis is true or not. The deductions drawn from the hypothesis are subjected to rigorous testing. Through experimentation, biologist learns which hypothesis is correct.

6. Summarization of the results: The biologist gathers actual quantitative data from experiments. This data arranged to draw results.

Symptoms of Malaria: The patient of malaria feels very chill and cold. His temperature rises above normal value of 98.6°F. The patient suffers from headache and has feeling of nausea. After some time, the person begins to sweat, feels better. The whole series of events are repeated after every 24, 48 or 72 hours depending upon the species of *Plasmodium*.

Cause of malaria

By adopting the steps of biological method, it was proved that malaria is caused by *Plasmodium*.

Recognition of the problem: Malaria was a problem since ancient times. It has killed more people than any other disease.

Observations: In 19th century, many different causes of malaria were being suggested. By that time, there were four major observations about malaria.

a. Malaria and marshy areas have some relation.
b. Quinine is an effective drug for treating malaria.
c. Drinking the water of marshes does not cause malaria.
d. Plasmodium is seen in the blood of malarial patient.

Hypothesis: Based on these observations and other information, following hypothesis was formulated.

"*Plasmodium* is the cause of malaria".

Deduction: Although hypothesis is a tentative idea, to draw deductions it is accepted to be true. One of the deductions from the above hypothesis was;

"If *Plasmodium* is the cause of malaria, then all persons ill with malaria should have *Plasmodium* in their blood"

Experiments: This deduction was tested through experiment. Experiment was designed as;

Blood of 100 patients was examined under microscope. For the purpose of having control group, the blood of 100 healthy persons was also examined under microscope.

Results: The results of experiments showed that almost all malarial patients had *Plasmodium* in their blood. Only 07 0ut of 100 healthy persons had *Plasmodium* in their blood. Other 93 healthy persons were without any trace of *Plasmodium* in their blood.

In the 07 healthy persons with *Plasmodium* in their blood, *Plasmodium* was in incubation period. The incubation period is time between the entry of parasite in the host and the appearance of the symptoms of disease.

Results were quite convincing to prove the hypothesis that "*Plasmodium* is the cause of malaria"

Reporting the results: Results of these experiments were announced worldwide which helped to control malaria.

Spread of malaria

Biological method helped to find that mosquitoes spread malaria.

Recognition of the problem: Malaria is a fatal disease since ancient times. After the confirmation that malaria is caused by *Plasmodium*, it was to find how *Plasmodium* gets into the blood of man. This disease was more common in areas near stagnant water ponds where mosquitoes breed. It was found that;

a. Malaria is associated with marshes.
b. Drinking water of marshes does not cause malaria.

From these points, it can be concluded that *Plasmodium* was not present in the marshy water. So *Plasmodium* must be carried by something that comes to marsh water. Problem in this study was to find that agent.

Observations: A physician A. F. A. King listed 20 observations about spread of malaria. Some important observations were;

a. People who slept outdoors were more likely to get malaria than those who slept indoors.
b. People who slept under fine nets were less likely to get malaria than those who did not use such nets.
c. Individual who slept near smoky fire usually did not get malaria.

Hypothesis: On the basis of these observations King suggested a hypothesis;

"Mosquitoes transmit *Plasmodium* so are involved in the spread of malaria"

Deductions: Following deductions were made considering the hypothesis true.

Deduction I: "Plasmodium should be present in mosquito".

Deduction II: "A mosquito can get Plasmodium by biting a malarial patient".

Experiments: In order to test the above deductions, many experiments were performed.

Experiments of Ronald Ross: Ross, a British army physician working in India performed an important experiment.

He allowed a female *Anopheles* mosquito to bite a malarial patient. He killed the mosquito some days later and found *Plasmodium* multiplying in mosquito's stomach.

Next Ross used sparrows in his experiments. He allowed female *Culex* mosquitos to bite on the sparrows suffering from malaria. He then allowed these mosquitoes to bite healthy sparrows. The sparrows got malaria.

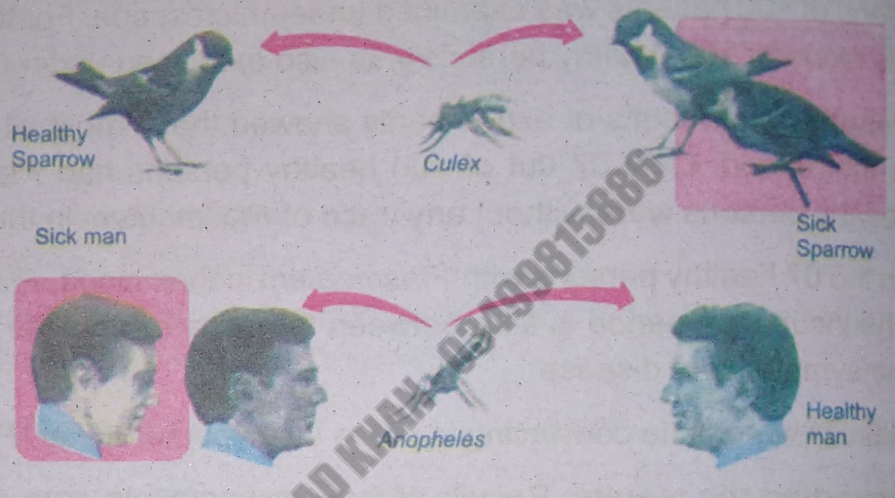


Fig. 2.1: Malaria in man is transmitted by *Anopheles* and in birds by *Culex*

In the end, the hypothesis was tested by direct experimentation on human being. An Italian biologist allowed an *Anopheles* mosquito to bite a malarial patient. The mosquito was kept for few days and then it was allowed to bite a healthy man. The person later became ill with malaria.

Results: All these experiments confirmed that mosquito transmit *Plasmodium* and spread malaria.

When a female mosquito pierces the skin with the mouthparts, a small amount of saliva is injected into the wound before drawing blood. The saliva prevents the blood from clotting in the food canal of the mosquito.

The word vector means transmitter. Any organism which carries a parasite and transfers it from one organism to another is called vector.

For the treatment of malaria, quinine extracted from the bark of *Cinchona* plant is used. Apart from quinine certain other anti-malarial drugs are also used for the treatment.

Dengue Fever It is a mosquito-borne viral disease. It is caused by a Dengue virus and transmitted by mosquito *Aedes aegypti*, which has zebra like white and black stripe on its body. Typical case of Dengue haemorrhage fever is characterized by high fever, bleeding from nose, blood in urine and enlarged liver etc. There is no specific antiviral drug available for the treatment of patients suffering from Dengue fever. The second attack can be more serious and dangerous. The best prevention is personal protection from mosquito bite and measures to prevent mosquito breeding.

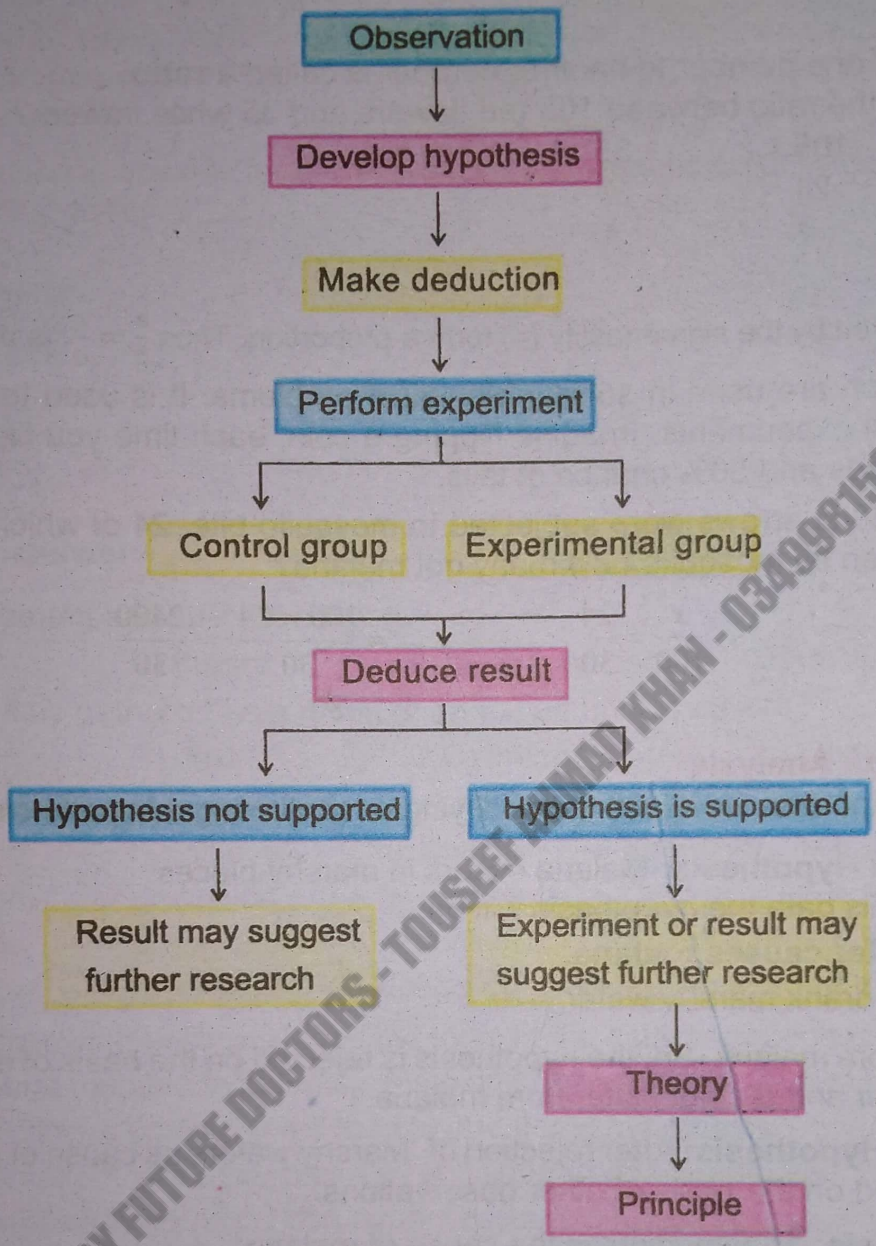


Fig. 2.2: Scientific method of study

2.1.2 THEORY, PRINCIPLE AND LAW

The ultimate goal of science is to understand natural world in term of theories. If the hypothesis is found to be correct then it becomes a **theory**. It is supported by a number of evidences. A theory can be changed if better evidence is available. For example, the theory of evolution. A theory that has been verified and appears to have wide application may become biological **principle** or **law**. For example, Mendel's law of inheritance.

2.1.3 DATA ORGANIZATION AND DATA ANALYSIS

The collection of facts or information is called data. First data is collected then data is organized by using techniques such as tables and graphs. To predict on the basis of data is called **analysis**. Analysis of data is done by means of ratio and proportion.

Ratio

The comparison of one number to another number is called a **ratio**.

Problem: What is the ratio between 105 red flowers and 35 white flowers?

Solution:

105 : 35
21 : 7
3 : 1

Proportion

Two equal ratios joined by the sign equality (=) form a proportion. Thus $\frac{a}{b} = \frac{c}{d}$ is a proportion.

Ratio and proportion are used in solving biological problems. It is used to calculate expected results of biological experiments. Imagine flipping a coin, each time you flip the coin there is a 50% chance of heads and 50% chance of tails.

In an experiment 30 sparrows were subjected to mosquito bite, 24 of which got malaria. If 100 sparrows were bitten by mosquito how many got malaria?

$$\frac{x}{100} = \frac{24}{30} \qquad x = \frac{100 \times 24}{30} = \frac{2400}{30}$$

$$x = 80$$

Importance of Data Analysis

Data analysis is important for rejecting, modifying or confirming a hypothesis.

1. **Rejecting a Hypothesis:** Malaria occurs in marshy places.
   Based on this data the hypothesis will be:
   Marshy water causes malaria.
   20 persons drank marshy water.

No one suffered from malaria. So, the hypothesis is rejected on the basis of data that 20 persons drank marshy water and did not suffer from malaria.

2. **Modifying Hypothesis:** After rejection of "Marshy waters as cause of malaria" hypothesis was modified on the basis of other observations.

Modified hypothesis: "Plasmodium is the cause of malaria".

3. **Confirming Hypothesis:** Data analysis of repeated experiments confirmed the hypothesis that "*Plasmodium* is the cause of malaria".

2.1.4 MATHEMATICS AS AN INTEGRAL PART OF SCIENTIFIC PROCESS

Mathematics is essential to many sciences. The most important function of mathematics in science is the role it plays in the expression of scientific models. Studying mathematics develops reasoning ability.

SUMMARY

1. Scientific method is a system of observing and recognizing problem, developing hypothesis, making a prediction that can be tested, performing experiments and drawing conclusions from the result that support or testify the hypothesis.
2. Data is the collection of facts.
3. A hypothesis is a possible explanation for a group of related observations.
4. Deduction is the logical explanation of hypothesis.

5. Data is organized by using techniques such as table and graphs. Analysis of data is done by means of ratio and proportion. Data analysis is important for confirming modifying or rejecting a hypothesis.
6. Mathematics is used in science for the expression of scientific model. Studying mathematics develops reasoning ability.

Exercise

MCQs

Select the correct answer:

1. The starting point of scientific investigation is
   A) hypothesis B) theory C) observation D) data
2. Information that is gathered as a result of an experiment is called:
   A) hypothesis B) data C) theory D) Observation
3. Which of the following represents the correct sequence of different steps of scientific study?
   A) observation, → hypothesis → experiment → deduction → theory
   B) observation, → deduction → hypothesis → theory → experiment
   C) hypothesis → observation → deduction → experiment → theory
   D) observation → hypothesis → deduction → experiment → theory
4. Which of the following best describes the logic of the scientific process?
   A) if I generate a testable hypothesis, tests and observations will support it
   B) if my prediction is correct, it will lead to a testable hypothesis
   C) if my observations are accurate, they will support my hypothesis
   D) if my hypothesis is correct, I can expect certain test results
5. Which of the following statements best distinguishes hypothesis from theories in science?
   A) theories are hypothesis that have been proven true
   B) theories are based on limited data while hypothesis are based on wide range of data
   C) theories are uncertain while hypothesis are certain
   D) theories are educated guess while hypothesis are widely accepted explanation of natural phenomenon
6. You are doing a control experiment which
   A) proceeds slowly enough that a scientist can record the results
   B) may include experimental groups and control groups tested in parallel
   C) is repeated many times to make sure the results are accurate
   D) proceed slowly enough that a scientist can test predictions
7. Malaria is caused by
   A) mosquito B) stagnant water C) swamp D) Plasmodium
8. The comparison of one number to another number is called a

A) ratio B) proportion C) mean D) frequency

9. Two equal ratios joined by the sign of equality (=) form a
   A) ratio B) frequency C) proportion D) median
10. Plasmodium was first observed in malarial patient by _____.
    A) Laveran B) A.F.A. King C) Ronald Ross D) Aristotle

Short Questions

1. What is the contribution of the following scientists?
   a) A.F.A King b) Ronald Ross
2. What is the importance of data organization and data analysis in biological sciences?
3. Can you distinguish between ratio and proportion?
4. Why it is impossible to eradicate malaria?
5. What was the main purpose of experiment by Ronald Ross?
6. Why Ross did not allow the infected mosquitoes to bite a healthy person?
7. Justify mathematics as an integral part of the scientific studies.
8. What ways do you use the scientific method in everyday life?

Extensive Questions

1. Discuss biological method of study and their application.
2. How a biological problem is solved? Explain with reference to malaria.

THE TERMS TO KNOW

• Data	• Hypothesis	• Proportion
• Deduction	• Observation	• Ratio
• Experiment	• Principle	• Theory

INITIATING AND PLANNING

1. Identify and pose meaningful answerable questions.
2. Formulate and test a working hypothesis for a given biological problem.
3. Write instructions for conducting investigations or following a procedure.
4. Write instructions for conducting investigation
5. Organize data to make predictions, decisions or draw conclusion.
6. Confirm, modify or reject a hypothesis using data analysis.
7. Use ratio and proportion in appropriate situations to solve problems.

USEFUL WEBSITES

1. http://www.spa3.k12.sc.us/sci/Scientific%20Method%20
2. http://fig.cox.miami.edu/~cmallery/150/unity/cell.text.htm

3

BIODIVERSITY

Major Concepts

In the previous chapters we have learned that biology is the study of living things. The living things have been divided into five major groups so that they can be identified easily. The similarity among living things is that they share all the characteristics of life, i.e., movement, respiration, sensitivity, nutrition, excretion, reproduction and growth. At the same time these living things differ from one another and their variety of appearance is enormous.

3.1 DEFINITION AND INTRODUCTION TO BIODIVERSITY

Biodiversity is the variety of the living organisms present in an ecosystem. Biodiversity is the richness and variety of living organisms on Earth.

Importance of Biodiversity in the Natural Ecosystem

The benefits and services provided by natural biodiversity include:

Maintenance of soil quality: The activities of microbial and animal species play a key role in the cycling of crucial elements such as nitrogen, carbon and phosphorous between the living and non-living parts of the biosphere.

Maintenance of air quality: Plant species purify the air and regulate the composition of the atmosphere.

Maintenance of water quality: Wetland ecosystems (swamps, marshes, etc.) absorb and recycle essential nutrients, treat sewage, and cleans wastes.

Pest control: Around 99 percent of potential crop pests are controlled by a variety of other organisms, including insects, birds and fungi.

Pollination and crop production: Many flowering plants rely on the activities of various animal species – bees, butterflies, bats, birds, etc. – to help pollination. More than one-third of human's food crops depend on this process of natural pollination and dispersal of seeds.

Provision of food and medicine: Biodiversity provides the majority of our foodstuffs and traditional medicines derived mainly from plants.

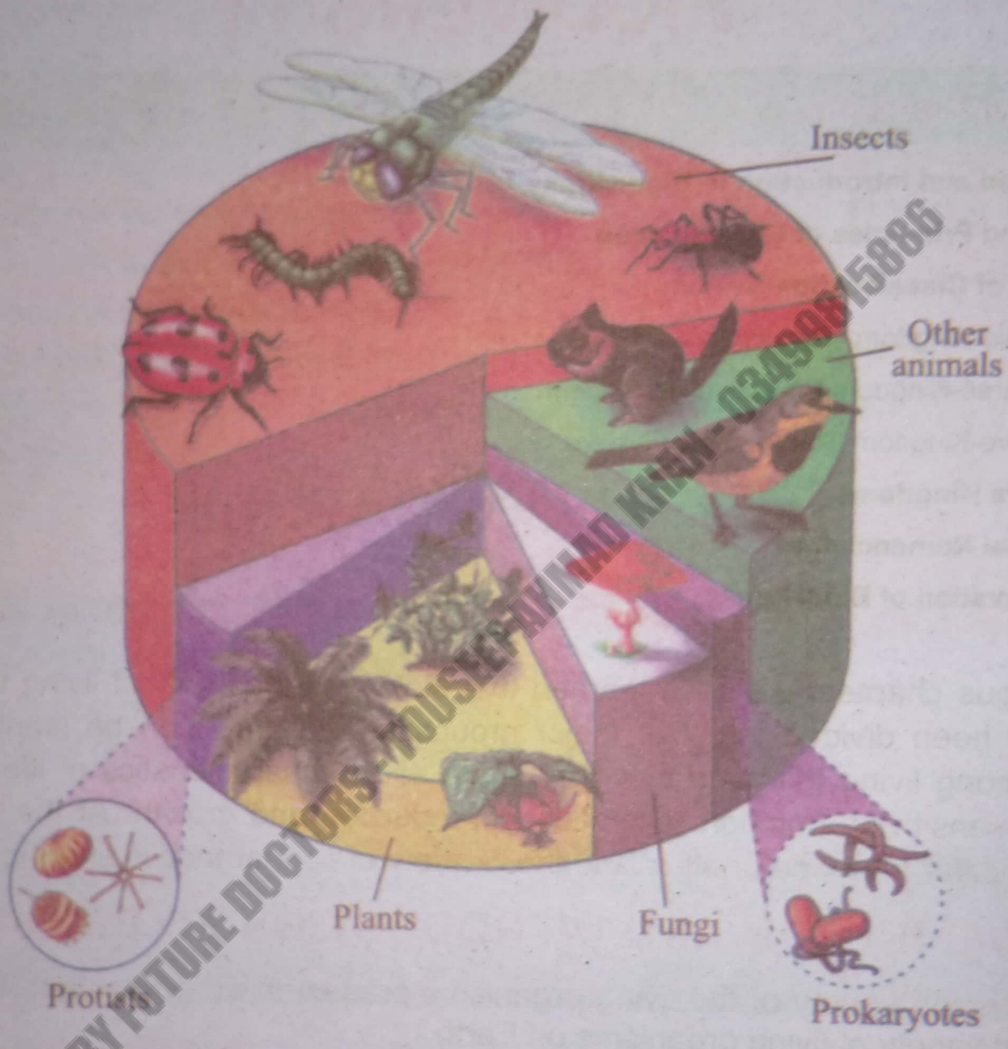


Fig: 3.1: Biodiversity

3.2 AIMS AND PRINCIPLES OF CLASSIFICATION

The main aims and objectives of classification are: (1) To determine similarities and differences between organisms. (2) To arrange organisms on the basis of similarities and differences. (3) Identify the organisms to study them systematically. (4) To find out evolutionary relationships among organisms.

Biologists have devised ways of grouping organisms. The grouping of organisms is called **classification**. **Taxonomy** is called the science of classification. It is the branch of biology concerned with identification and naming of organisms. Suppose you were asked to classify the living organisms of your surroundings. What criteria would you use to classify the organisms? The scientific study of diversity of organisms and their evolutionary relationship is called **systematic**.

Basis of Classification of Living Organisms

The classification of organisms is based on the similarities in them. Similarities and differences are studied in the internal as well as external features.

3.3 HISTORY OF CLASSIFICATION

Many system of classification have been devised. Whenever any new information becomes available, it is incorporated. Living organisms have been classified into two to five kingdoms.

3.3.1 TWO KINGDOM SYSTEM OF CLASSIFICATION

The two kingdom system was first proposed Aristotle. The two kingdoms are kingdom **Plantae** (plants) and Kingdom **Animalia** (animals). Plants have cell wall and can make their own food, while animals cannot make food in their body.

3.3.2 THREE KINGDOM SYSTEM OF CLASSIFICATION

A German scientist, Ernst Haeckel, proposed adding a third kingdom Protista in order to separate unicellular microscopic organisms from multicellular ones.

3.3.3 FIVE KINGDOM SYSTEM OF CLASSIFICATION

Five kingdom system of classification better explains Diversity of Living Organisms. In the five kingdom system, the **Monera** are distinguished by their prokaryotic structure. The kingdom **Protista** contains a diverse group of unicellular organisms that are hard to classify and define. The five kingdom classification system places **fungi** in a separate kingdom.

Table 3.1 Comparison: Classification Systems

Two Kingdom Classification System	Five Kingdom Classification System
It includes two Kingdoms: Plantae and Animalia.	It includes five kingdoms: Monera, Protista, Fungi, Plantae and Animalia.
Bacteria and Cyanobacteria were placed in plant kingdom.	Bacteria and cyanobacteria are placed in kingdom Monera.
Unicellular or simple multicellular eukaryotes wrongly placed in kingdom Plantae and Animalia.	Unicellular or simple multicellular eukaryotes placed in kingdom Protista.
Fungi are wrongly placed in kingdom Plantae.	Fungi are placed in kingdom Fungi.

Al- Jahiz

Al-Jahiz was a famous Muslim zoologist. He wrote books on theories of evolution, adaptation, animal psychology, migration of fishes and ants.

The organisms which lack nucleus in their cells are called **prokaryotes** while the organisms which have nucleus in their cells are called **eukaryotes.**

3.4 THE FIVE KINGDOMS

At present the organisms have been divided into five kingdoms: Monera, Protista, Fungi, Plantae and Animalia.

1. **Monera**: All prokaryotic organisms are included in kingdom Monera. They are unicellular, filamentous or colonial and are relatively simple in structure. This kingdom includes bacteria and cyanobacteria.

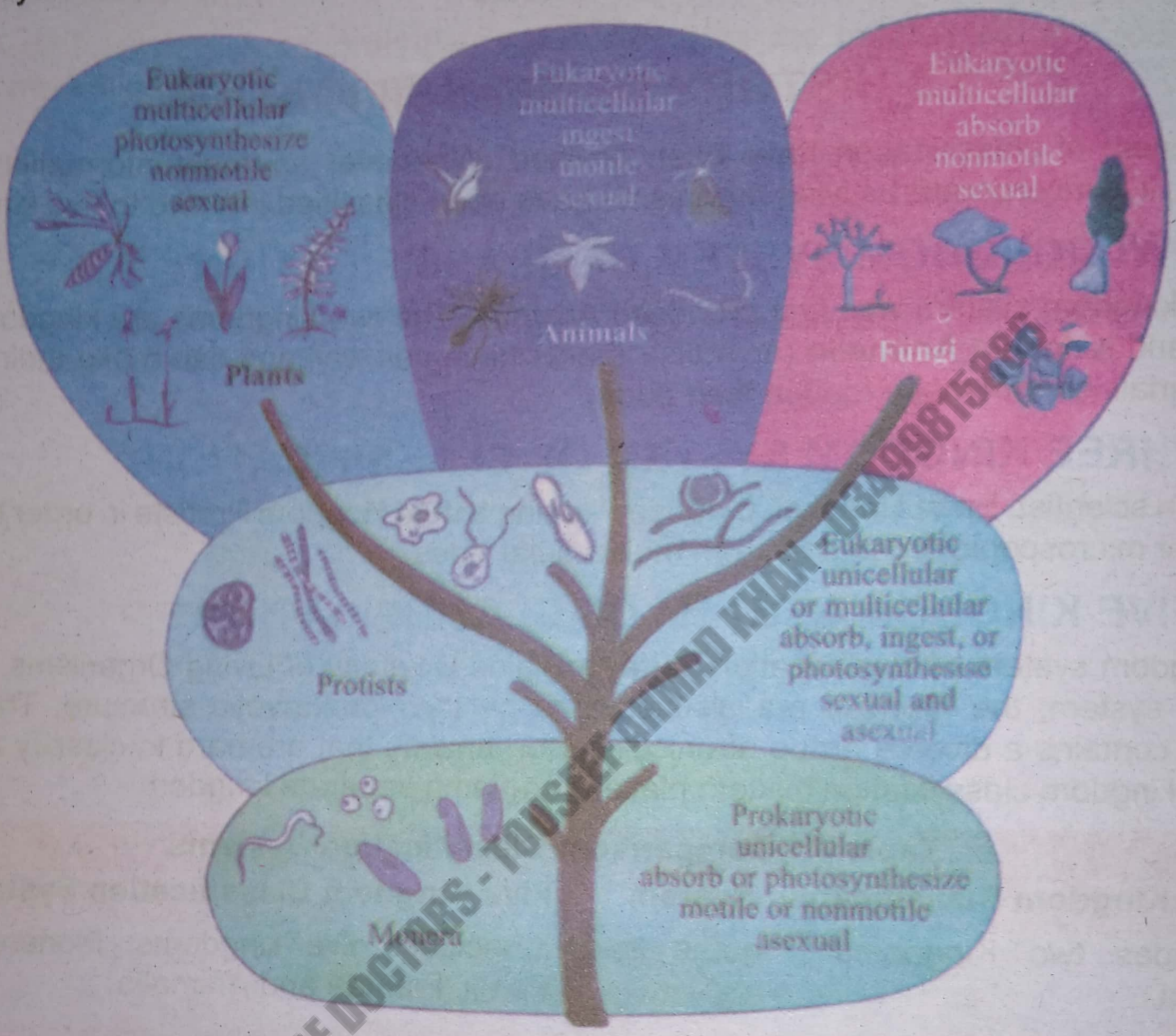


Fig: 3.2: Five kingdom system of classification

2. **Protista:** These include eukaryotic organisms with a unicellular or simple multicellular structure. These are mostly aquatic. It is a diverse group of organisms. It includes: Animal like protist called protozoa e.g., *Amoeba*. Plant like protists called algae e.g., *Euglena*. Fungi like protists e.g., slime molds.
3. **Fungi:** Fungi are eukaryotic organisms which have chitin in their cell wall. Fungi may be saprotrophic decomposers. Mostly fungi are multicellular. Some fungi are unicellular. The examples of fungi are black bread mold, yeast, mushroom, etc.
4. **Plantae**: The members of kingdom plantae are eukaryotic multicellular and autotrophic with

The organisms that are capable of producing their own food are called **autotrophs** (photosynthetic mode of nutrition) e.g., green plants, autotrophic bacteria, and algae.

Organisms which eat other things as food are called **heterotrophs** (ingestive mode of nutrition) e.g., animals, animal like protists, etc.

The organisms that depend on dead, decaying matter are called **saprotrophs** (absorptive mode of nutrition) e.g., fungi, bacteria. These are decomposers.

chloroplasts containing chlorophyll. Their cell wall is made up of cellulose e.g., moss, mustard.

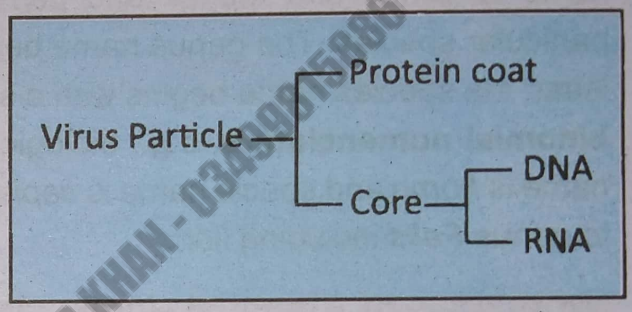
5. **Animalia:** Animals are multicellular heterotrophic eukaryotes. Animals lack cell wall and chlorophyll. They can generally move from place to place. This kingdom includes invertebrates e.g., insects, star fish and vertebrates e.g., fish, frogs.

Virus

Viruses are acellular structures and are not included in the five kingdom classification system. Viruses are particles that lack structural characteristics of cells. They cannot carry out metabolic activities independently. Viruses are on the borderline between living and non-living world. The study of virus is known as **virology**.

Structure of Virus

All viruses have a central **core** surrounded by a protein **coat**. Core can be of DNA or RNA. Following are the reasons why viruses are excluded from five kingdom classification:



1. Viruses have no nucleus, cytoplasm, cell organelles or cell membrane.
2. They do not feed, respire, excrete or grow.
3. Viruses do reproduce, but only inside the cells of living organisms; usually the host cell provides materials.

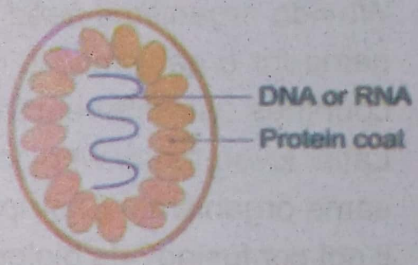
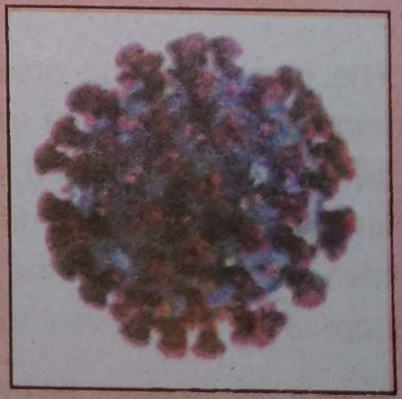


Fig: 3.3: Structure of Virus

COVID 19

Coronaviruses are a family of viruses that can cause illnesses such as the common cold. The virus is now known as the severe acute respiratory syndrome coronavirus 2. The disease it causes is called coronavirus disease 2019 (COVID-19). The COVID-19 outbreak is a pandemic. It spreads mainly from person to person among those in close contact (within about 6 feet, or 2 meters). The virus spreads by respiratory droplets released when someone with the virus coughs, sneezes, breathes, sings or talks. These droplets can be inhaled or land in the mouth, nose or eyes of a person nearby. Most common symptoms: fever, dry cough and tiredness. Most infected people will develop mild to moderate illness and recover without hospitalization.



A vaccine might prevent you from getting COVID-19. No medicine is available. Avoid close contact, wash your hands often with soap and water for at least 20 seconds, or use sanitizer. Cover your face with a cloth face mask in public spaces, avoid touching your eyes, nose and mouth. Stay home from work, school and public areas.

Prions are infectious particles that are composed only of **proteins**, i.e., they contain no DNA or RNA. They cause diseases in sheep and man. Prions can replicate or reproduce.

Viroid consists of a single molecule of circular RNA without a protein coat or envelope. They cause diseases in plants e.g., potato, apple etc.

3.5 BINOMIAL NOMENCLATURE

A species is defined as a group of organisms capable of interbreeding and producing fertile offspring.

Linnaeus introduced a naming system to give each organism a name consisting of two Latin names. The first name is genus and the second name represents the particular species. The genus name begins with a capital letter; the species name begins with a small letter. Since each name has two parts so it is called **binomial nomenclature**, e.g., biological name of human beings is *Homo sapiens*. Our genus name is *homo* and specie name is *sapiens*. A genus may have many species e.g., all cats belong to genus *Felis* including lion.

Importance of Binomial Nomenclature

Why do organisms need to be given a scientific name in Latin? Why can't we just use common name for organisms? A common name will vary from country to country just because different countries use different languages. Hence there was a need for a universal language such as Latin. Even those who speak the same language sometime use different common name for the same organisms. Example: Brinjal is **Baigun** in Urdu, **Bataoon** in Punjabi, **Vagton** in Sindhi. Is it not confusing? Its biological name is *Solanum melangena*. Find out the Punjabi, Sindhi, Pushto or other local names or German, French, Spanish, Arabic, Russian, Chinese names of the following which will show the importance of biological name.

1. Potato - *Solanum tuberosum*
2. Rice - *Oryza sativa*

A scientific name has the advantage of standing for a single kind of animal, plant or microorganism all over the world.

3.6 CONSERVATION OF BIODIVERSITY

The protection and preservation of all the natural resources needed for the existence and maintenance of life on earth is called conservation. So, we must protect all those things, which affect directly or indirectly the life on earth. Conservation biology brings together people and knowledge from many different fields to attempt to solve biodiversity crisis. Conservation biology tries to understand the effects of human activities on ecosystems and develop practical approaches to prevent the extinction of species and the destruction of ecosystems.

A species of plant or animal that no longer lives anywhere on Earth is said to be **extinct**. ny living organisms are in danger of becoming extinct. These species of plants and mals are called **endangered species**. The Bengal tiger, panda, etc., are some examples

of endangered species. Snow leopard falcon, green turtle etc., are the endangered species of Pakistan.

Bengal Tiger | Snow Leopard | Mountain Gorilla | Panda

Fig: 3.4 Endangered species

Human Impact on Biodiversity

Hunting: Hunting has increased the rate of extinction by killing the organisms. Wild plants and animals are called wild life. One way that people threaten wildlife is by damaging or destroying their habitat. Forests and grassland are being cleared for new roads, farms, cities and also other human activities like mining and building of dams, destroy habitats. The accidental or purposeful introduction of **new species** into an ecosystem can cause the extinction of local species or can cause effect on nature.

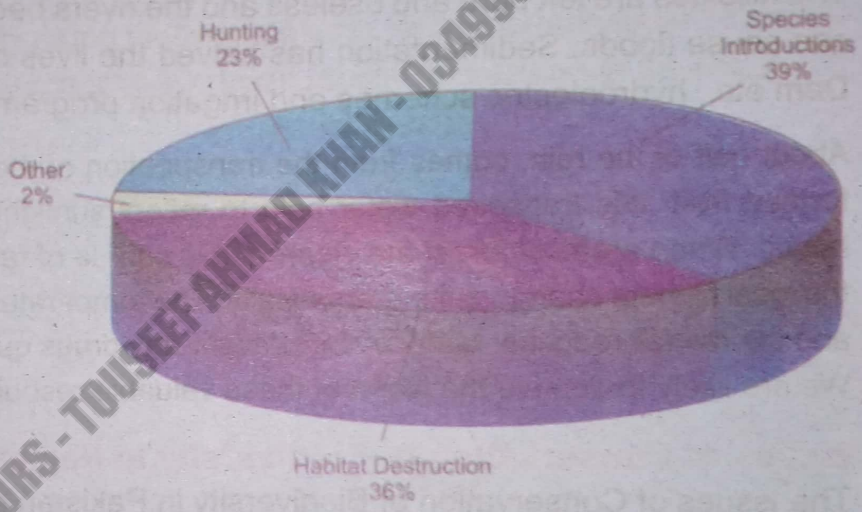


Fig: 3.5: Known causes of species extinctions

Eucalyptus plants were imported from Australia and introduced in Pakistan. These plants consume more water and have disturbed the water table (level of underground water). It harms other small plants that grow near Eucalyptus trees.

Pollution

Pollution also affecte environment and biodiversity. The global climate change may occur so rapidly that many species will be unable to adjust their range and may become extinct. Pesticides have caused the abundance of predatory birds to decrease and acid deposition has caused worldwide decline in amphibian population.

Deforestation

The cutting down of trees, destruction of forest, leaves the soil barren, which is called deforestation. We are destroying forests (a) for timber (b) to get land for

Fig: 3.6: Chopping trees in Pakistan

agriculture (c) to make roads, airports etc (d) to make houses, buildings for the settlement of ever-increasing number of human population and urban development (e) to get land for grazing.

Effects of Deforestation on Biodiversity

Removal of forests causes soil erosion, silting up of lakes and rivers, flood and the loss of thousands of species of animals and plants.

Fig: 3.7: Soil erosion in Islamabad

Trees can grow on hillsides even when the soil layer is quite thin. When the trees are cut down and the soil is ploughed, there is less protection from the wind and rain. Heavy rainfall washes the soil off the hillsides into rivers. The hillsides are left bare and useless and the rivers become choked up with mud and silt, which can cause floods. Sedimentation has halved the lives of reservoirs e.g., Tarbella Dam, Mangla Dam etc., hydroelectric schemes and irrigation program.

About half of the rain, comes from the transpiration of the trees themselves. The clouds which are formed from this transpired water help to reflect sunlight and keep the region relatively cool and humid. When areas of forest are cleared, this source of rain is removed, cloud cover is reduced and the local climate change quite dramatically. The temperature range from day to night is more extreme and the rainfall reduces. Many of our present-day drugs quinine, aspirin etc., are derived from plants. We are likely to deprive the world of these valuable resources.

Issues of Conservation of Biodiversity in Pakistan

The Issues of Conservation of Biodiversity in Pakistan are deforestation and hunting.

Deforestation: Pakistan is facing a real deforestation crisis as a very large area of forest is being used either for fuel purpose or for wood furnishing in the country.

Hunting: Hunting is a threat to animals in Pakistan. So, hunting of some animals and birds is completely banned e.g., black deer, spotted deer etc. Hunting of some animals is allowed only in particular seasons. Still there is threat to wildlife in Pakistan.

Extinct and endangered animals in Pakistan

Cheetah, Tiger, Asian Lion etc., have been declared extinct. While Indus dolphin, Blackbuck, Snow leopard etc., have been declared as endangered species in Pakistan. Population growth is also an issue of conserving biodiversity. The conservation strategies adopted by government of Pakistan for checking deforestation and hunting are:

(a) There is department of forestry having forest officer and forest guards. They check the unauthorized cutting of trees. e.g., nobody is allowed to cut trees in the Capital territory of Islamabad. Those who cut trees or jungle anywhere in Pakistan are arrested and prosecuted as per law.

(b) Hunting of endangered species is prohibited. Hunting of birds is not allowed during their breeding seasons.

FEW ENDANGERED SPECIES IN PAKISTAN

Houbara Bustard

The houbara bustard, is a large bird. It is hunted for its meat; widespread hunting has almost put it on the endangered list.

Indus Dolphin

The Indus dolphin is blind so it uses sonar waves (like bats) to find its way in the muddy water of river. The Indus river dolphin is found in the river Indus of Pakistan. It is now seriously threatened in its only habitat. With the construction of dams along the river Indus today the species is only found between Jinnah and Kotri barrages.

Marco Polo Sheep

Marco Polo sheep, in Pakistan, are mostly found in the Khunjerab National Park and adjoining areas. These are endangered and their numbers have been rapidly decreasing in the last two decades.

Houbara Bustard

Indus Dolphin

Marco Polo Sheep

Fig: 3.8: Endangered species in Pakistan

SUMMARY

1. Biodiversity is the variety of the living organisms living in an ecosystem.
2. Biologists use a system of classification based on the similarities and differences in the organisms.
3. In Binomial system the name of each species has two parts the genus name and the specific epithet.
4. The five kingdom classification recognizes the kingdom: Monera, Protista, fungi, plantae and animalia.
5. Viruses cannot strictly be classified as living organisms. Each virus particle consists of a DNA or RNA core enclosed in a protein coat.
6. Although extinction is a natural phenomenon, human activities are causing a great increase in the rates of extinction of living organisms.

7. Conservation of species requires international agreements and regulations. These regulations may prohibit killing or collecting species and prevent trade in them or their products.
8. Deforestation and hunting are the two major issues of conservation of biodiversity in Pakistan.
9. Indus dolphin, Marco Polo sheep and Houbara Bastard are endangered in Pakistan.

Exercise

MCQs

Select the correct answer:

1. Into which kingdom you place a multicellular land organism that carries on photosynthesis:
   A) monera B) protista C) plantae D) animalia
2. Which kingdom is mismatched with the characteristics?
   A) fungi – usually saprotrophic B) animalia – rarely ingestive
   C) protista – various modes of nutrition D) plantae – photosynthetic
3. The kingdom to which the algae belongs is:
   A) monera B) protista C) plantae D) fungi
4. Scientific name has advantages of:
   A) same name applied to different organisms.
   B) same organisms have different name in different areas
   C) has no scientific basis.
   D) has scientific basis and universally accepted.
5. Binomial nomenclature was introduced by:
   A) Aristotle B) Carolus Linnaeus C) Ernest Haekel D) R.H Whittaker
6. Which animal has not become extinct in Pakistan?
   A) lion B) Asiatic cheetah C) Marcopolo sheep D) Tiger
7. Who introduce three kingdoms of classification?
   A) Aristotle B) Carolus Linnaeus C) Ernest Haekel D) R.H Whittaker
8. The organisms that feed on dead, decaying matter are called:
   A) saprotrophs B) autotrophs C) heterotrophs D) parasites
9. In Pakistan these are mostly found in the Khunjerab National Park and adjoining areas:
   A) lion B) Asiatic cheetah C) Marcopolo sheep D) Tiger
10. Viruses are assigned to the kingdom:
    A) Monera B) Protista C) Fungi D) Not included in any kingdom

Short Questions

1. Why are the following scientists famous for?
   Aristotle, Abu Usman Umer Aljahiz.
2. Compare two kingdom and five kingdom classification system.
3. Can you differentiate between:
   (a) Bacteria and Protists (b) Fungi and Plants (c) Plants and Animals
4. Draw and label a virus.
5. Why are viruses regarded as acellular?
6. Why viruses are considered at the borderline of living and non-living organisms?
7. Write the importance of Binomial nomenclature.
8. Why should we be concerned with preserving biodiversity?

Extensive Questions

1. What is biodiversity? Write the importance of biodiversity in the natural ecosystem.
2. Describe classification? How can you classify organisms?
3. Give an account of history of classification system.
4. Describe the diagnostic characteristics of the five kingdoms.
5. What is Binomial nomenclature? Describe aims, principles and importance of Binomial nomenclature using local examples.
6. What is the conservation of biodiversity? Explain impact of human beings on biodiversity.
7. Identify causes of deforestation and its effects on biodiversity with examples.
8. Discuss issues of conservation of biodiversity in Pakistan with reference to deforestation and hunting.
9. What is the possible connection between cutting down trees on hillsides and flooding in the valleys.

THE TERMS TO KNOW

• Acellular	• Deforestation	• Protista
• Animalia	• Endangered species	• Soil erosion
• Binomial nomenclature	• Fungi	• Species
• Biodiversity	• Monera	• Systematics
• Class classification	• Plantae	• Taxonomic hierarchy
• Conservation	• Prion	• Viroid

SCIENCE, TECHNOLOGY AND SOCIETY CONNECTIONS

Determine the importance of scientific investigation in classifying organisms

1. Evaluate how taxonomy has helped in the classification of organisms.
2. Associate advancements in scientific understanding with classification of organisms to develop a more reliable system.
3. Apply the knowledge of classification to assess the characteristics of different organisms when visit to zoos, herbaria and gardens.
4. Explain the importance of binomial nomenclature in developing a more comprehendible sharing of scientific research
5. Describe the importance of research workers after whose names, organisms have been named e.g., *Bauhinia variegata*. (Kachnar)
6. Write a short article for publication in newspaper about endangered species.
7. Analyse the impact of human beings on biodiversity.

SKILL INITIATING AND PLANNING

1. Describe the ways in which society benefits from biodiversity?
2. Evaluate graphs of a population of an insect, which is endangered (due to excessive use of insecticides and interpret the reasons for its endangered status.

PERFORMING AND RECORDING

1. Distinguishing taxonomic characters of fresh and preserved specimens kept in laboratory.
2. Examine some living or preserved plants and animals.
3. Classify representative plants and animals into their respective kingdoms, using data.

ANALYZING AND INTERPRATING

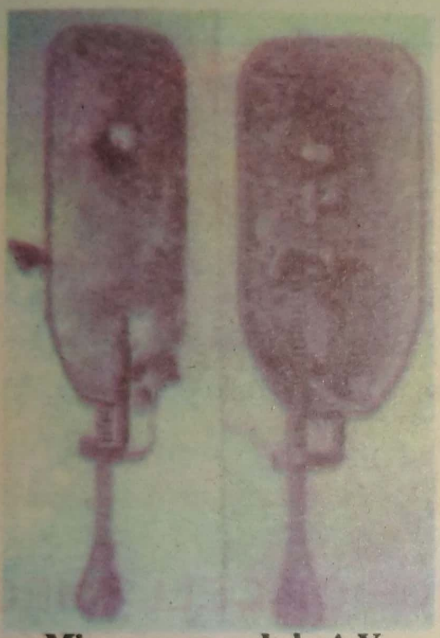
1. Make the binomials of some common local organisms from a two-column list on the basis of generic name and specific epithet.

USEFUL WEBSITES

1. http://en.wikipedia.org/wiki/Biodiversity
2. http://en.wikipedia.org/wiki/Scientific_classification

SECTION 2

Cell Biology

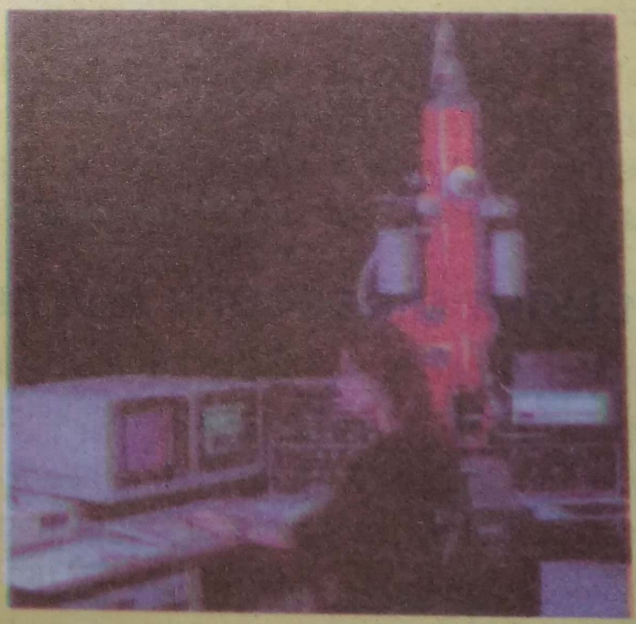


Microscope made byA.V. Leeuwenhoek

Microscope made by Robert Hooke

Compound microscope

Transmission electron microscope



Scanning electron microscope

4

CELLS AND TISSUES

Major Concepts

4.1 MICROSCOPY AND THE EMERGENCE OF CELL THEORY

The most basic tool of biologist is the microscope. The first compound microscope was developed by Zacharias Janssen (1595) in Holland. An instrument used to see small things is called microscope, and the use of microscope is called **microscopy**. Microscope increases the magnification and resolution of the object. Increase in apparent size of an object when seen under microscope is called **magnification**.

Resolving power or **resolution** is the ability of an optical instrument to show two objects separate. Resolution is defined as the minimum distance that two points can be separated and be distinguished as two separate points. With the help of lenses resolution can be increased. Resolution of human eye is 0.1mm.

4.1.1 LIGHT MIROSCOPY AND ELECTRON MCROSCPY

Light microscope uses visible light to view objects. It has two lenses i.e., eye piece and objective. Its magnification can be 1500X and resolution can be 0.2μm

Electron microscope (EM) uses a fine beam of electrons transmitted to a specimen in vacuum. EM uses electromagnets as lenses and image is formed on screen. Its magnification can be up to 1,000,000 X and resolution can be 0.2 nm.

1 mm = 1000 μm

1 μm = 1000 nm

There are two types of electron microscopes: Transmission Electron Microscope (TEM) and Scanning Electron Microscope (SEM).

TEM is used to study the details of internal cell structure. Specimens are cut into extremely thin sections. SEM is used to study the cell surface which reveals the three-dimensional details of the surface.

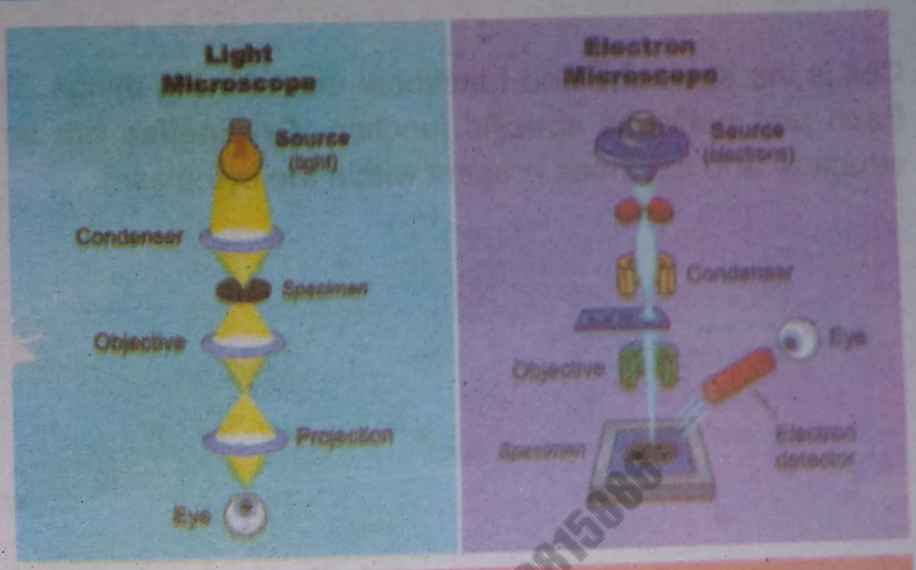


Fig. 4.1: Light and electron microscope

4.1.2 HISTORY OF THE FORMATION OF CELL THEORY

Biological science began independently all over the world. The ancient Greeks were the first to make comprehensive attempts to organize the data of the natural world. The contribution of Aristotle was his awareness that all knowledge of animals and plants somehow could be related.

Robert Hooke (1665) looked at a thin slice of cork under his microscope. Hooke saw that the cork was made of tiny empty spaces with walls around them. He called the little box-like structures as cells because it reminded him the small rooms. Today scientists know that what Hooke really saw was only one part of the cells. He saw the thick cell walls.

Fig. 4.2 Cork cells as seen by Hooke

Robert Brown (1831) discovered nucleus in the plant cells. **Schleiden** (1838): He was a botanist. He came to the conclusion that all plants are composed of cells. **Theodor Schwann** (1839) was a zoologist who came to the conclusion that animals also consist of cells. **Virchow** (*Firkoh*) (1855) proposed that living cells arise from pre-existing cells and wrote," omniscellula *e cellula*" (all cells arise from cells).

Louis Pasteur (1862) experimentally proved that microorganisms i.e., bacteria could be formed only from existing bacteria. From all these information scientists were led to one of the important concepts in biology. This concept is **cell theory.**

Modern cell theory states that:

1. **All living organisms are made up of cells.**
2. **A cell is the structural and functional unit of organisms.**
3. **New cells are formed when pre-existing cells divide.**

4.2 CELLULAR STRUCTURES AND FUNCTIONS

Cell is the structural and functional unit of living things. This structure consists of many parts. Each part performs specific function. **Organelles** are small subcellular, bodies with specific structure and functions present within the cytoplasm.

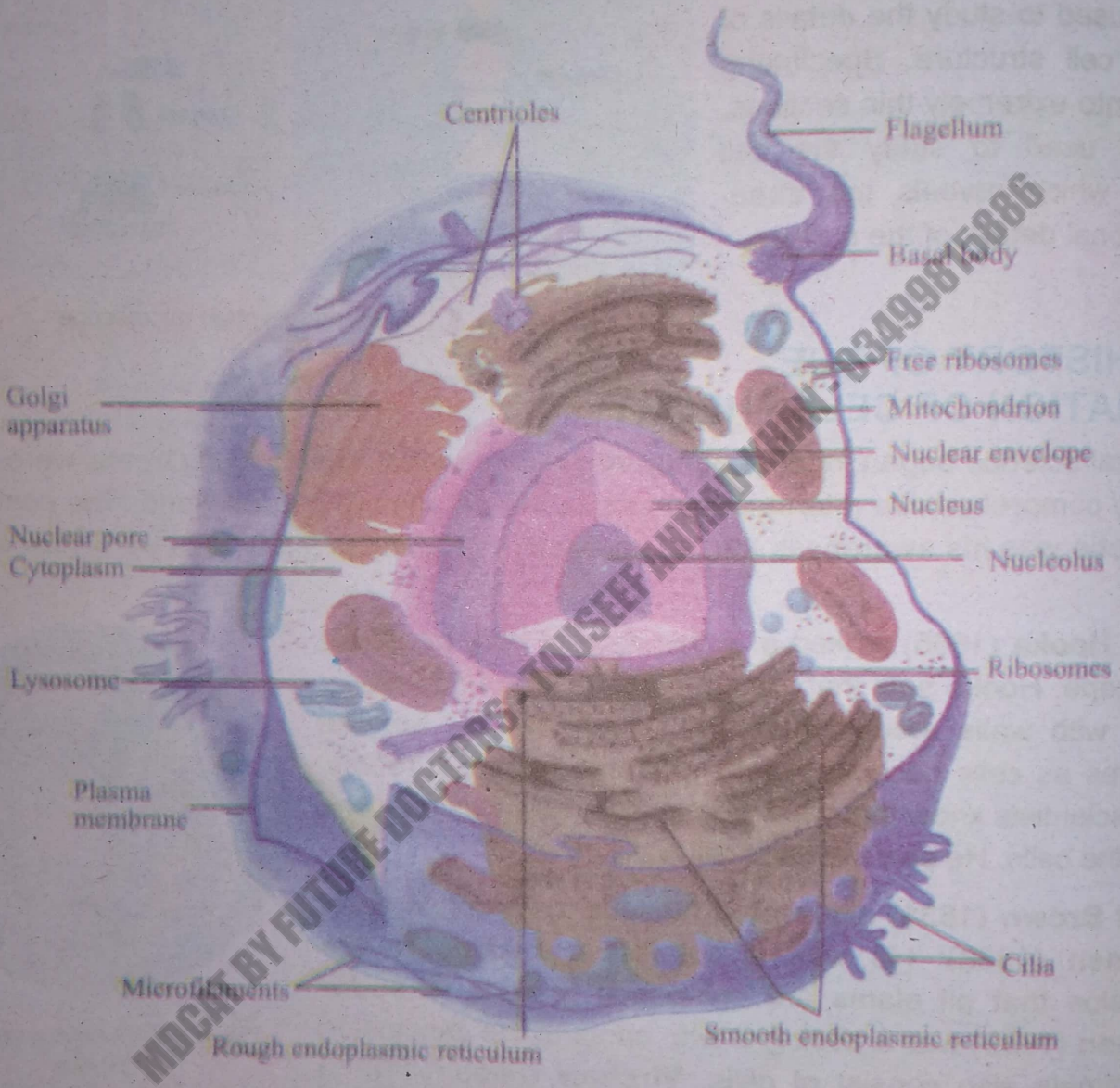


Fig. 4.3: Electron microscope structure of animal cell

4.2.1 STRUCTURE AND FUNCTIONS OF CELLORGANELLES

All organisms are made up of cells and cell is the smallest unit of living organisms. There are two main types of eukaryotic cells: animal cell and plant cell.

An Animal Cell

A eukaryotic cell has membrane bound nucleus and organelles. Animal cells have no cell wall and chloroplast.

1. Cell Membrane

It is also called **plasma** membrane. An animal cell is surrounded by a cell membrane. Chemically cell membrane consists of proteins, lipids and a small quantity of carbohydrates. The membrane structure is represented by **fluid mosaic model.**

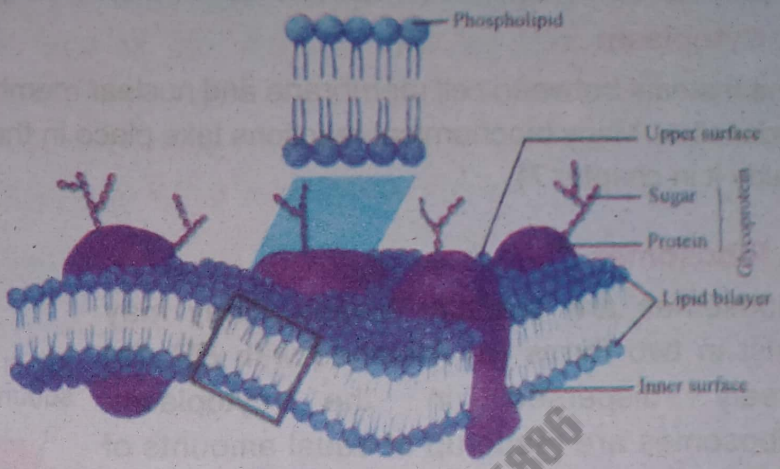


Fig. 4.4: Fluid mosaic model of plasma membrane

It proposed that the cell membrane has a fluid phospholipid bilayer in which protein molecules are either partially or wholly embedded. The plasma membrane forms the cell's point of contact with its environment.

It stops the cell contents from escaping and also controls the substances, which are allowed to enter and leave the cell. In general, oxygen, food and water are allowed to enter, waste products are allowed to leave and harmful substances are kept out. So, the cell membrane is called differentially or selectively permeable membrane.

2. Nucleus

It is located in central region. Nucleus consists of a double nuclear membrane, nucleoplasm, nucleolus and chromosomes. The surface of the nucleus is bounded by a double nuclear membrane called **nuclear envelope.**

The nuclear membrane has many pores. The fluid inside the nucleus is called **nucleoplasm.** The dark staining region in the nucleus is called **nucleolus**. The threads like structures in the nucleus are called **chromosomes**. Chemically chromosomes consist of deoxyribonucleic acid (DNA) and protein. The **centromere** is a constriction in chromosome. Nucleus controls all the activities of the cell.

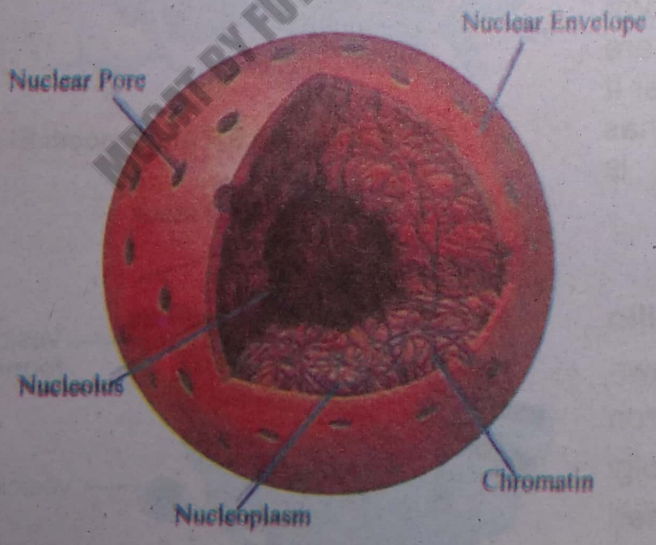


Fig. 4.5: Structure of Nucleus

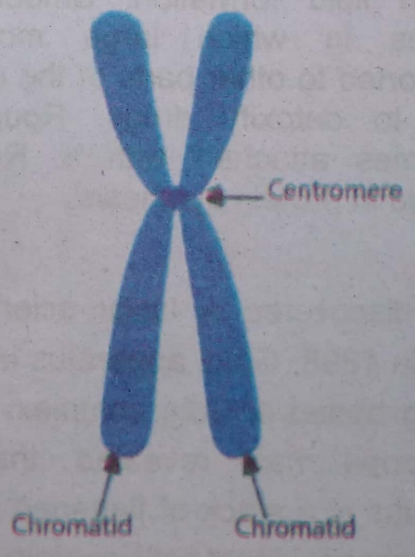


Fig. 4.6: Chromosome

3. Cytoplasm

The material between cell membrane and nuclear membrane is called cytoplasm. It contains all the organelles. Many biochemical reactions take place in the cytoplasm for example glycolysis (you will study it in chapter 7).

4. Ribosomes

Ribosomes are granular bodies. They may exist in two forms (a) Attached with ER. (b) Freely dispersed in the cytoplasm. Ribosomes are made up of equal amounts of RNA and protein

Ribosomes are not bounded by membrane. They are found in prokaryotes and eukaryotes.

Ribosomes are composed of two subunits of different sizes, the large and the small. The two subunits on attachment form ribosomes. Ribosomes are the sites of protein synthesis i.e.; amino acids are joined one by one to form protein.

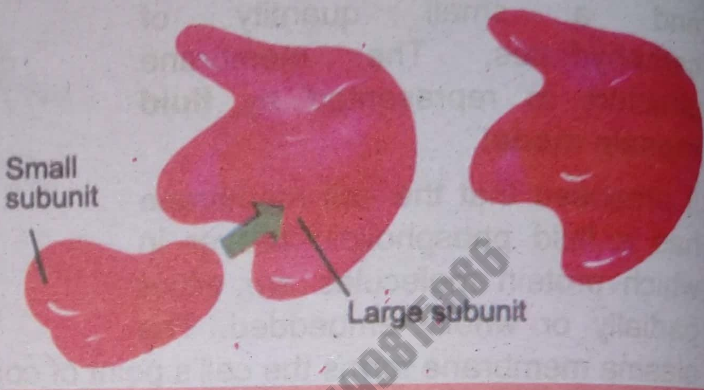


Fig. 4.7: Ribosomes

5. Endoplasmic Reticulum (ER)

It is a network of interconnected channels. The ER is continuous with plasma membrane, nuclear membrane, and Golgi apparatus. There are two types of ER i.e.; **smooth ER** and **rough ER**. In smooth ER ribosomes are not attached to it. Smooth ER plays an important role in lipid formation. Smooth ER form vesicles in which large molecules are transported to other parts of the cell. In liver it helps to detoxify drugs. Rough ER has ribosomes attached with it. Rough ER is involved in protein synthesis.

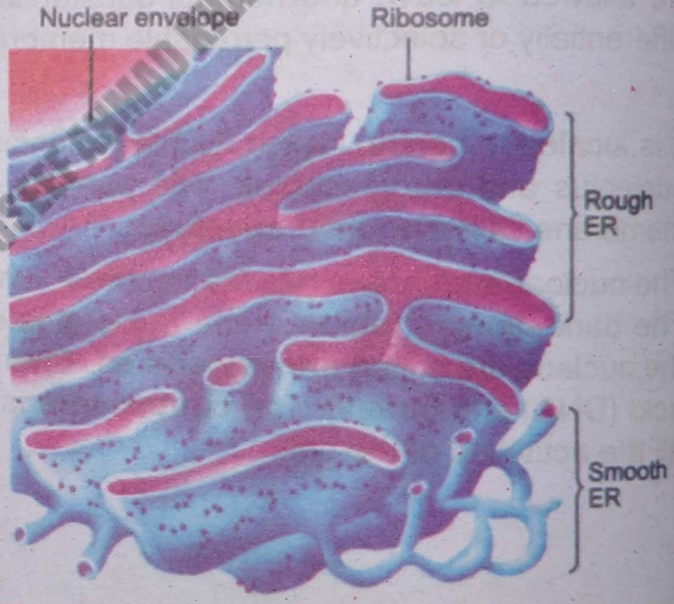


Fig. 4.8: Rough ER and smooth ER

6. Golgi Apparatus

It was discovered by Italian scientist **Camillo Golgi** in 1898. Golgi apparatus is also known as Golgi bodies or Golgi complex. The electron microscope has revealed that a Golgi apparatus is a stack of flattened sacs formed of membranes. Most cells contain 10 to 20 sets of these flattened membranes. In cells, the **inner face** of the stack is directed toward the

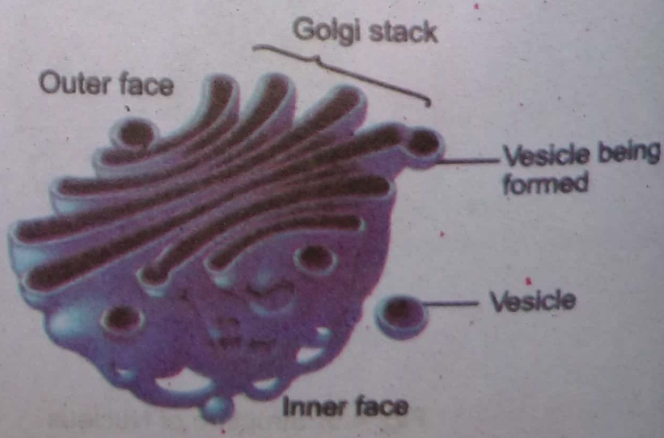


Fig. 4.9: Golgi Apparatus

endoplasmic reticulum and the **outer face** of the stack is directed towards the plasma membrane. Vesicles are seen at the edges of the stack. The Golgi apparatus receives vesicles that bud off from the endoplasmic reticulum and modify them. They store the secretion and finally release them in secretory vesicles. They also give rise to lysosome.

7. Lysosomes

Lysosomes are roughly spherical structures bounded by a single membrane. Lysosomes contain various active hydrolytic enzymes which breakdown proteins, nucleic acids, lipids and carbohydrates. Lysosomes have several types of digestive functions. Many cells engulf nutrients into tiny cytoplasmic sacs called food vacuoles. Lysosomes fuse with food vacuole, exposing the nutrients to hydrolytic enzymes that digest them. Small molecular products of digestion, such as amino acids, leave the lysosomes and are reused by the cell. Lysosomes serve as recycling centres for damaged organelles.

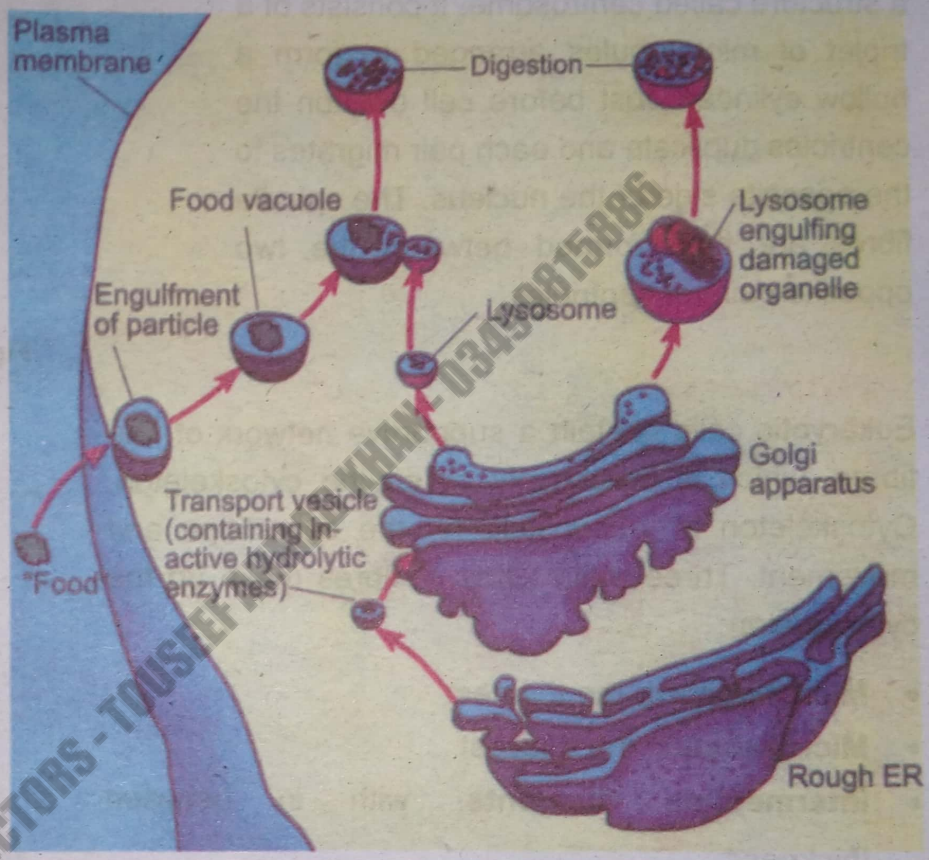


Fig. 4.10: Lysosomes: formation and functions

8. Mitochondrion

Mitochondria are spherical, rod-like or elongated tiny organelles. Under EM a mitochondrion is a double membrane structure. The outer membrane is smooth. The inner membrane is folded to form cristae. Cristae provide a much greater area. Mitochondrial solution is called matrix.

The mitochondria are called the powerhouse of the cell because it produces energy in the form of ATP (Adenosine triphosphate). DNA, ribosomes and enzymes are present in mitochondria.

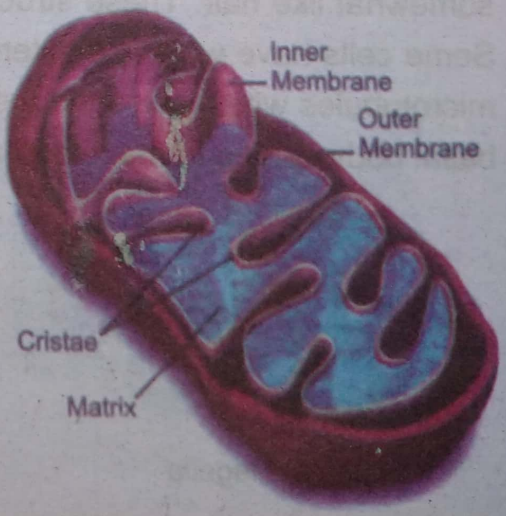


Fig. 4.11: Mitochondrion

9. Centriole

A pair of centrioles located near the outer surface of the nucleus. The two centrioles are usually placed at right angles to each other in a structure called centrosome. It consists of a triplet of microtubules arranged to form a hollow cylinder. Just before cell division the centrioles duplicate and each pair migrates to the opposite side of the nucleus. The spindle fibres are then formed between the two opposite pairs of centrioles.

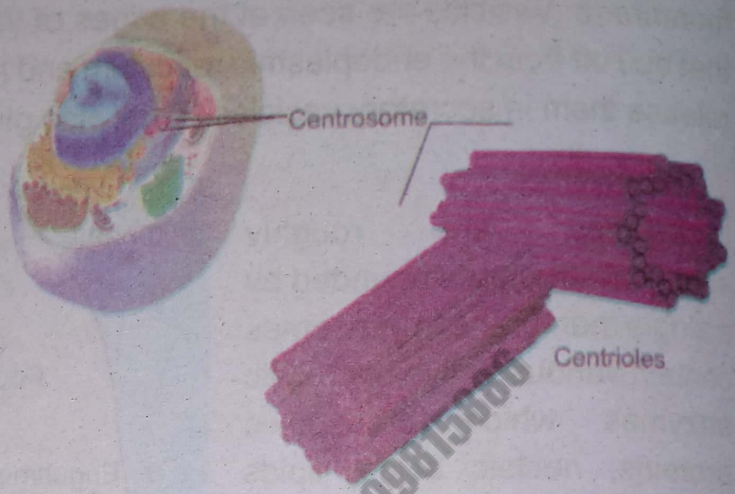


Fig. 4.12: A pair of centrioles

10. Cytoskeleton

Eukaryotic cells contain a supportive network of fine fibres, which is collectively called the cytoskeleton. Cytoskeleton is responsible for the cell shape and movement. Three main kinds of fibres make up the cytoskeleton:

- **Microfilament,** the thinnest
- **Microtubules,** the thickest
- **Intermediate filaments**, with in between thickness.

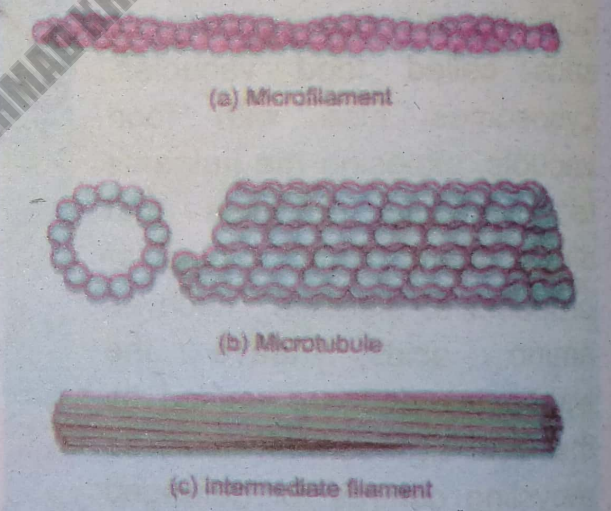
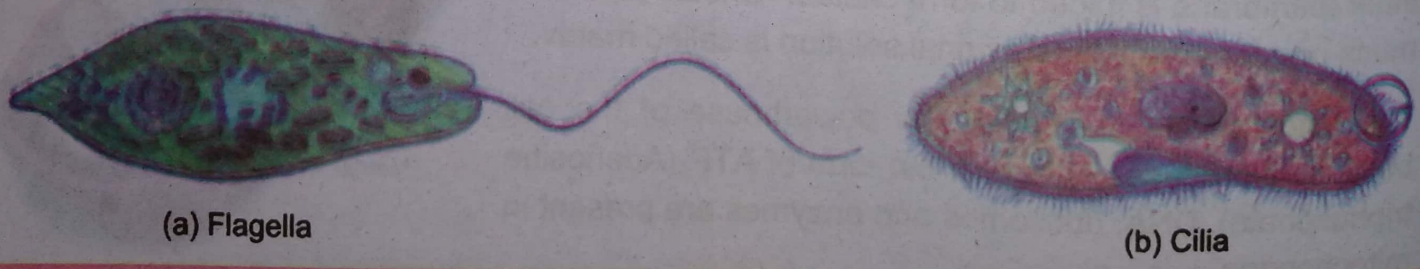


Fig. 4.13: Cytoskeleton (a) Microfliament (b) Microtubule (c) Intermediate filament

11. Cilia and Flagella

Some eukaryotic cells have extensions that look somewhat like hair. These structures are called **cilia.** Some cells have whip like extensions called **flagella**. Cilia and flagella consist of nine pairs of microtubules which surround a single central pair. They are connected to the **basal body**. The basal body serves to make and anchor a cilium or flagellum to the cell.



(a) Flagella (b) Cilia

Fig. 4.14: Cilia and Flagella

A Plant Cell

Plant cells differ from animal cells in having cell wall, a single large vacuole and plastids.

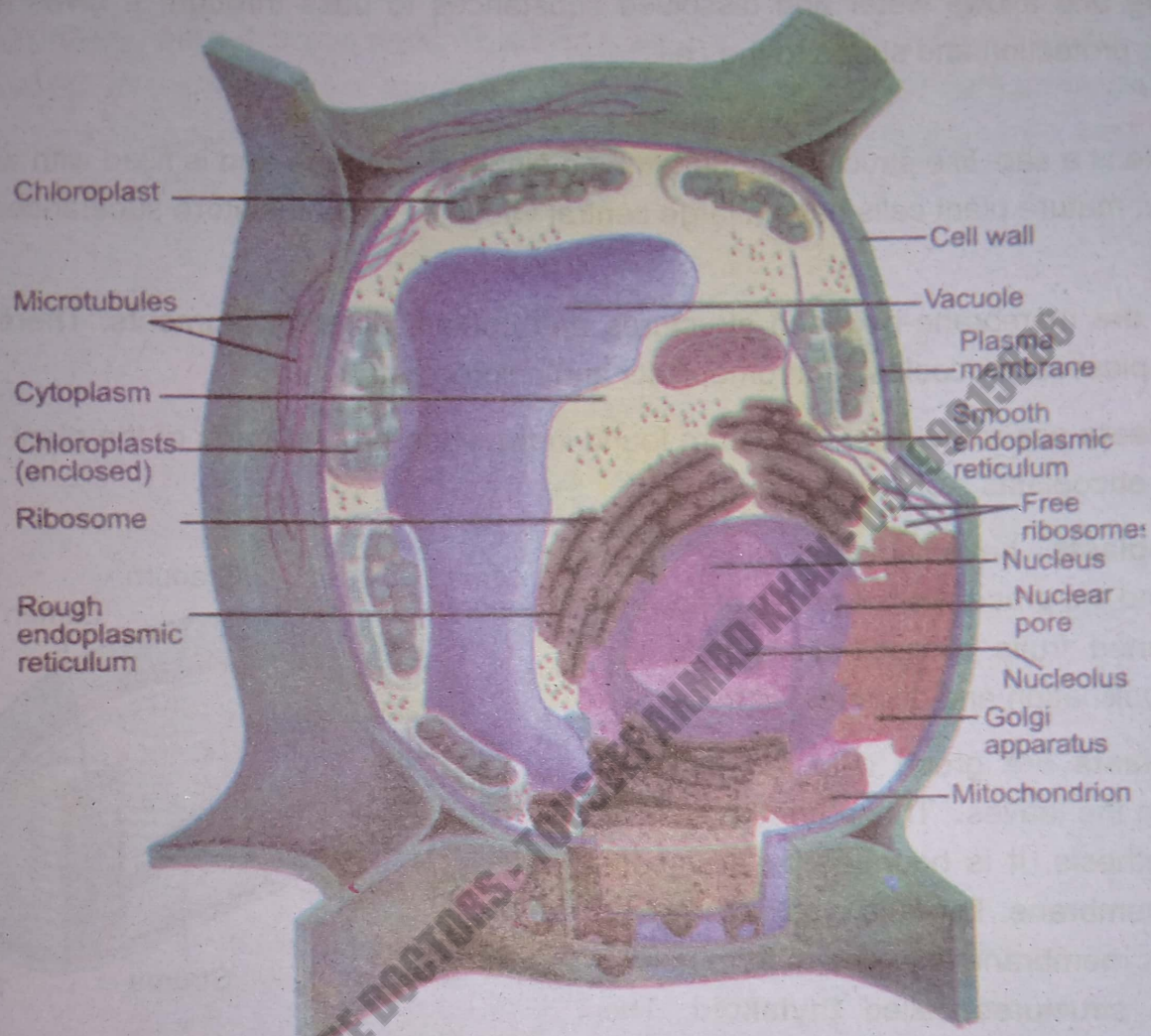


Fig. 4.15: Electron microscopic structure of a plant cell

Cell Wall

The cell wall surrounds the cell membrane. It consists of three main layers.

Middle lamella is present between adjacent primary walls of the two cells. It is formed of sticky gel like substance.

Primary cell wall is a true wall and develops in newly growing cells. It consists of cellulose and other compounds.

Secondary cell wall is formed between the primary cell wall and the plasma membrane. It is formed in

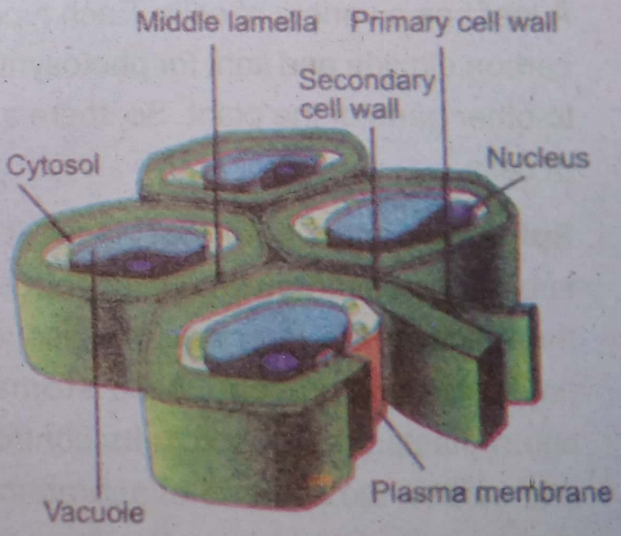


Fig. 4.16: Plant cell wall

woody tissues e.g., stem and nuts. It has lignin and cellulose.

The cell walls have minute pores forming living connection between the cells. The cell wall is non-living and allows water and dissolved substances to pass through. It gives mechanical strength, protection and shape to the cell.

Vacuoles

A vacuole is a sac- like structure, bounded by a single membrane and is filled with watery fluid. Typically, mature plant cells have a large central vacuole. Vacuoles store substances.

Plastids

Plastids are membrane-bounded structures and contain different pigments. There are three types of plastids: leucoplasts, chromoplasts and chloroplasts.

Leucoplasts are colourless. These are found in the underground parts of the plant e.g., roots, tubers. Leucoplasts store food.

Chromoplasts have colours other than green, and are present in the petals of flowers and ripened fruits. Chromoplasts help the plant in pollination and dispersal of fruits

Chloroplasts are green coloured and are located in the leaves. These are the sites of photosynthesis. It is bounded by a smooth double membrane. The fluid is called **stroma**. The inner membrane is folded to form hollow coin like structures called **thylakoid**. The stacks of thylakoids are called **grana**.

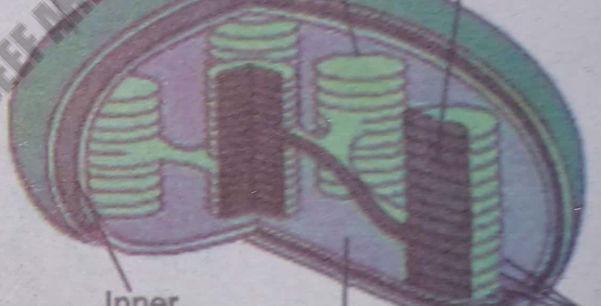


Fig. 4.17: Chloroplast

Structure and Functions of Cells of a Leaf

A leaf has a variety of cells. Each type of cell performs a special function. Leaf cells need water, carbon dioxide and light for photosynthesis. It also needs oxygen for respiration. It transfers food to other parts of the plant. So, there are varieties of functions and accordingly there are varieties of cells.

Epidermis is the outermost layer. It is single layer of cells, covering the leaf surface. A waxy substance called **cutin**, which forms the cuticle, covers the upper epidermis. The function of the epidermis is to protect the tissues and to prevent loss of water. On the lower epidermis tiny pores are present called **stomata**. Each stoma is enclosed by two guard cells, having chloroplasts. The **guard cells** control the opening and closing of stoma. Exchange of oxygen and carbon dioxide and evaporation of water vapour takes place through stomata. Between the two-epidermal layers lies the group of cells called **mesophyll**. These are of two types –

a **palisade mesophyll** and the **spongy mesophyll**. The palisade mesophyll consists of two or three layers of cylindrical cells. These cells contain many chloroplasts. The spongy mesophyll consists of loosely arranged irregular cells having chloroplast. Large intercellular spaces are present among these cells. This arrangement facilitates diffusion of gases. **Xylem** vessels present in the leaves are long and dead cells. Through xylem cells transportation of water from root to leaves takes place. The **phloem** cells carry the prepared food from the leaf to other parts of the plant.

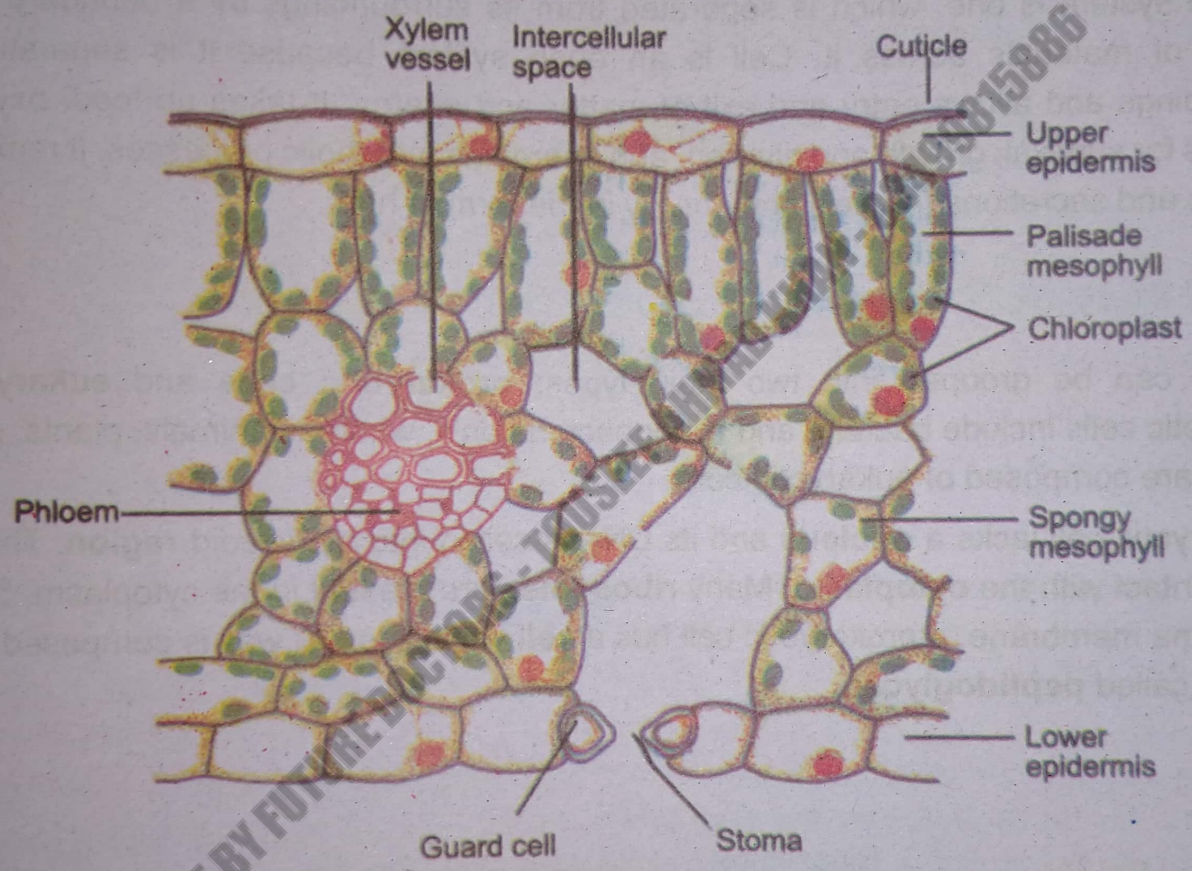


Fig. 4.18: Transverse section of a leaf

4.2.2 RELATIONSHIP BETWEEN CELL FUNCTION AND CELL STRUCTURE

There are different types of plant and animal cells. These cells differ in shape, size and structure. Cells are modified according to their function.

Root Hair Cells

The root hairs are the extensions of the epidermal cells. The root hair is long and narrow. It provides large surface area for the absorption of water and mineral salts from the soil.

Xylem Vessels

They transport water and mineral salts. As there is no cross wall and the cells are empty, so water can move easily through the xylem vessel.

Red Blood Cells

The red blood cells are enucleated (without nucleus), disk shaped and slightly biconcave. The biconcave shape provides a larger surface for gas diffusion into and out of the cell at a faster rate. Lack of nucleus provides more space for haemoglobin.

The Cell as an Open System

An open system is one, which is separated from its surroundings by a boundary that allows transfer of materials across it. Cell is an open system because it is separated from its surroundings and allows entry and exit of matter and energy. It takes up food, oxygen, water and salts for survival, growth and division, and energy for metabolic processes. It removes waste products and secretions (matter) and energy in the form of heat.

4.2.3 PROKARYOTIC AND EUKARYOTIC CELLS

All cells can be grouped into two main types; **prokaryotic cells** and **eukaryotic cells**. Prokaryotic cells include bacteria and cyanobacteria only, whereas animals, plants, protists and fungi all are composed of eukaryotic cells.

A prokaryotic cell lacks a **nucleus** and its DNA is coiled into a nucleoid **region**. The DNA is in direct contact with the **cytoplasm**. Many **ribosomes** are present in the cytoplasm. Surrounding the plasma membrane, a prokaryotic cell has a **cell wall**. The cell wall is composed of complex material called **peptidoglycan**.

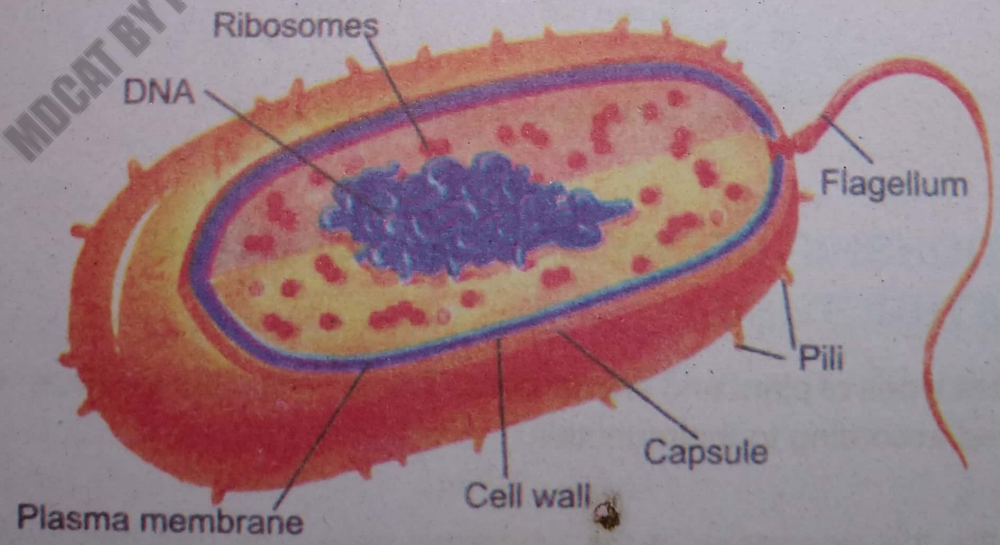


Fig. 4.19 A Prokaryote (Bacterium)

Table: 4.1 Comparison between Prokaryotic and Eukaryotic cells	
Prokaryotic cells	**Eukaryotic cells**
Prokaryotes include bacteria and cyanobacteria.	Eukaryotes include protists, fungi, plants and animals.
Have no nucleus. DNA is coiled into nucleoid region.	Have nucleus. DNA is in the nucleus. Nucleus is surrounded by nuclear membrane.
DNA is in direct contact with the cytoplasm.	DNA is not in direct contact with the cytoplasm.
No membrane bounded organelles are present.	Membrane bounded organelles are present.
Ribosomes are of small size and freely scattered in the cytoplasm.	Ribosomes are of large size and are present on endoplasmic reticulum and also freely dispersed in the cytoplasm.
Cell wall is composed of peptidoglycan. Cellulose is absent.	Cell wall of plant cell is composed of cellulose, while in fungi it is of chitin.
Prokaryotic cells are comparatively smaller in size.	Eukaryotic cell is comparatively larger in size.

4.2.4 RELATIONSHIP BETWEEN CELL SIZE AND SHAPE AND SURFACE AREA TO VOLUME RATIO

The sizes and shapes of cells are related to the function they perform. Some cells, such as *Amoeba* and the white blood cell, can change their shape as they move about. Sperm cells have, whip-like tails called flagella for locomotion. Nerve cells are long and thin, so they can transmit messages over great distance.

Why are most cells so small? Most animal cells are extremely small, ranging in diameter from about 10 to 30 micrometre (μm). To understand why cells are so small, you must first realize that most cells are constantly working, doing such jobs as breaking down molecules for energy, producing substances that cells need and getting rid of wastes. Each cell must move substances in and out of the plasma membrane quickly enough to meet its needs. As cells are small, the distances, molecules travel within them are relatively small, which speed up many cellular activities. The more surface area (plasma membrane) the cell has, the faster a given quantity of molecules can pass through it. This means that the factor, which determines cell size, is the ratio of its membranous surface to the volume it encloses.

CELL SURFACE AREA TO VOLUME RATIO

Metabolically active cells require rapid and efficient exchange of substances across the cell membrane. As a cell grows bigger, its internal volume enlarges and cell membrane expands. Beyond a certain limit, surface area available to pass materials is not enough to perform rapid exchange. The surface area to volume ratio gets smaller as the cells get larger. It can be understood by following example. If a large cube shaped cell has each side of 3 μm then its volume is 27 μm^3 and its surface area is 54 μm^2. In its place if 27 small cells are taken then their

total surface area will be 162 μm^2. Surface area to volume ratio of one large cell is 2 while for 27 small cells it is 6.

Only few cells are large in nature like bird's eggs but they are mainly storage structures. Metabolically active cells are always small so that their surface area to volume ratio is high. Rapid and efficient exchange of material is possible when cell surface area to volume ratio is high.

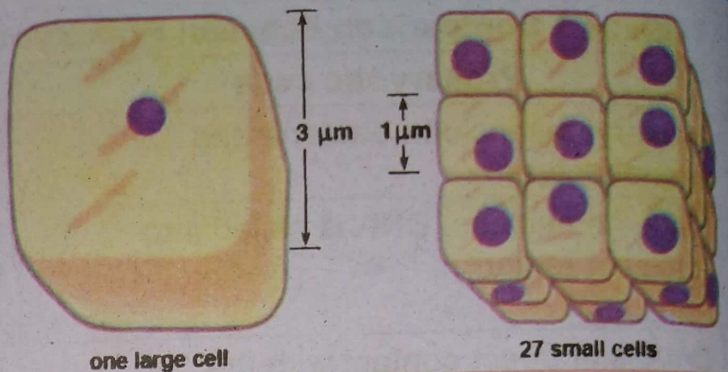


Fig. 4.20: Effect of cell size on surface area

	One large cell	27 small cells
Total Surface Area (height x width x sides x number of cells)	54 μm^2	162 μm^2
Total Volume (height x width x length x number of cells)	27 μm^3	27 μm^3
Surface area to volume ratio	2	6

What does Surface Area: Volume mean to a Cell?

The surface area to volume ratio limits the cell size because the bigger the cell gets the less surface area it has for its size. Thus, if the cell grows beyond a certain limit, not enough materia will be able to cross the membrane fast enough to support life.

4.3 PASSAGE OF MOLECULES INTO AND OUT OF CELLS

Molecules must pass into and out of the cell. This passage of molecules takes place through the cell membrane. Molecules of cells are dissolved in water, which provides a fluid environment within which the molecules can move.

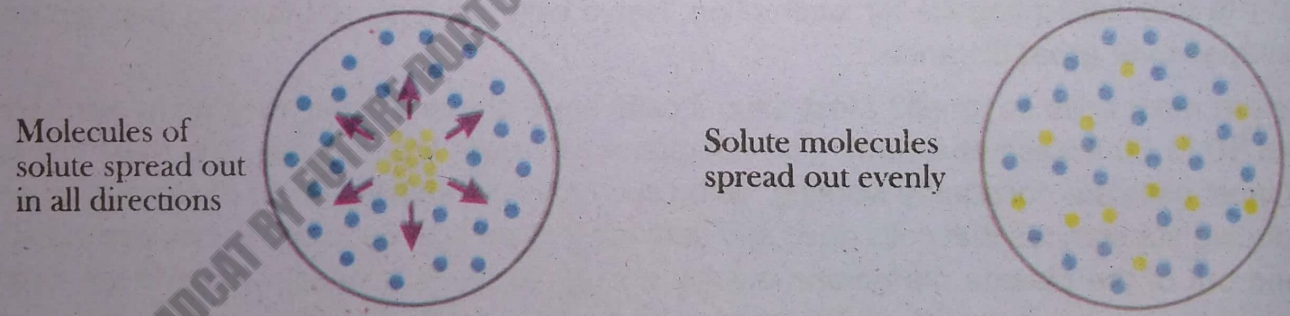


Fig. 4.21: Moving molecules

Passive Transport – Movement that Does Not Require Energy

In this type of movement, molecules move from regions of higher concentration to those of lower concentration i.e., down a concentration gradient without any expenditure of energy. There are four types of passive transport:

a. diffusion b. facilitated diffusion
c. osmosis d. filtration

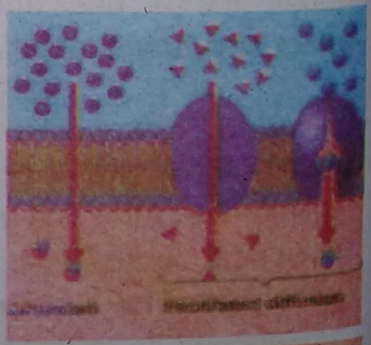


Fig. 4.22 Diffusion and Facilitated diffusion

a) Diffusion

Diffusion is the tendency of particles to spread out from more concentrated to less concentrated area. Diffusion results from random motion of atoms and molecules.

b) Facilitated Diffusion

The cell membrane has channels made of transport protein. Only a particular molecule can pass through them. Facilitated diffusion is the movement of selected molecules across the cell membrane by specific transport proteins along the concentration gradient and without an expenditure of energy. Transport of glucose into cells takes place through facilitated diffusion.

c) Osmosis

The cell membrane allows water to pass through it more rapidly than dissolved substances. Osmosis is a special type of diffusion involving water molecules. It occurs when a **partially permeable membrane** separates two solutions of different concentrations.

Osmosis is the passage of water molecules from a dilute solution into a concentrated solution through a partially permeable membrane.

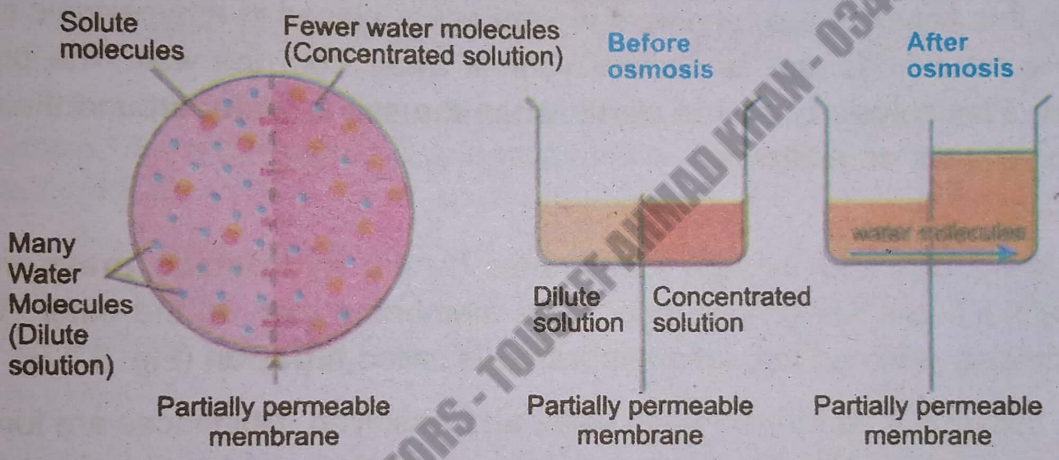


Fig. 4.23: Osmosis

Tonicity

The strength of a solution in relationship to osmosis is called tonicity. The solutions are of three types, **isotonic solution, hypotonic solution** and **hypertonic solution.**

Cells are normally placed in solutions that cause them neither to gain nor loss water. Such a solution is called **isotonic solution**. That is the solute concentration is the same on both sides of the membrane and therefore there is no gain or loss of water. A 0.9% solution of sodium chloride is known to be isotonic to red blood cells because the cells neither swell nor shrink when placed in this solution.

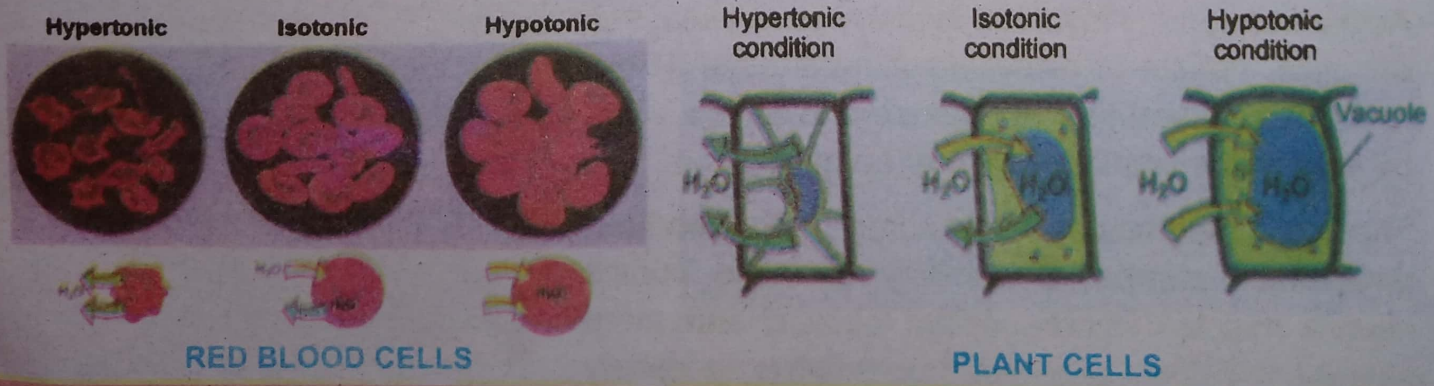


Fig. 4.24: Osmosis cells

Solutions that cause cells to swell or even burst due to an intake of water are said to be **hypotonic solution** i.e., a solution with a lower percentage of solute (more water) than the cell. If a cell is placed in a hypotonic solution, water enters the cell; the net movement of water is from the outside to the inside of the cell. Any concentration of salt solution lower than 0.9% is hypotonic to red blood cells. Red blood cells placed in such a solution expand and sometimes burst. The swelling of a plant cell in hypotonic solution creates **turgor pressure**. When a plant cell is placed in hypotonic solution the cytoplasm expands because the larger central vacuole gains water and plasma membrane pushes against the rigid cell wall. The cell in this state becomes **turgid**. The plant cell does not burst because the cell wall does not give way.

Solutions that cause cells to shrink due to a loss of water are said to be **hypertonic solutions** i.e., a solution with higher percentage of solutes. In hypertonic solution, water leaves the cell; the net movement of water is from the inside to the outside of the ell. A solution with a concentration higher than 0.9% sodium chloride is hypertonic to red blood cells. If red blood cells are placed in this solution, they shrink. If a plant cell is placed in a hypertonic medium, it loses water to its surroundings and its contents shrink away from the wall. The process is called **plasmolysis**. Plasmolysis occurs in plants when the soil or water around them contains high concentration of salts or fertilizers.

d) Filtration

The molecules are forced through membranes by the **hydrostatic pressure,** called blood **pressure**, which is greater on one side of the membrane than on the other. This process by which molecules are forced through membranes is called **filtration** (Fig. 9.12).

In the body, **tissue** fluid is formed when water and dissolved substances are forced out through the thin, porous walls of blood capillaries, but; larger particles such as blood proteins molecules are left inside.

ACTIVE TRANSPORT – Movement that Does Require Energy

Sometimes substances move against a concentration gradient in the reverse direction to normal diffusion. Such movement is called **active transport**. This process requires energy in the form of ATP.

Active transport is involved in many processes. For example, uptake of dissolved mineral salts by the root hairs, absorption of glucose and amino acids by cells in the small intestine of humans.

The cell membranes of neuron have **sodium potassium pumps**. By activity of these pumps neuron maintain more sodium outside and more potassium inside. Such ionic distribution is necessary for proper working of neuron.

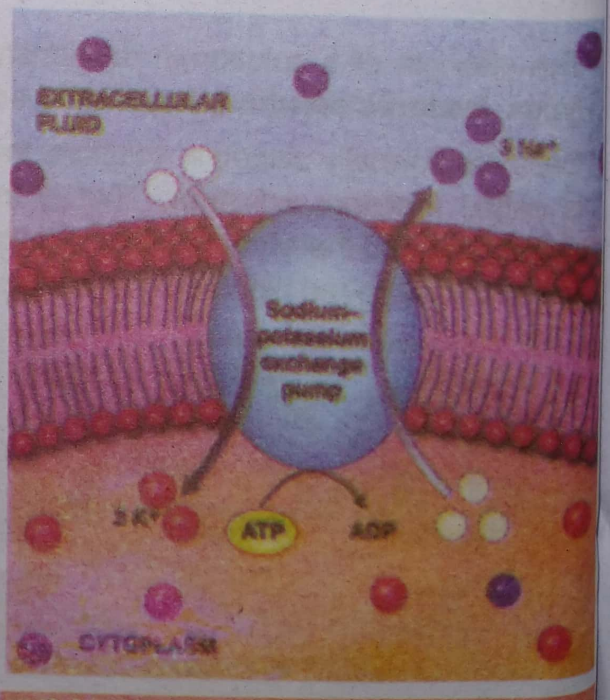


Fig. 4.25: Sodium potassium pump

Endocytosis

During endocytosis cells engulf substances by vesicle formation. Endocytosis is of two types (a) Phagocytosis (b) Pinocytosis.

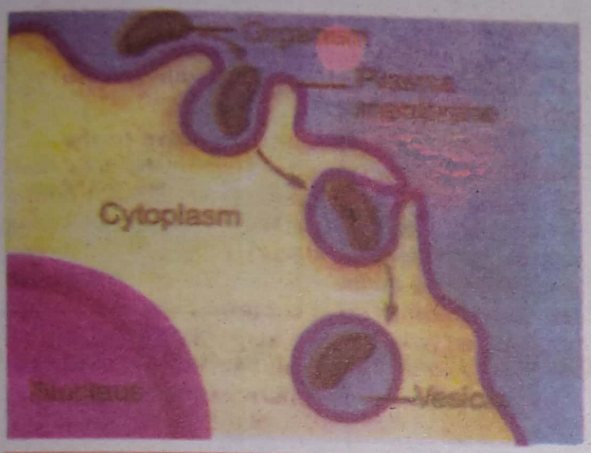


Fig. 4.26: Phagocytosis

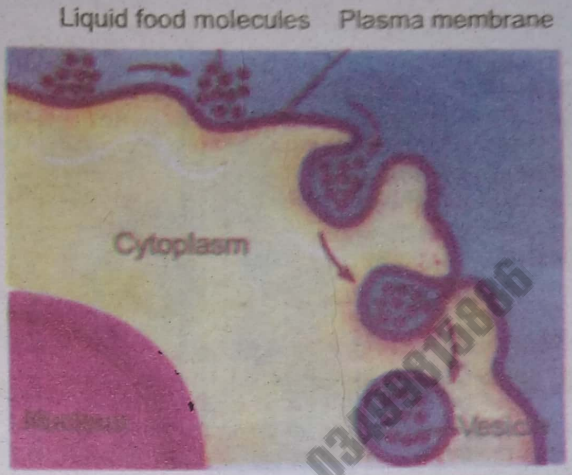


Fig. 4.27: Pinocytosis

Phagocytosis: When the material taken in by the endocytosis is in solid form, the process is called phagocytosis. *Amoeba* engulfs Paramecium etc, and some white blood cells take up bacteria by phagocytosis.

Pinocytosis: It occurs when material taken up is in liquid form. In humans, this process occurs in cells lining the small intestine and is used primarily for absorption of fat droplets.

Exocytosis

During exocytosis a cell discharges material by packaging it in secretory vesicles and moving the vesicle to the cell surface. The membrane of the vesicle fuses with the cell membrane and the contents are expelled out.

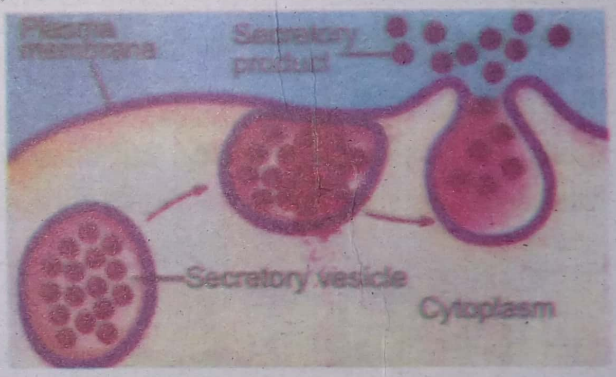


Fig. 4.28: Exocytosis

4.4 TISSUES

Tissues are groups of cells that have a similar structure and act together to perform a specific function. The bodies of multicellular organisms are made up of different types of cells. Each type of cell is specialized to perform a particular biological function.

Animal Tissues

Animal tissues are divided into four groups namely **epithelial tissue**, **connective tissue**, **muscular tissue** and **nervous tissue**.

1. Epithelial Tissue

Epithelial tissue is also called **epithelium.** It consists of tightly packed cells that form a continuous layer or sheet covering the entire body surface and lining most of the inner cavities. There are five types of epithelium.

a) Squamous Epithelium

The cells are thin and flattened and arranged as a single layer It is present in the alveoli of lungs, blood vessels etc. Its function is passage of material by diffusion and filtration.

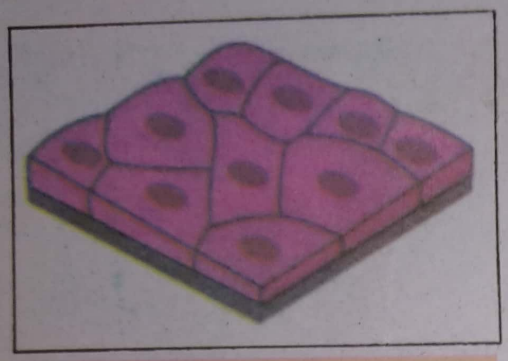


Fig. 4.29: Squamous epithelium

Fig. 4.30 Cuboidal Epithelium

Fig. 4.31: Columnar epithelium

b) Cuboidal Epithelium

Cells are cube shaped, arranged in a single layer. They are present in tubules of kidney, and ducts of glands etc. Its function is secretion and absorption.

c) Columnar Epithelium

These cells are long and narrow. Columnar epithelium lines stomach, intestine etc. Its function is secretion, absorption and protection.

d) Ciliated Epithelium

Cells are columnar in shape but bear cilia at their free surfaces. These cells line the respiratory passages. It transports materials through tubes or passage ways.

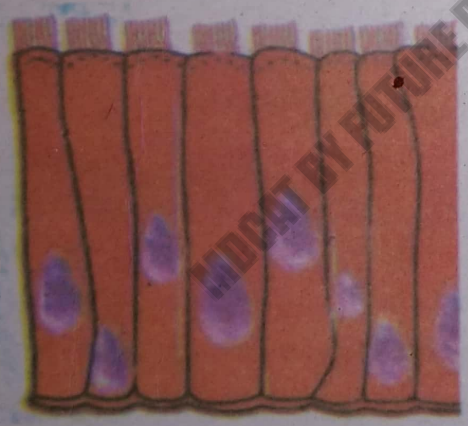


Fig. 4.32: Ciliated Epithelium

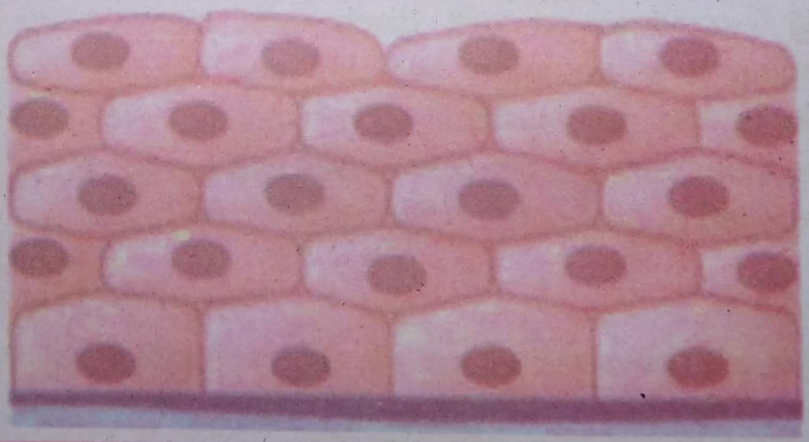


Fig. 4.33: Stratified Epithelium

e) Stratified Epithelium

This tissue is made up of a number of layers. It is present in oesophagus, skin etc. Its main function is protection.

2. Connective Tissue

The connective tissue cells are widely separated by a **matrix**, which is found between the cells and consists of a noncellular material that varies from solid to semisolid to fluid. The matrix may

have fibres. **Bone** and **cartilage** are hard connective tissue which support body and help in movement. Tendons and ligaments are **fibrous connective tissues** which maintain skeletal structure. **Adipose tissue** is a fatty tissue which provides insulation and stores energy. **Blood** is a fluid connective tissue which transports substances in the body.

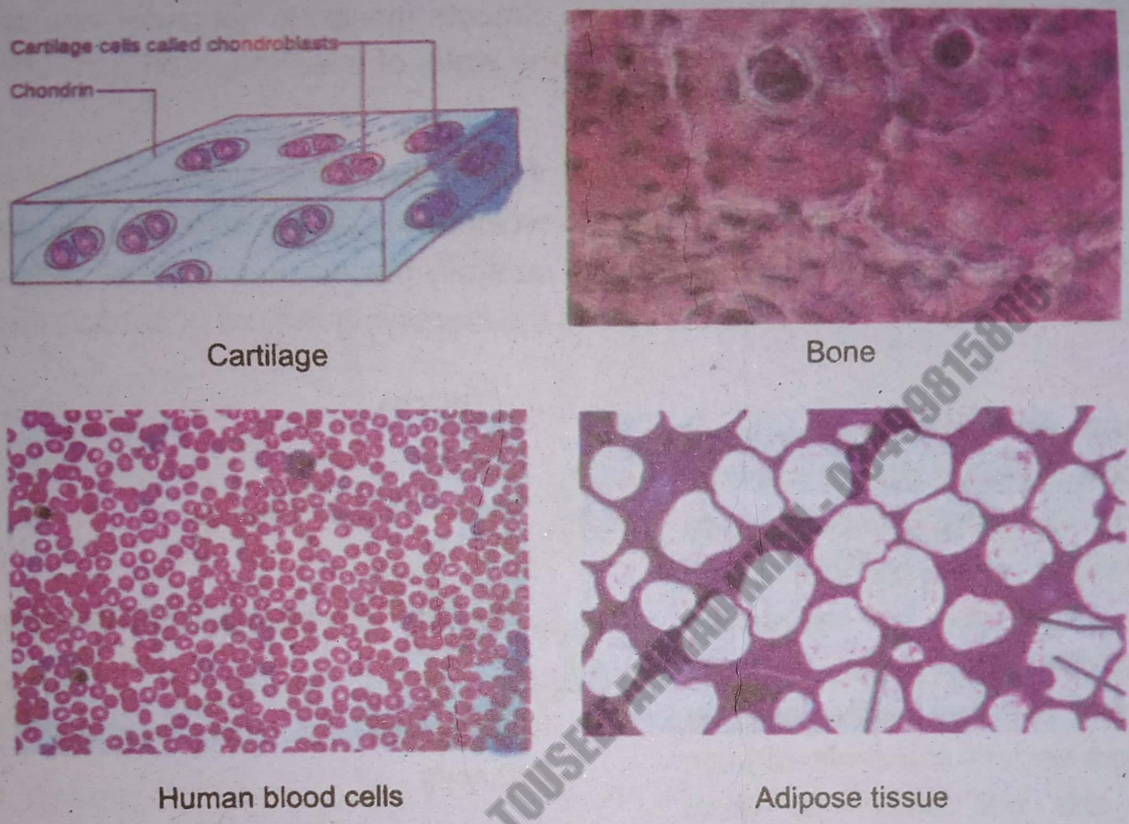
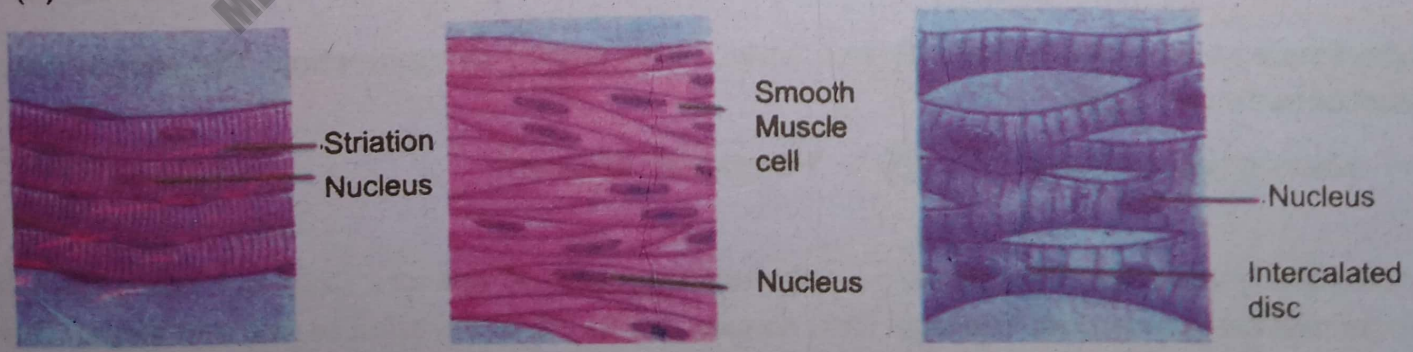


Fig. 4.34: Types of Connective tissues

3. Muscular Tissue

Muscular tissue is composed of bundles of long cells called **muscle fibres**. These fibres are contractile, held together by connective tissue. Muscle fibres contain **actin filaments** and **myosin filaments**. The filaments cause the movement of the body and body parts. All the vertebrates have three types of muscular tissue:

(a) Skeletal muscle (b) Smooth muscle (c) Cardiac muscle



Skeletal muscle **Smooth muscle** **Cardiac muscle**

Fig. 4.35 Types of muscles

a) **Skeletal Muscle:** Skeletal muscle fibres are attached to the bones by tendons. It is also called **striated muscle**. It is responsible for the voluntary movements of the body. Skeletal muscles are multinucleated.

b) **Smooth Muscle:** Each cell of smooth muscle is spindle shaped with a centrally located nucleus. It is called smooth muscle as it lacks striation. Smooth muscle is not under voluntary control so it is called **involuntary** muscle. It is found in the walls of intestine, stomach, urinary bladder, blood vessels and other internal organs.

c) **Cardiac Muscle:** It is found only in the walls of the heart. It has striations like skeletal muscle, but the contraction of the cardiac muscle is involuntary. Cardiac muscle cells also differ from skeletal muscle cells in that they have single, centrally placed nucleus. The cells are branched and are bound end to end. Intercalated disc is the identifying feature of cardiac muscle.

Nervous Tissue

The structural and functional unit of nervous tissue is nerve cell or neuron. Each neuron consists of **cell body** having a **nucleus**, and a number of thin extensions. One type of extension called **dendrite**, generally conveys signals toward the cell body, another type, the **axon** usually transmits signals away from the cell body. To carry messages, the neurons are thin and long.

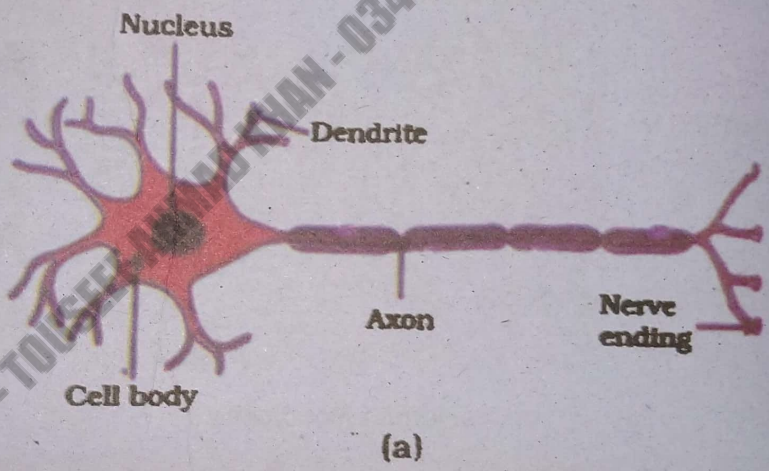


Fig. 4.36: A nerve cell (neuron)

PLANT TISSUES

Plant tissues have been divided into two main groups:

(1) Simple tissues (2) Compound tissues

1) Simple Tissues

Simple tissues are composed of only one type of cells having same function. The simple tissues consist of two main types:

(a) Meristematic tissues (b) Permanent tissues

Meristematic Tissues

Meristematic tissues are composed of cells having power of division. Cells are thin walled and have no intercellular spaces. Meristematic tissues are found at the apex of root and shoot. These tissues are called **apical meristem**, which divides to form more primary tissue and as a result the root and shoot elongate. This type of growth is called **primary growth.**

Meristematic cells are also found on the lateral sides of roots and stem. The two lateral meristems are: vascular cambium and cork cambium. These cells divide to form secondary tissues, which increase the thickness i.e., girth of stem and root. This is called **secondary growth**.

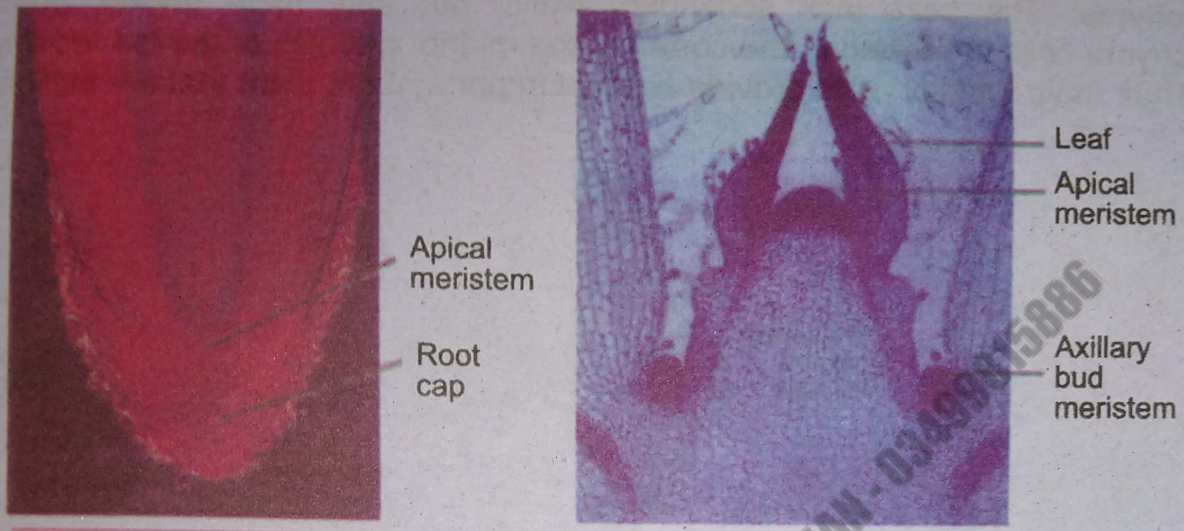


Fig. 4.37: Apical meristematic tissues

Permanent Tissue

The cells of permanent tissue do not divide. These cells originate from primary meristem. There are three types of permanent tissues: (a) Epidermal tissue (b) Ground tissue (c) Supporting tissue

Epidermal Tissue: Epidermis is one cell thick layer that covers the whole of the plant body i.e., root, stem and leaf. The cells of the epidermal tissue are living, thick walled and closely packed with no intercellular spaces. The epidermis of leaves has pores called **stomata**, for the exchange of gases. Root epidermal cell grow hair like extension, which increases its surface area.

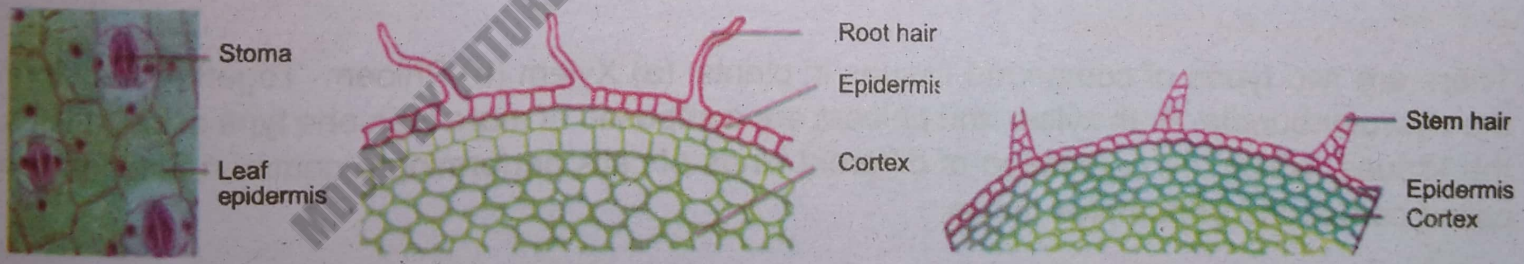


Fig. 4.38: Epidermal tissue

Ground Tissue: The herbaceous plants are mainly composed of ground tissue, which consist of parenchyma cells. Parenchyma cells may be spherical or elongated. The cells are large in size, surrounded by thin primary wall and have no secondary walls. Parenchyma cells are responsible for photosynthesis and food storage e.g., mesophyll tissues of leaves.

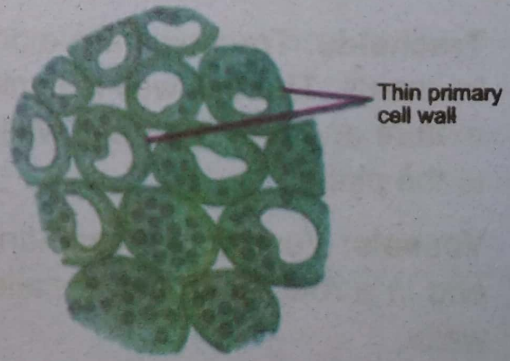


Fig. 4.39: Parenchyma cells

Supporting Tissues

Supporting tissues are also known as **mechanical tissues**. They provide strength and flexibility to plant. Supporting tissues are of two types: a) Collenchyma (b) Sclerenchyma

a) **Collenchyma:** The cells lack secondary walls, but they have thicker primary walls. Collenchyma cells are found in the cortex of the midrib, petioles of the leaves and in young stem. Their main function is to provide support in parts of the plant that are still growing.

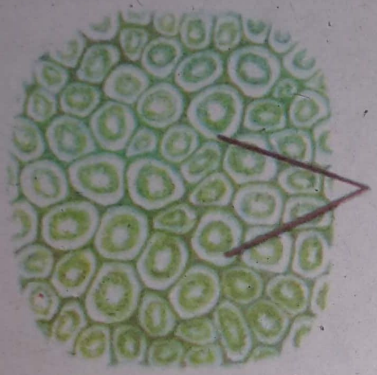


Fig. 4.40: Collenchyma cells

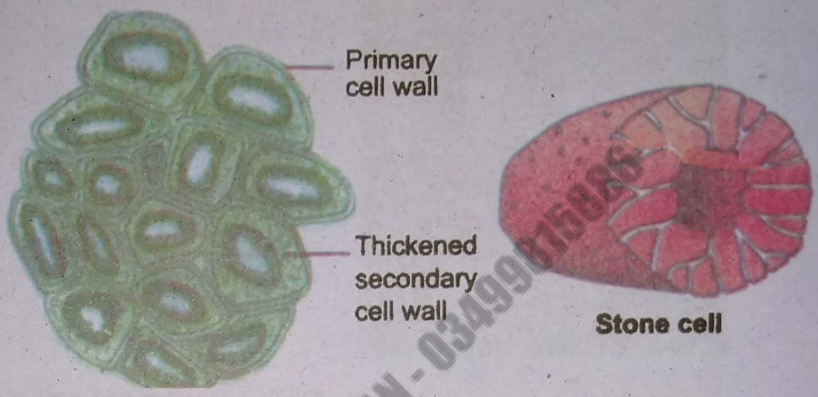


Fig. 4.41: Sclerenchyma

b) **Sclerenchyma:** The cells of sclerenchyma are dead and thick walled. The secondary cell walls are heavily thickened with the deposit of lignin, which provides hardness and strength to the cell. There are two types of sclerenchyma cells, namely fibre and sclereid. **Fibre** is long and slender, and usually occurs in xylem and phloem. **Sclereid** is also known as **stone cell**. Sclereids are usually spherical in shape. It is found in seed coats and provides hardness. The main functions of the sclerenchyma are to assist in providing support and mechanical strength to the plant.

2. Compound Tissues

There are two types of compound tissues in plants: (a) Xylem (b) Phloem. Together they form the vascular bundle. Both xylem and phloem are composed of more than one type of cells. Thus, the tissues, which are composed of different kinds of cells performing a common function, are called compound or complex tissue.

a) Xylem

Xylem has two main functions, the conduction of water and mineral salts, and to provide support and strength. Xylem consists of two main types of cells namely tracheids and vessel elements.

Tracheids: Tracheids are elongated cells having tapering end walls that overlap with adjacent tracheids. The cell wall is lignified and has pits. Tracheids are hollow, empty, dead cells when mature and only their cell walls remain. Tracheids have mechanical strength and give support to the plant.

Vessels: Vessels are very long, tubular structures formed by the fusion of several cells end to end in a row. Each cell is called vessel element. It is a dead, empty cell having dissolved end walls.

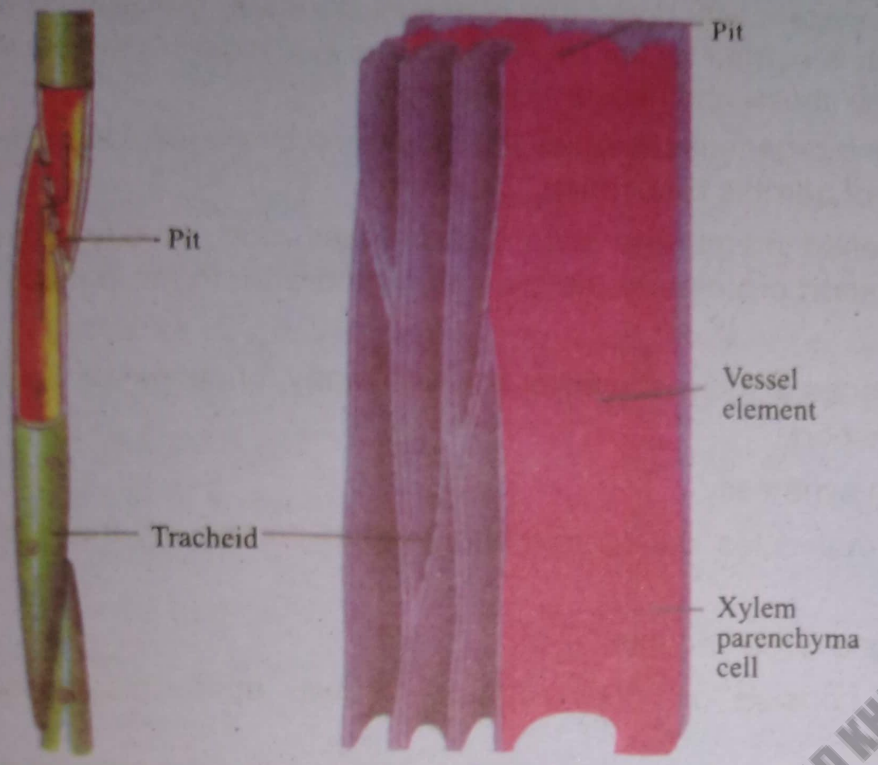


Fig. 4.42: Xylem cells – Tracheid and vessel

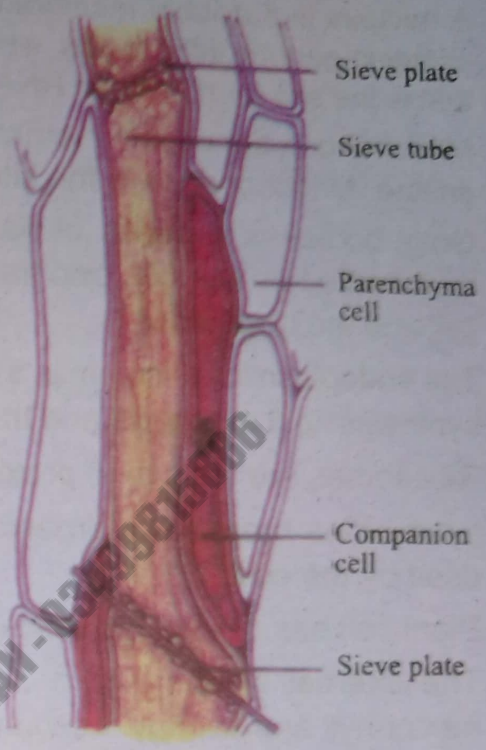


Fig. 4.43: Phloem cells

b) Phloem

It has a tubular structure. It conducts prepared food from leaves to stem and roots etc. Phloem tubes are composed of living cells with cytoplasm and have no mechanical function. There are two main types of cells in the phloem, namely sieve tube element and companion cells.

Sieve Tubes: These are formed by end-to-end fusion of cells called **sieve tube elements.** Sieve tube elements have porous end walls called sieve plate. The cytoplasm is continuous through sieve plate pores.

Companion Cells: The cells attached to sieve tube elements are called companion cells. They regulate or control the movement of food through the sieve tube.

SUMMARY

1. The light microscope enables us to see the overall shape and structure of a cell.
2. The greater resolving power of electron microscope allows greater magnification and reveals cellular details.
3. The cell is considered as the basic unit of life because it is the smallest unit of living material.
4. Modern cell theory states that organisms are composed of cells and products of cells. All cells arise by division of pre-existing cells.
5. Every cell is surrounded by cell membrane. The cell membrane is a highly fluid mixture of phospholipids and proteins.

6. A nucleus is a double membrane system with pores that communicates with the cytoplasm. It contains genetic information, which is carried by the DNA. Nucleolus is a region in the nucleus that is the site for ribosomal RNA synthesis and ribosome assembly.
7. Mitochondria are double membrane organelles in which the inner membrane is folded to form cristae. Mitochondrion is the site of aerobic respiration.
8. Golgi bodies is a series of flattened membrane sacs that process, sort, modify proteins synthesized on the ER, and transport proteins to the plasma membrane, to the outside the cell and the lysosomes.
9. The endoplasmic reticulum is a series of internal membrane with many functions, i.e., protein synthesis lipid synthesis and transport.
10. Ribosomes are the site of protein synthesis.
11. Lysosomes breakdown organic molecules like protein into simpler compound that can be used by the cells.
12. Plant cell has cell wall, plastids and large vacuole.
13. The internal structure of a leaf consists of upper epidermis, lower epidermis, palisade, mesophyll and spongy mesophyll.
14. Root hair cells, xylem vessels and red blood cells are adapted to their particular functions.
15. Prokaryotic cells are bounded by a plasma membrane but lack a nucleus and have little or no internal membrane organization.
16. Cell's size and shape relate to function. At minimum a cell must be large enough to house the parts it needs to survive and reproduce.
17. The maximum size of a cell is limited by the amount of surface needed to obtain nutrients from its environment and dispose of waste.
18. A small cell has a greater ratio of surface area to volume than a large cell of the same shape.
19. Diffusion is the net movement of a substance down its concentration gradient (from a region of high concentration to one of low concentration).
20. Osmosis is a kind of diffusion in which molecules of water pass through a selectively permeable membrane from a region where water has a higher effective concentration to a region where its effective concentration is lower.
21. Some substances pass through membranes by facilitated diffusion in which a carrier protein helps a molecule move through the membrane.
22. In endocytosis material, such as food may be moved into the cell. In exocytosis the cell ejects waste products or secretes substances such as mucus.
23. A tissue consists of group of similarly specialised cells that associate to perform one or more functions.
24. Animal tissues are classified as epithelial, connective, muscular or nervous.
25. The simple plant tissue consists of meristematic tissues and permanent tissues. A compound tissue consists of xylem and phloem.

Exercise

MCQs

Select the correct answer:

1. A network of channels extending from cell membrane to nuclear membrane is called:
   A) centriole B) endoplasmic reticulum
   C) ribosomes D) centrosome
2. The site of enzyme synthesis in cells is:
   A) lysosome B) smooth endoplasmic reticulum
   C) Golgi bodies D) ribosome
3. In which organelle are nucleic acids absent?
   A) chloroplast B) Golgi apparatus
   C) mitochondrion D) nucleus
4. The concentration of calcium in a cell is 0.9%. The concentration of calcium in the surrounding fluid is 0.1%. How could the cell obtain more calcium?
   A) passive transport B) osmosis
   C) diffusion D) active transport
5. What is the main advantage of small cell size?
   1. small cells can better take up what they need from the environment
   2. small cells are less likely to burst than large cells
   3. small cells can change shape easily
   4. small cells require less energy to divide
6. Which of the following clues would tell you whether a cell is prokaryotic or eukaryotic?
   1. whether or not the cell is partitioned by internal membrane.
   2. the presence or absence of a single rigid wall.
   3. the presence or absence of ribosomes.
   4. whether or not the cell contains DNA.
7. Which of the following helps root hair cells to take up water?
   A) fibres B) vacuole
   C) xylem vessel D) large surface area
8. What is the major advantage of using a light microscope instead of an electron microscope?
   A) ability to observe living matter B) superior resolution
   C) use of very thin section D) constant depth of focus

9. Which of the following clues would tell you whether a cell is prokaryotic or eukaryotic?
   1. whether or not the cell is partitioned by internal membrane
   2. the presence or absence of a single rigid wall
   3. the presence or absence of ribosomes
   4. whether or not the cell contains DNA
10. Which of the following helps root hair cells to take up water?
    A) fibres B) vacuole
    C) xylem vessel D) large surface area
11. What is the major advantage of using a light microscope instead of an electron microscope?
    A) ability to observe living matter B) superior resolution
    C) use of very thin section D) constant depth of focus.
12. How do nitrate ions, oxygen and water enter root hair cells?

	By diffusion	By osmosis	By active transport
A	oxygen	water	nitrate ions
B	water	oxygen	nitrate ions
C	nitrate ions	water	oxygen
D	water	nitrate ions	oxygen

13. The table shows three functions of cells which row is correct?

	absorption	support	transport
A	red blood cell	muscle cells	root hair cell
B	root hair cell	xylem vessel	red blood cell
C	muscle cell	red blood cell	xylem vessel
D	xylem vessel	root hair cell	muscle cell

14. The resolving power or resolution of a microscope may be defined as:
    A) sharpness of image B) smallest object can be seen
    C) highest magnification D) ability to distinguish between two objects
15. The table shows the presence or absence of nucleus in three types of cells. Which option is correct?

	Red blood cells	Companion cells	Sieve element
A	absent	present	absent
B	absent	present	present
C	present	absent	present
D	present	absent	absent

16. What are the functions of xylem and phloem in green plants?

	xylem	phloem
A	transport of water	support and transport of sugars
B	transport of sugars	support and transport of water
C	support and transport of water	transport of sugar
D	support and transport of sugars	transport of water

17. What are the functions of mitochondria?

A) lipid synthesis B) protein synthesis

C) photosynthesis D) cellular respiration

18. A red blood cell and a plant root hair cell both have

A) a cellulose cell wall B) haemoglobin

C) a large surface area D) a nucleus

19. Which cell component is related to pinocytosis?

A) cell membrane B) lysosomes

C) nucleus D) ribosomes

20. Which of the following is present in all eukaryotic cells?

A) cell wall B) membrane bound organelles

B) flagellum D) flagellum

Short Questions

1. Can you differentiate between:
   (a) Light microscope and electron microscope
   (b) Transmission electron microscope and scanning electron microscope
   (c) Viruses and prions (d) Prokaryotic cells and eukaryotic cells
   (e) Meristematic and permanent tissue (f) Xylem and phloem
   (g) Pinocytosis and phagocytosis (h) Exocytosis and endocytosis
   (i) Diffusion and osmosis (j) Turgor pressure and osmotic pressure.
2. How the cell theory was developed?
3. Why are the following scientists famous for?
   (a) Aristotle (b) Robert Hooke (c) Robert Brown (d) Schawnn and Schleiden.
4. How the size and shape of the cell is related to surface area to volume ratio?

5. Explain the importance of following:
   (a) diffusion (b) facilitated diffusion (c) osmosis
   (d) active transport (d) cells smaller in size (d) turgor
6. Why osmosis can be considered as a special type of diffusion?
7. Why electron microscope cannot be used to study life processes?

Extensive Questions

1. Describe the structure and functions of animal cell. How it is different from plant cell?
2. Justify how the cells of leaf system have a variety of specialized structure and function.
3. State the relationship between all structure and function of root hairs, xylem vessels and red blood cell.
4. Describe diffusion of glucose from intestine to villus epithelium and active transport of sodium ions from nerve cell to outside.
5. Describe the role of the cell membrane in maintaining equilibrium while exchanging matter?
6. Can you compare magnification and resolution?

THE TERMS TO KNOW

• Active transport	• Epithelial tissue	• Nucleus
• Cell	• reticulum	• Organelle
• Cell membrane	• Epithelial tissue	• Osmosis
• Cell theory	• Facilitated diffusion	• Passive transport
• Cell wall	• Golgi apparatus	• Phagocytosis
• Centriole	• Hypertonic solution	• Pinocytosis
• Chloroplast	• Hypotonic solution	• Plasmolysis
• Chromoplast	• Isotonic solution	• Plastid
• Connective tissue	• Leucoplast	• Ribosome
• Cytoplasm	• Lysosome	• Semipermeable
• Diffusion	• Mitochondria	• Tissue
• Endoplasmic reticulum	• Muscle tissue	• Turgor pressure

INITIATING AND PLANNING

1. Assess the capabilities of plant and animal cell owing to the presence or absence of chloroplast and cell wall.
2. Assess the capabilities of prokaryotic and eukaryotic cells owing presence or absence of nucleus and mitochondria.

3. Compare the parts of the cells to the human body. For example, the nucleus is the brain of the cell while the endoplasmic reticulum is the cell's circulatory system; mitochondria are the lungs of the cell etc.
4. Justify why a colony of cells does not get tissue level of organization in spite of having many cells.
5. Formulate operational definitions of major variable e.g., define concentration gradient; define osmosis in terms of hypotonic and isotonic solutions.
6. State a prediction and a hypothesis based on available evidence and background information e.g., hypothesize how biochemical interconversions of starch and glucose might regulate the turgor pressure of guard cells.

Activity

1. Use instruments effectively and accurately for collecting data e.g., use a microscope to observe movement of small objects.
2. Estimate quantities e.g., compare sizes of various types of cells under the microscope.
3. Draw diagrams to represent differences between plant and animal cells.
4. Draw diagrams to represent differences between prokaryotes and eukaryotes.
5. Perform an experiment to determine the effect of tonicity on plasmolysis and deplasmolysis in plant cells or in Red Blood Cells
6. Identify from diagrams or photomicrograph, the cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts of the plant cell.
7. Identify from the slides or diagrams photomicrograph, the cell membrane, nucleus and cytoplasm in an animal cell.

COMMUICATION AND TEAMWORK

1. Describe the function of cell organelles and structures in a cell in terms of life processes and use models to explain these processes and their applications.

INITIATING AND PANNING

1. State a prediction and a hypothesis based on available evidence and background information e.g., hypothesize how biochemical interconversions of starch and glucose might regulate the turgor pressure of guard cells.

ANALYZING AND INTERPRETING

1. Use models to explain and visualize complex processes like diffusion and osmosis. Compile and display the evidence and information in a variety of formats, including diagrams, flow chart, tables and graphs

2. Collect data on the number of stomata per unit area on various plant leaves that grow in area if differing humidity, and compile this data in a spreadsheet and graph it to determine whether there is a relationship between the variables.

SCIENCE TECHNLOGY AND SOCIETY

1. Investigate the diagnostic and research applications of the electron microscope
2. Conceptualize how the developments in microscopy were related to the development of cell theory
3. Describe how advancements in knowledge of cell structure and function have been enhancing and are increasing as a direct result of developments in microscope technology and stain techniques.,
4. Draw analogies between division of labour in cells and in communities
5. Describe how knowledge about semi-permeable or differentially permeable membranes, diffusion and osmosis is applied in various contexts (e.g., separation of bacteria from viruses, purification of water, cheese making, use of honey as an antibacterial agent)
6. Investigate careers that require an understanding of cell biology.

USEFUL WEBSITES

1. en.wikipedia.org/wiki/Biological_tissue
2. biology.about.com/library/weekly/aa030101a.html
3. biology.about.com/library/weekly/aa02220

5

CELL CYCLE

Major Concepts

The ability of organisms to reproduce their own kind is the one characteristic that best distinguishes living things from non-living things. The continuity of life is based on the reproduction of cell or **cell division.** As you grow and develop, the cells of your body are constantly dividing. Cells only grow to a certain size then divide. Cells divide to replace dead or injured cells. Your body is constantly making new blood cells to replace the ones that have died. The cell division is necessary for an organism's growth. The dividing cell is called parent cell and the two new cells formed are called **daughter cells.**

5.1 CELL CYCLE

A cell cycle is a series of events from the time a cell is produced until it has produced daughter cells. The duration of the cell cycle depends on the type of cell.

5.1.1 PHASES OF CELL CYCLE

There are two main phases of cell cycle, a) interphase, b) mitotic phase. Interphase is the period between two cell divisions. Mitotic phase is the phase of division.

Interphase

Most of the cell cycle is spent in interphase. Chromosomes duplicate during this period; many cell parts are made and the cell does most of its growth. Typically, interphase lasts for at least 90% of the total time required for the cell cycle. Interphase has three main sub-phases.

G1 Phase: The first sub -phase, is the period before DNA synthesis begins. In G_1 phase, the cell increases proteins production, increases the number of many of its organelles, such as mitochondria and ribosomes, and grows in size. Towards the end of G_1 phase there is an increased activity of enzymes required for DNA synthesis.

S Phase: It is the synthetic phase. Following G_1 phase is the sub-phase S, in which DNA synthesis actually occurs. At the beginning of the S phase, each chromosome is single. At the end of this phase, after DNA replication, each chromosome consists of two sister chromatids.

G_2Phase: It is last sub-phase before cell division. In this phase increased protein synthesis occurs for the production of spindle fibres.

M Phase: In this phase the cell is divided into two daughter cells. This phase is called mitosis.

G_0 Phase: Cells that have stopped dividing are in G_0 phase. In multicellular eukaryotes, cells enter G_0 phase from G_1. Some cells of liver and kidneys enter the G_0 phase temporarily. While neurons remain in G_0 phase for indefinite period. Other cells, such as epithelial cells do not enter G_0 phase.

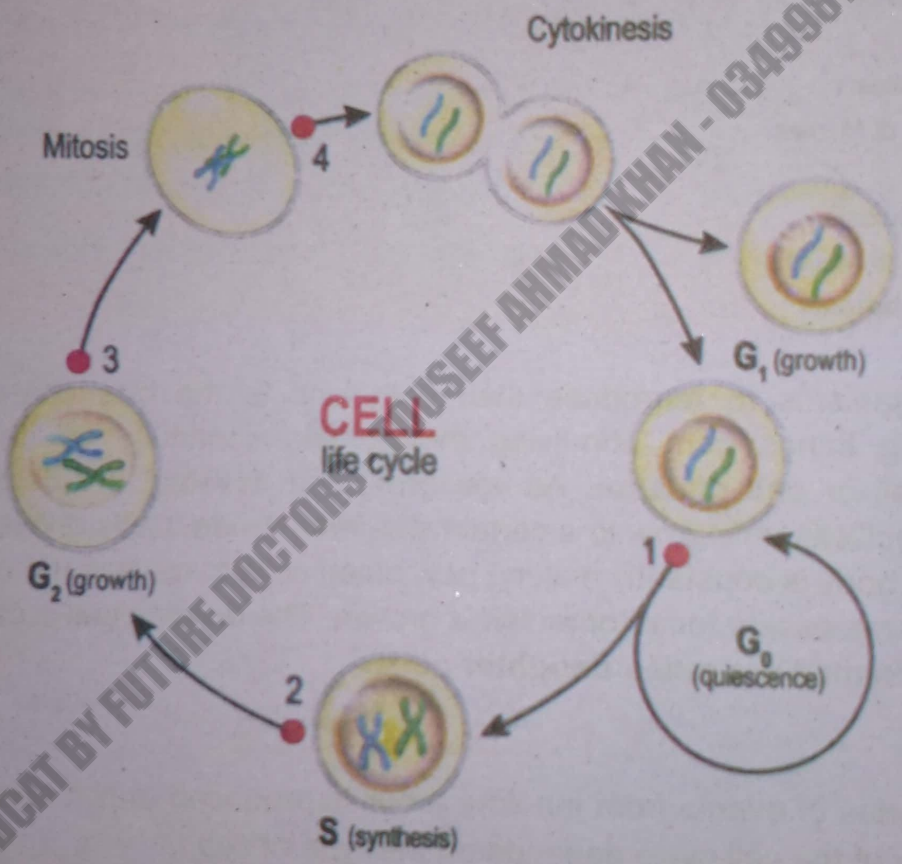


Fig. 5.1: Cell cycle

Cell Division

There are two main types of cell division i.e., mitosis and meiosis. There are two types of cells in plants and animals. The first one is **somatic cell,** which divides by mitosis. The second one is a **germ line cell**, which divides by meiosis.

5.2 MITOSIS

Mitosis occurs in the **somatic cells** of animals and plants. It is the division of a cell to form two new cells that are exactly alike. Mitosis can be defined as "The division of the cell in

such a manner that the chromosomes number remains same in the daughter cells as in the parent cells"

5.2.1 PHASES OF MITOSIS

Mitosis is divided into two major phases; Karyokinesis and Cytokinesis.

Karyokinesis: Division of Nucleus

Karyokinesis is studied in four stages, but actually it is a continuous process:

1. Prophase 2. Metaphase 3. Anaphase 4. Telophase

Prophase

Early in the prophase, the centrioles divide and the two centriole move to opposite poles of the cell. In the beginning of prophase, the chromosomes are not visible as they are in the form of fine thread like structure called **chromatin**. The chromatin begins to shorten, thicken and coil by a process called condensation. It results in the appearance of chromosomes. Spindle fibres are formed between the centriole; thus, mitotic apparatus is established. Nucleolus disappears and to the end of prophase nuclear membrane disintegrates.

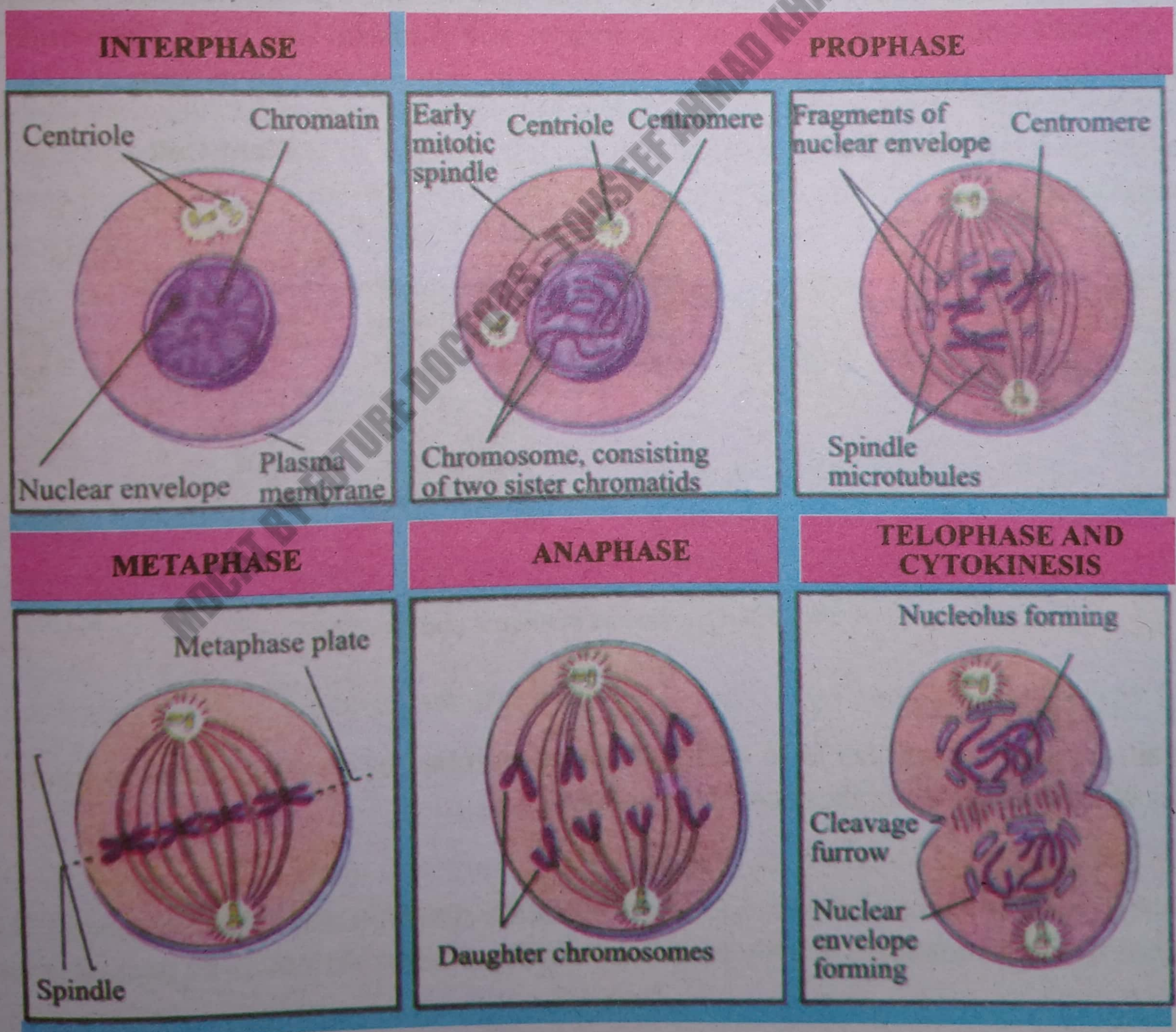


Fig. 5.2: Mitosis in animal cell

Metaphase

Spindle fibres become attached with centromere of chromosome and arrange them on equator of the cell forming metaphase plate.

Anaphase

In anaphase spindle fibres contract, sister chromatid of each chromosome separates and begin to move to the opposite poles. Finally, they reach the respective poles.

Telophase

Spindle fibres disintegrate. Chromosome uncoil to form chromatin fibre. Nuclear membrane is formed around each set of chromatin fibres at both poles. Nucleoli reappear.

Cytokinesis

Nuclear division is followed by separation of the cytoplasm into two parts. The process of cytoplasmic division is called **cytokinesis**. In animal cells this separation is achieved by pinching of the cell membrane in the middle forming, a cleavage furrow. In plant cells, vesicles derived from Golgi apparatus move to the equator and fuse to form phragmoplast. **Phragrmoplast** grows outward and fuse with the cell membrane and parental cell wall. The contents of the phragmoplast form middle lamella. Each cell forms its primary wall on its side.

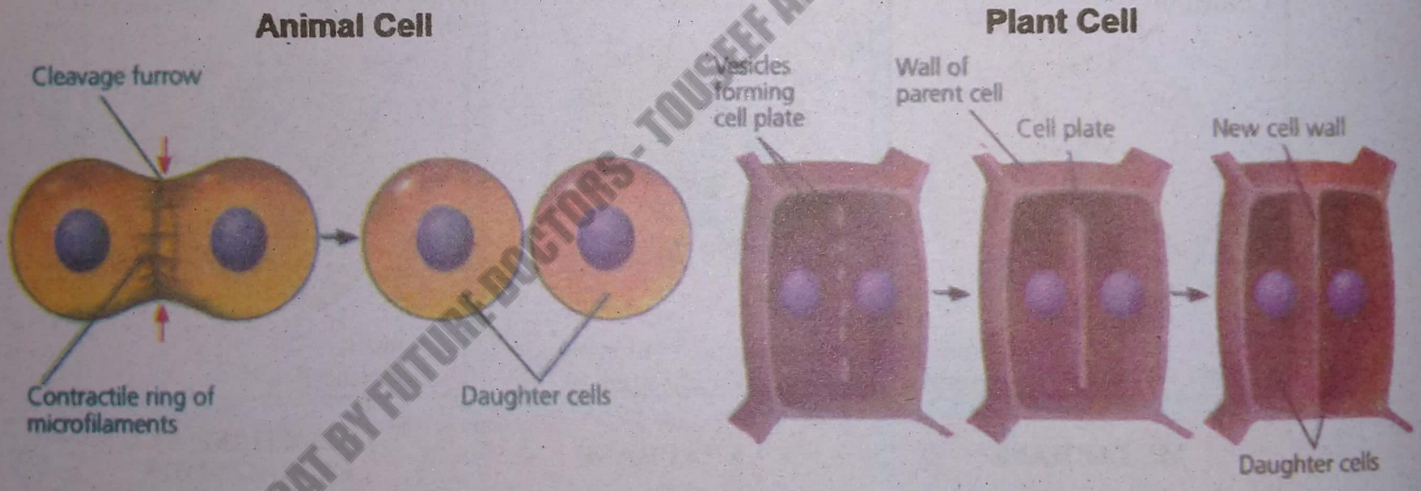


Fig. 5.3: Cytokinesis in animal and plant cell

5.2.2. SIGNIFICANCE OF MITOSIS

The main function of mitosis is to maintain same number of chromosomes in each daughter cells. Following are the significance of the mitosis.

1. Genetically Identical Cells

The genetic information i.e., DNA is regularly and equally distributed to the daughter cell. The diploid number (2n) of chromosomes is maintained in the cell, and thus maintains its genetic stability.

2. Growth

It is the basis of growth and development in multicellular organisms, because body cells or somatic cells are formed by mitosis.

3. Replacement of Cells

Healing of wound and replacement of damaged cells is done by mitosis: (a) dead or worn-out red blood cells and white blood cells are constantly replaced. (b) When skin is cut, new skin cells grow over the cut and replace the skin cells that are damaged.

4. Asexual Reproduction

Mitosis is a means of asexual reproduction in many organisms. For example, Hydra is a tiny multicellular organism that reproduces by either sexual or asexual means. Hydra reproduces asexually by mitosis through budding. In plants natural vegetative propagation occurs by means of: creeping stem e.g., grasses, sweet potato, strawberry; underground buds, e.g., ginger, potato, onion, etc.

Fig. 5.4: Budding in *Hydra*

ERRORS IN MITOSIS

Cancer is a disease of cell cycle. Unlike normal cells of the body, cancer cells do not have a proper functioning cell cycle control system and therefore divide excessively. This excessive growth can result in an abnormal mass of cells called tumour. Not all tumours are cancerous however, a benign tumour is an abnormal mass of essential normal cells. They always remain at their original site in the body. A malignant tumour is cancerous. It is capable of spreading into neighbouring tissues and often to other parts of the body. The spread of cancer cells beyond their original site is called metastasis.

Table 5.1: Comparison between Mitosis in Animal cell and Plant cell

Animal cell	Plant cell
1. Centriole is present and divides into two during early prophase.	Centriole is absent.
1. Centriole and spindle fibres form mitotic apparatus.	Only spindle fibres form Mitotic apparatus.
2. Cytokinesis occurs by pinching of the cell membrane in the middle forming a cleavage furrow.	Cytokinesis occurs by the phragmoplast, which separates the two cells.
3. Cell division occurs in all tissues of the body.	Cell division occurs only in meristematic cells of plants.

5.3 MEIOSIS

Sexual reproduction takes place in organisms by forming gametes. The gametes fuse to form zygote. The zygote forms the organism. The number of chromosomes remains constant in the successive generations. How the number of chromosomes remains constant from generation to generation?

August Weismann proposed the hypothesis that "there must be a kind of cell division in which the chromosome number is halved". Both somatic cells and germ line cell are **diploid (2n)** i.e.,

have full number of chromosomes e.g., in man the diploid number of chromosomes is 46. When a germ line cell undergoes division, it produces cells with half of the number of chromosomes. Cells having half number of chromosomes are called **haploid (n)**, e.g., the haploid number of chromosomes in man is 23. This process of division is called **meiosis**.

5.3.1 PHASES OF MEIOSIS

Meiosis is a continuous process. It can be described by dividing it into two stages i.e., meiosis I and meiosis II. Meiosis I is subdivided into prophase I, metaphase I, anaphase I and telophase I. Meiosis II is further subdivided into prophase II, metaphase II, anaphase II and telophase II.

Interphase I: The DNA duplicates by replication process. Each chromosome consists of two sister chromatids.

The First Meiotic Division

Prophase I: It is a lengthy process of meiosis. Due to condensation of chromatin, chromosomes become apparent and distinct. In the cell there are two of each type of chromosome. The similar chromosomes are called **homologous chromosomes.** The homologous chromosomes begin to pair length wise with their homologue. The process of pairing is called **synapsis**. Each pair of synapsed chromosome consists of four chromatids, two centromeres and is called a **tetrad** or **bivalent.**

Crossing over: The chromatids of the homologous pair may cross each other and the point of crossing is X shaped. It is called **chiasma**. Chromosome segment is exchanged between the two non-sister chromatids of homologous chromosomes at the chiasmata and is called **crossing over.**

The paired homologous chromosomes begin to separate by repelling. The nucleoli disappear and the nuclear membrane disintegrates. Centrioles move to opposite poles and form spindle fibres.

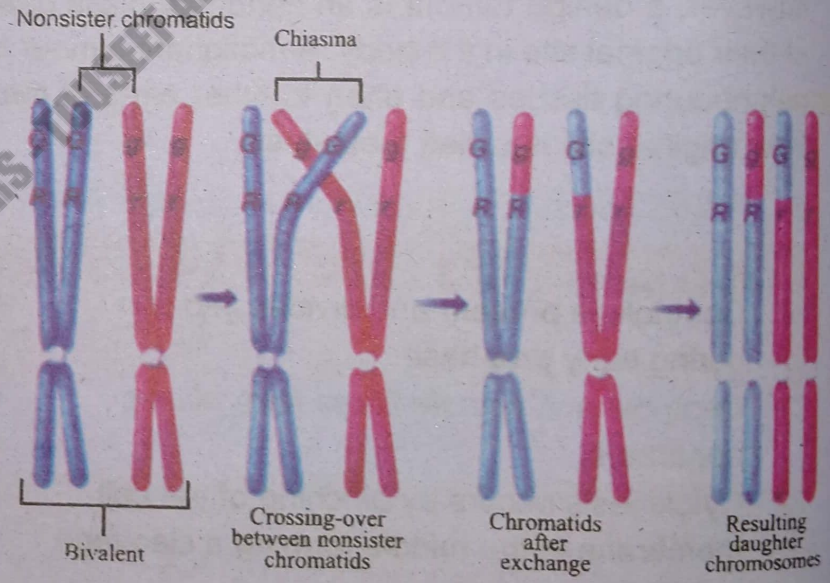


Fig. 5.5: Crossing over

Metaphase I

Spindle fibres attach with the centromere of chromosome but they bind only to one of each centromere i.e., two spindle fibres from opposite poles attach with a pair of chromosomes. The pair of homologous chromosomes align on equator forming the metaphase plate.

Anaphase I

The spindle fibres become shorter. The chromosomes that are attached to the spindles are also pulled towards each pole. When the shortening of spindle fibre is completed, each pole has half set of chromosomes, consisting of one member of each homologous pairs.

Telophase I

Spindle fibres disintegrate. Chromosomes uncoil to form chromatin fibre. Nuclear membrane forms around each set of chromatin fibres at both poles. Nucleoli reappear.

By cytokinesis two **haploid** cells are formed.

Interphase II: DNA does not duplicate in interphase II. Interphase II is very brief. Each of the two cells resulting from meiosis I progress into meiosis II.

The Second Meiotic Division: Meiosis II is simply a mitotic division. It occurs to separate the sister chromatids as in mitosis.

Prophase II

Chromatin condenses, nucleoli and nuclear membrane disappear. Centrioles move to opposite poles and make spindle fibres.

Metaphase II

The chromosomes line up in a single row at the equator of the cell. Here a random distribution of chromosomes takes place.

Fig. 5.6: Meiosis in an animal cell

Anaphase II

The **centromere** divides; as a result, the two chromatids are separated. As each chromatid is now a separate structure, they are called **chromosomes**. Chromosomes move to opposite pole.

Telophase II

The nuclei are reconstructed in the typical manner. Each nucleus now contains **haploid set** of chromosomes.

5.3.2 SIGNIFICANCE OF MEIOSIS

Meiosis is necessary to maintain the number of chromosomes as well as to produce variations in the next generation.

Maintenance of the chromosome number in next generation

Meiosis takes place during sexual reproduction to maintain the number of chromosomes in the next generation. In animals, germ line cells undergo meiosis to produce haploid gametes. Male and female gametes unite to form diploid zygote, which undergoes repeated mitosis and develops into a new diploid organism. In plants, germ line cells produce haploid spores by meiosis, which produce haploid gametes. The gametes combine to form diploid zygote. Many haploid fungi and protozoans produce haploid gametes through mitosis.

Production of variations in next generation

The chromosomes undergo crossing over during meiosis. The daughter cells i.e., gametes have genetic variations. When gametes fuse and form zygote, it is genetically different from both parents. Thus, meiosis provides variations in next generation.

Table 5.2: Comparison of Mitosis and Meiosis

MITOSIS	MEIOSIS
1. Takes place in somatic cells	It takes place in germ line cells of sex organs
2. It consists of one division.	It consists of two divisions.
3. Crossing over does not take place during prophase.	Crossing over takes place during prophase I
4. Centromere divides at metaphase	Centromere does not divides at metaphase I
5. Individual duplicated chromosomes align at the metaphase plate during metaphase.	Paired homologous chromosomes align at metaphase plate during metaphase I
6. Daughter chromosome move to opposite poles during anaphase.	Homologous chromosomes with two sister chromatids, separate and move to opposite poles during anaphase I
7. Two diploid daughter cells are formed.	Four haploid daughter cells are formed.
8. The daughter cells are genetically identical to each other and to the parent cell.	The daughter cells are not genetically identical to each other and to the parent cell.
9. The number of chromosomes remains constant.	The number of chromosomes becomes half in meiosis.
10. Mitotic products are usually capable of undergoing additional mitotic divisions.	Meiotic products cannot undergo further divisions.

Errors in Meiosis

When chromosomes fail to separate at anaphase it is called nondisjunction. In meiosis chromosomal nondisjunction may occur during first or second meiotic division. The number of chromosomes in man is 46. Due to nondisjunction the number of chromosomes in next generation may be 47 or 45 etc.

5.4 NECROSIS AND APOPTOSIS

There are two patterns of cell death; **necrosis** and **apoptosis**.

Necrosis

The death of most of the cells due to disease, injury or failure of the blood supply is called **necrosis**. It is premature and accidental death of the cells. Necrosis causes severe cell swelling, cell rupture and breakdown of cell organelles. When the cell swells and bursts, it releases its toxins, which can damage neighbouring cells and cause inflammation. Untreated necrosis can lead to serious injury or even death. For example, If the blood supply to a segment of the heart is cut off 10 to15 minute and then restored, the cells of the cardiac muscle experience injury but can recover and function normally. If blood flow is not restored until one hour later, however, necrosis will occur and many heart cells will die.

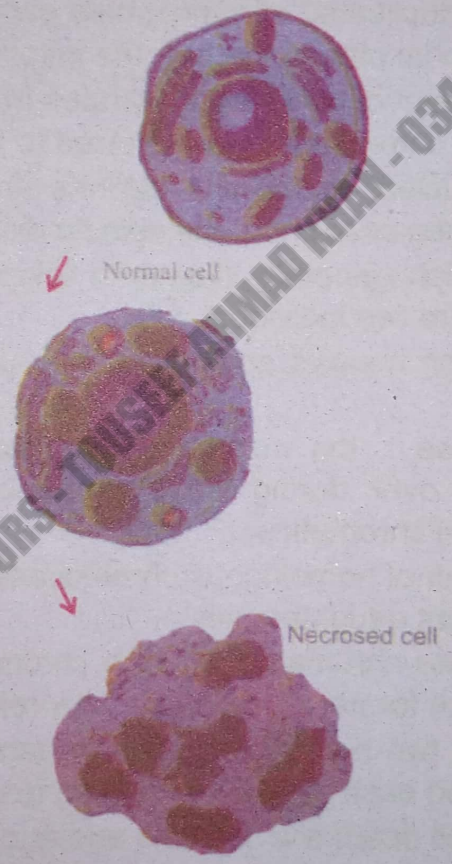


Fig. 5.7: Cell death by Necrosis

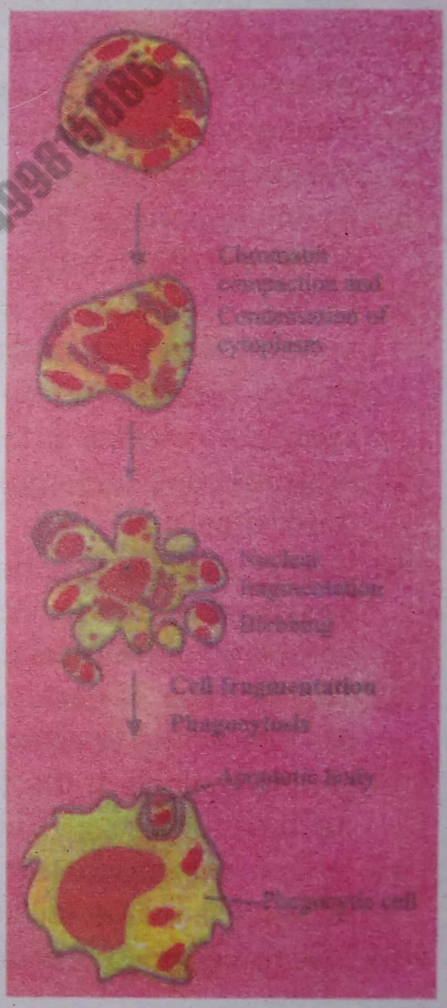


Fig. 5: 8 Cell death by apoptosis

Apoptosis

Apoptosis is programmed cell death. The cells in multicellular individual have genetic program of growth, development, reproduction and even death. Many cells proceed to self-destruction when they complete a prescribed function. The cell death by self-destruction is called apoptosis. The cells undergoing apoptosis show cell shrinkage and chromatin condensation. Blebs are irregular buds on cell surface that form apoptotic bodies. Phagocytosis of apoptotic bodies takes place by white blood cells.

Examples of apoptosis: (1) As a homeostatic mechanism to maintain cell population in tissues. (2) As a defence mechanism such as in immune reaction. (3) When cells are damaged by disease. (4) In aging. (5) During embryonic development the growth of the cells between fingers that are no longer needed undergo apoptosis.

SUMMARY

1. The cell cycle is the period from beginning of one division to the beginning of the next division.
2. Interphase can be divided into the first gap phase (G_1), the chromosomal synthesis (S), and the second gap phase (G_2).
3. During G_1 phase the cell grows and prepares for the S phase. DNA and the chromosomal proteins are synthesized during the S phase.
4. During G_2 phase, protein synthesis increases for cell division.
5. During mitosis, identical chromosomes are distributed to each pole of the cell, and a nuclear membrane forms around each set.
6. During prophase, the chromosomes become visible with the microscope, the nucleolus disappears, the nuclear membrane breaks down, and the mitotic spindle begins to form.
7. During metaphase the duplicated chromosomes each composed of a pair of sister chromatids, line up along the equatorial plan of the cell; the mitotic spindle is complete.
8. During anaphase, the sister chromatids, separates from one another and move to opposite poles of the cell. Each former chromatid is now referred to as a chromosome.
9. During telophase, a nuclear membrane reforms around each set of chromosomes, nucleoli appear, the chromosomes uncoil, and the spindle disappears.
10. During cytokinesis, which generally begins in telophase and therefore overlaps mitosis, the cytoplasm divides to form two individual cells.
11. A diploid cell undergoing meiosis completes two successive cell divisions to give rise to four haploid cells.
12. During meiotic prophase I, the members of a homologous pair of chromosomes undergo synapses and crossing over, during which segments of DNA strands are exchanged between homologous (non-sister) chromatids.
13. The member of each pair of homologous chromosomes separate during meiotic anaphase I and are distributed to different daughter cells.
14. During meiosis II the two chromatids of each chromosome separate and one is distributed to each daughter cell. Each former chromatid is now referred to as chromosomes.
15. In sexual reproduction, two haploid sex cells or gametes fuse to form a single diploid zygote. When a zygote is formed each parent contributes to one member of each homologous pair.
16. The two principles of cell death are necrosis and apoptosis.

Exercise

MCQs

Select the correct answer:

1. The period of cell cycle between two consecutive divisions is termed as:
   A) prophase B) metaphase C) telophase D) interphase
2. Which of the following phases of mitosis is essentially the opposite of prophase in terms of nuclear change?
   A) Telophase B) interphase C) Metaphase D) anaphase

3. When do homologous chromosomes pair up?
   A) only in mitosis B) only in meiosis I
   C) only in meiosis II D) in both mitosis and meiosis
4. The arm of the chromosomes are called:
   A) chromatin B) chromatids C) diploids D) centromere
5. Cytokinesis is:
   A) division of nucleus B) mitosis
   C) division of cytoplasm D) division of centromeres
6. Meiosis produces:
   A) cell with only one homologue of each chromosome pair
   B) cells with diploid number of chromosomes
   C) an increasing number of cells all with the same DNA compliment
   D) an increase in the amount of RNA
7. It is difficult to observe chromosomes during interphase because:
   A) the DNA has not been replicated
   B) they have uncoiled to form long, thin strand
   C) they leave the nucleus and dispersed to other parts of the cell
   D) homologous chromosomes do not pair up until division starts
8. Crossing over occurs during:
   A) telophase B) interphase C) metaphase D) anaphase
9. When do homologous chromosomes pair up?
   A) only in mitosis B) only in meiosis I
   B) only in meiosis II D) in both mitosis and meiosis
10. In which stage of cell cycle, the cell stops dividing:
    A) G_1 phase B) S phase C) G_2 phase D) G_0 phase

Short Questions

1. Can you distinguish between?
   (a) mitosis and meiosis (b)chromatin and chromosome
   (c) chromosome and chromatids (d) centromeres and centrioles
   (e) cytokinesis and karyokinesis (f) centromeres and kinetochores
   (g) haploid and diploid number of chromosomes
2. Compare the following:
   (a) mitosis and meiosis (b) mitosis in animal cell and plant cell
   (c) necrosis and apoptosis (d) meiosis II and mitosis
3. Write the significance of:
   a) mitosis b) meiosis
4. How does meiosis contribute to genetic recombination?
5. What kind of a life cycle includes a multicellular haploid stage? Can haploid cells divide by mitosis or by meiosis?

6. Why do cells of a tissue need to undergo mitosis?
7. Can haploid cells divide?

Extensive Questions

1. Describe cell cycle with the help of labelled diagram.
2. Draw the diagram of mitosis in an animal cell. Write the main features of mitosis in brief. What is the significance of mitosis in your life?
3. Describe meiosis in an animal cell. Elaborate your answers with the help of labelled diagram.
4. Write the differences between mitosis and meiosis.
6. Compare necrosis and apoptosis.

THE TERMS TO KNOW

- Anaphase
- Apoptosis
- Benign
- Budding
- Cell cycle
- Chiasmata
- Crossing over
- Go phase
- G2phae
- Homologous
- Interphase
- Karyokinesis
- Kinetochore
- M phase
- Malignant
- Metaphase
- Metaphase plate
- Mitosis
- Necrosis
- Non-sister
- chromatids
- Phragmoplast
- Prophase
- S phase
- Sister chromatids
- Spindle
- Synapsis
- Telophase

ANALYZING AND INTERPRETING

1. Identify from prepared slides or charts, the main phases of cell cycle
2. Arrange in correct sequence the various stages of mitosis shown in photomicrographs or prepared slides. Explain the events of each stage through hints observed in the prepared slide of these stages.
3. Identify stages of meiosis through observation of prepared slides/flash cards and draw observations in sequential order. Explain the events of each stage through hints observed in the prepared slides of these stages.

SCIENCE, TECHNOLOGY AND SOCIETY CONNECTIONS

1. Describe the inability of some mature cells (nerve cells) to divide and the uncontrolled division of certain cells (tumor).

USEFUL WEBSITES

1. www.cellsalie.com/cell_cycle.htm
2. en.wikipedia.org/wiki/Cell_cycle
3. users.rcn.com/jkimball.ma.ultranet/BiologyPages/C/CellCycle.html
4. www.landesbioscience.com/journals/cc
5. www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells2.html
6. www.biologycorner.com/bio1/cellcycle.html

6

ENZYMES

Major Concepts

Different types of cells are performing specific functions. To perform various functions, a cell needs energy. This energy is provided by the chemical reactions. The sum of all the chemical reactions going on within the cells is known as **metabolism**. It consists of **catabolism** and **anabolism.** Reactions which break down complex molecules into simpler molecules, are called **catabolic reactions** or **catabolism**. Reactions which build complex molecules from simpler molecules are called **anabolic reactions** or **anabolism.** Usually, energy is released in catabolism and it is utilized in anabolism. Most of the essential reactions taking place in the body must occur quickly and precisely for a cell to survive. Enzymes work as biological catalyst and control all the chemical reactions making up the metabolism.

Enzymes work on substances called **substrates.** The reaction takes place on a part of the surface of enzyme called the **active site**. The **substrates** are the molecules entering into chemical reactions. The substrates undergo a chemical change resulting in new bonding arrangement between the molecules. The changed substrates are called **products.**

The flow of energy within an organism consists of a long series of coupled reactions. These chains of reactions are called **metabolic pathways.** All the metabolic pathways taking place in our body work to help us to survive.

The enzymes, which remain inside the cells to speed up the reactions, are called **intracellular enzymes** (e.g., enzymes of glycolysis working in the cytoplasm). Often the enzymes made inside the cells are allowed to go out of the cell to do their work outside. These enzymes are called **extracellular enzymes** (e.g., pepsin enzyme working in the stomach cavity). Fungi and bacteria release extracellular enzymes to digest their food.

6.1 ENZYMES AND THEIR CHARACTERISTICS

Enzymes are very important for life and they serve many functions in the body. They are organic catalysts that speed up a reaction in living things. Enzymes have following characteristics.

1. Enzymes are Proteins

All Enzymes are protein in nature except ribozyme. They are made up of amino acids.

2. Enzymes Increase Rate of Reaction

In the absence of enzymes, it may take **months** or years to complete the reactions. The enzymes speed up the reactions millions of times faster as compared to non-catalysed reaction.

3. Enzymes are Required in Small Quantity

Enzymes are not changed in chemical reaction. So they can be used over and over again. Thus, a very small quantity of an enzyme is capable of catalysing a huge amount of substrate.

4. Enzymes are Specific

Enzymes can act only on one substrate and it will not act on a different substrate. For example, amylase will only act on starch and not on proteins or fats.

5. Enzymes Require Co-factor

Many enzymes require a non-protein helper called **cofactor** for their proper working. There are three types of cofactors: activator, prosthetic group and coenzyme.

- **Activator:** Many enzymes require ions such as zinc, iron, copper and chlorides etc. For example, salivary amylase activity is increased in the presence of chloride ions.
- **Prosthetic group:** If the cofactor is tightly bound to the enzyme on permanent basis it is known as prosthetic group. Prosthetic groups are organic molecules. For example haem group.
- **Coenzyme:** When the cofactor is detachable organic molecule it is called **coenzyme.** Examples of co-enzymes are NAD (nicotinamide adenine dinucleotide), coenzyme A and vitamin A.

6. Regulation of enzyme production and activity

Enzyme production can be increased or decreased by a cell according to requirements. Enzyme activity can be regulated by inhibitors or activators.

7. Enzymes make metabolic pathway

Many enzymes can work together in a specific order making metabolic pathways. Metabolic pathway is a series of connected chemical reactions that lead to the conversion of a substance into final product.

6.1.1 ENERGY OF ACTIVATION

The energy needed to start or activate the reaction is called **energy of activation**. At body temperature of living organisms, it is not possible to provide required activation energy for all the metabolic processes. Enzymes lower the activation energy so that these reactions can take place at body temperature. The ways enzymes lower the activation energy are: 1. Enzymes may change the shape of the substrate. 2. Some enzymes alter the charge distribution on substrate. 3. Enzymes may position substrates together in the proper orientation. 4. Some enzymes add or remove functional groups on the substrate.

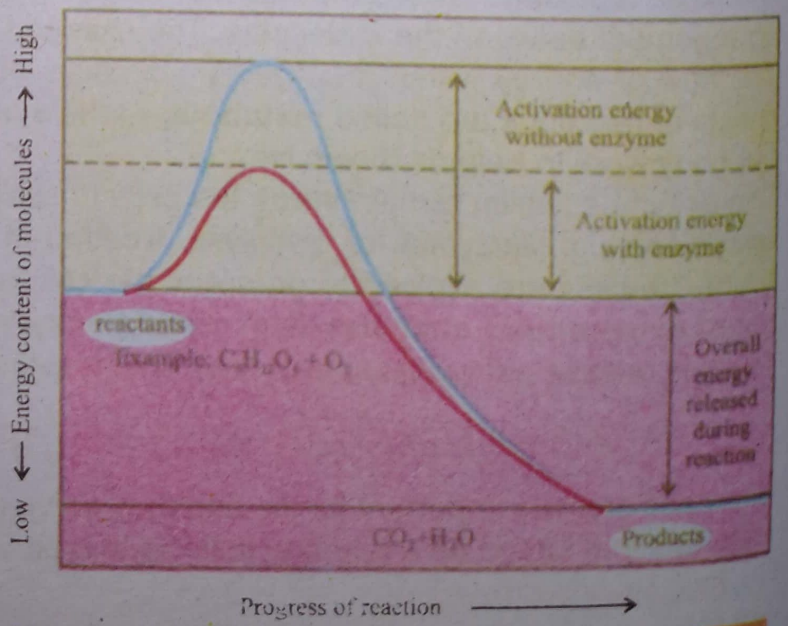


Fig. 6.1: Energy of activation: High activation of energy (blue line) without enzymes. Low activation of energy (red line) with enzymes.

6.1.2 FACTORS AFFECTING ENZYME ACTIVITY

The activity of an enzyme is affected by following conditions:
(1) pH (2) temperature (3) substrate concentration

pH

pH is the **hydrogen ion concentration** in a solution. Enzymes are affected by pH of medium. Each kind of enzyme works best at a particular pH, which is called **optimum pH**. In the stomach enzymes work in acidic medium and in intestine other enzymes work in alkaline medium. For example, enzyme pepsin in the stomach has an optimum pH of about 2. If the pH is much higher or lower than its optimum pH, then an enzyme is **denatured** i.e., it loses its shape.

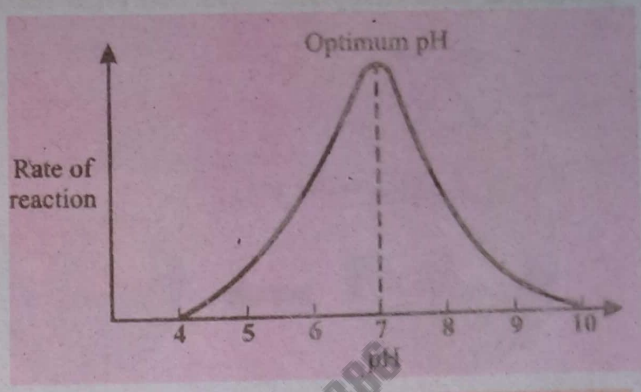


Fig. 6.2: Effect of pH on the rate of enzyme-controlled reaction

Temperature

Heat increases molecular motion. Thus, the molecules of the substrates and enzymes move more quickly, so the rate of reaction increases. The temperature at which an enzyme catalysed reaction happens fastest, is called **optimum temperature.** Different enzymes have different optimum temperature e.g., optimum temperature for human enzymes is 36°C to 38°C.

If the temperature is increased above optimum temperature, then a decrease in the rate of reaction occurs due to denaturation i.e., breakdown at high temperature. If temperature is reduced to below freezing point, enzymes are inactivated but not denatured. They will regain their catalytic activity when higher temperatures are restored.

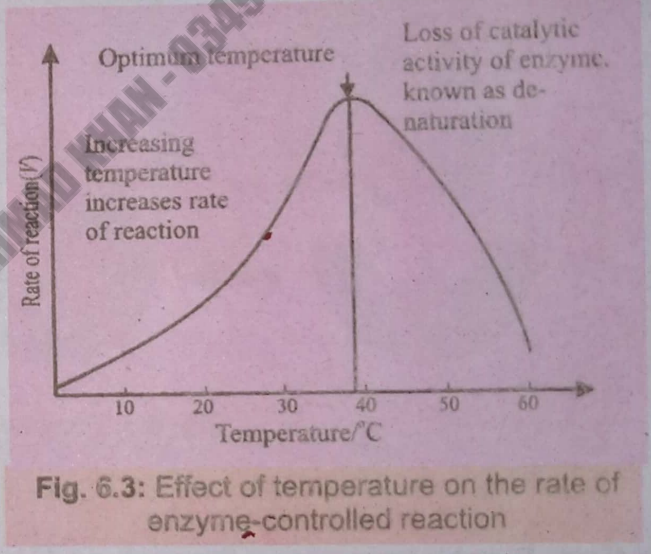


Fig. 6.3: Effect of temperature on the rate of enzyme-controlled reaction

Substrate Concentration

For a given enzyme concentration as the substrate concentration increases the rate of reaction increases up to a limit. A further increase in substrate concentration does not increase the rate any further. This is because at any given moment the active sites of all the enzyme molecules are saturated by substrate molecules.

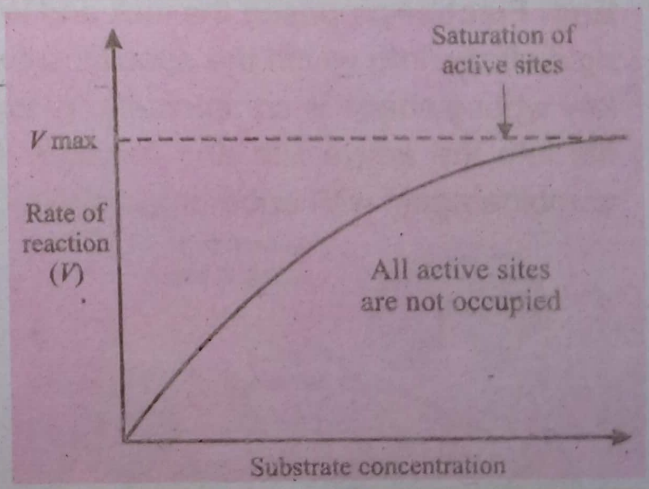


Fig. 6.4: Effect of substrate concentration on the rate of enzyme-controlled reaction

6.2 MECHANISM OF ENZYME ACTION

Most enzymes are far larger molecules than the substrates they act on. The site where the substrate binds with enzyme is known as the **active site**, which has a specific shape. The active

site is usually only a very small portion of the enzyme. The enzyme combines with its substrate to form enzyme substrate complex. Once a reaction has occurred, the complex breaks up into products and enzyme. The enzyme remains unchanged at the end of the reaction.

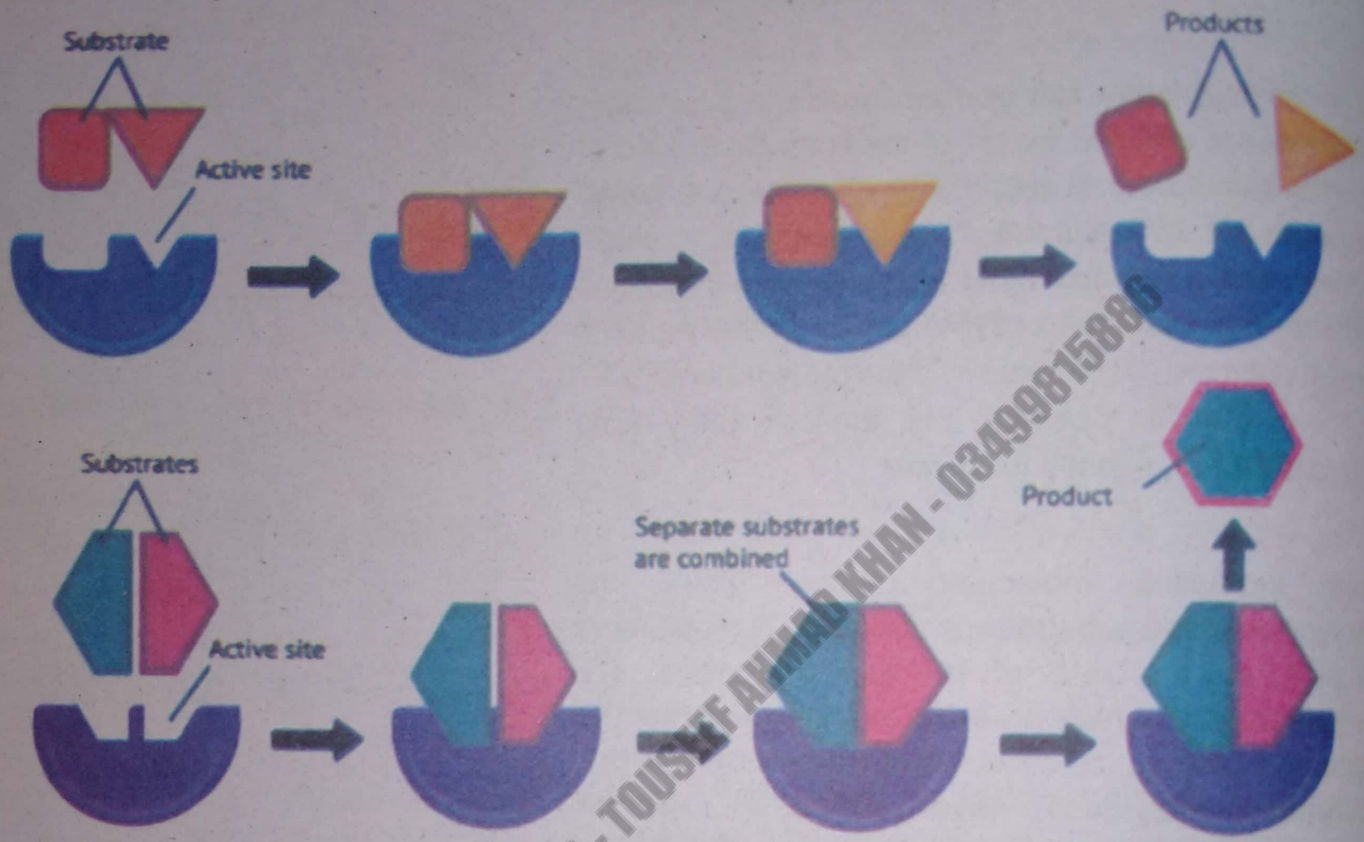


Fig. 6.5: Enzyme actions (a) Breakdown (b) Synthesis

Lock and Key Model

Emil Fischer proposed the lock and key model of enzyme action. The active site has particular rigid shape into which the specific substrate fits exactly. The substrate is imagined being like a key whose shape is complementary to the enzyme or lock. Once formed, the product no longer fits into the active site and escapes into the surrounding medium. The active site is free to combine again with another substrate molecule.

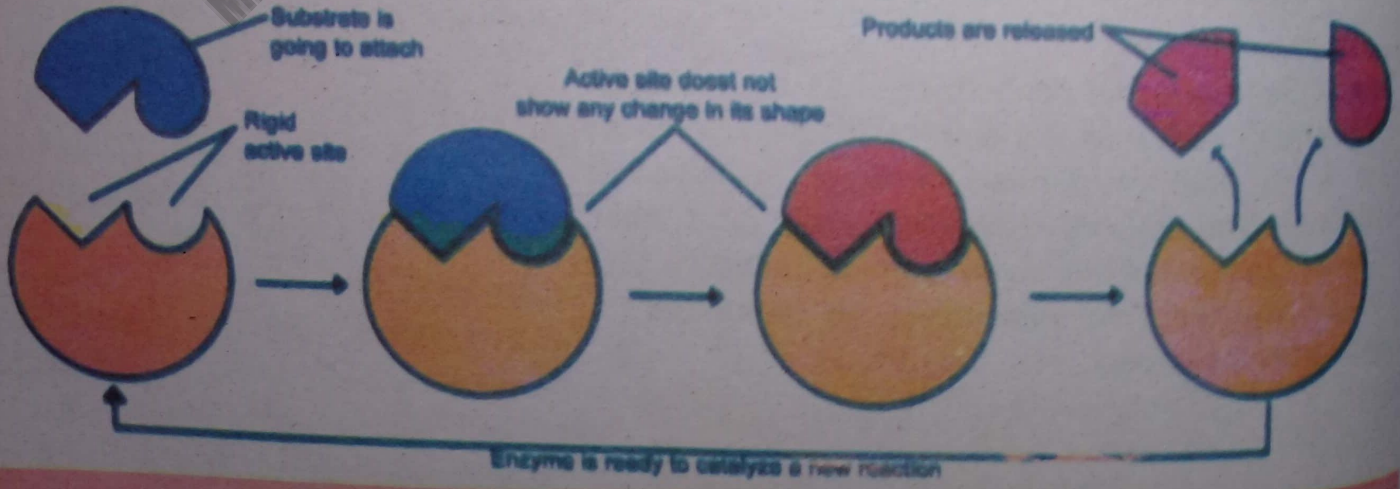


Fig. 6.6: Fischer's "Lock and Key" hypothesis of enzyme action

Induced fit model

Daniel Koshland proposed induced fit model. This model is more acceptable than the lock and key model. It describes that the binding of a substrate to enzyme causes a change in the shape of its active site. Active site is not a rigid structure rather it is flexible.

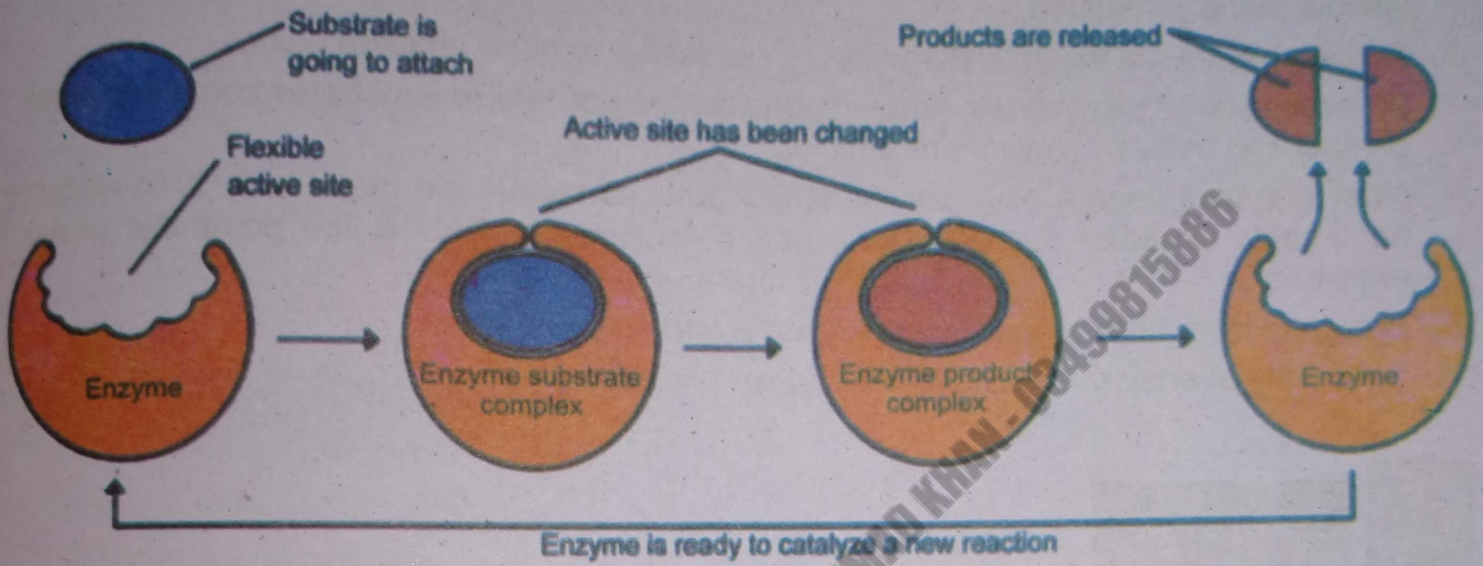


Fig. 6.7: Koshland's "Induced fit model" hypothesis of enzyme action

6.3. SPECIFICITY OF ENZYMES

We have already seen that enzymes are specific. It means one enzyme can act only on particular substrate. It cannot act on any other substance. The examples of specificity of enzymes are:

a. **Proteases** break up proteins into an acid.
b. **Lipase** breaks down only lipids.
c. **Amylase** acts on starch.

Specificity of Enzyme is Due to Its Shape

The figure shows an enzyme protease. There are three-substrates: protein, carbohydrate and fat. You can guess that it is the shape of the active site of an enzyme, which exactly fits the shape of protein, but would not fit the shape of carbohydrate or fat. So, it is the shape of active site that decides what substances it will combine with.

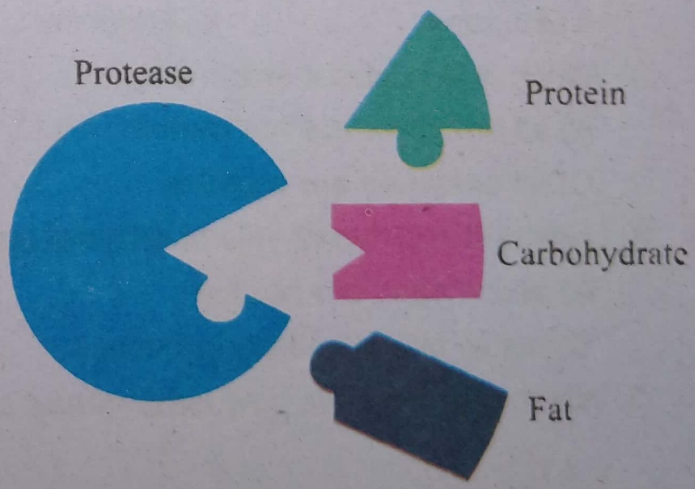


Fig. 6.7: Specificity of enzyme is due to the shape of active site

SUMMARY

1. The sum of all the chemical reactions that occur within a cell or organisms is called metabolism.
2. An enzyme is a biological catalyst which greatly increases the speed of a chemical reaction without being consumed.
3. An enzyme lowers the activation energy necessary to get a reaction going.
4. An active site of enzyme is a three dimensional region where substrates come into close contact and there by react more rapidly.
5. Most enzymes need a co-factor. Most inorganic co-factors are metal ions. A co-enzyme is an organic co-factor such as NAD, and co-enzyme A. FAD is the prosthetic group for enzymes.
6. Enzymes work best at specific temperature and optimum pH.
7. Specificity of enzymes is due to the shape of its active site.

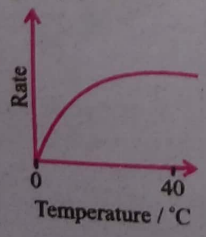
Exercise

MCQs

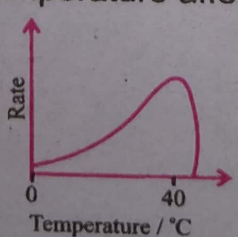
Select the correct answer:

1. The catalytic activity of an enzyme is restricted to its small portion called:
   A) active site B) passive site C) binding site D) intermediate site
2. Hydrolysis of starch occurs with the help of:
   A) sucrase B) amylase C) cellulase D) lipase
3. Which is true about enzyme?
   A) all enzymes are not protein B) all enzymes are vitamins
   C) all enzymes are proteins D) all proteins are enzyme
4. Lock and key hypothesis of enzyme action supports that:
   A) active sites are flexible B) active sites are rigid
   C) active site efficiency increases D) active site can change its shape
5. Which graph shows how temperature affects the rate of an enzyme-controlled reaction?

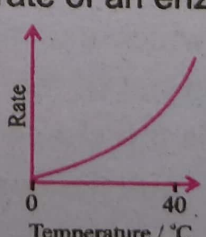
A)



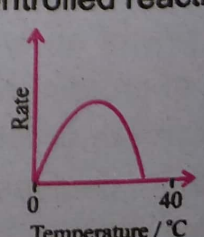
B)



C)



D)



6. The sum of all the chemical reactions in a cell is called:
   A) metabolism B) anabolism C) catabolism D) intracellular space

7. What is true about cofactors?
   A) break hydrogen bond in proteins
   B) help facilitate enzyme activity
   C) increase activation energy
   D) are composed of proteins
8. Enzymes are chemically made up of:
   A) Proteins B) Carbohydrates C) Fats D) Nucleic acids
9. Change in pH can alter the active site by affecting the:
   A) ionization of amino acids
   B) Shape of substrate
   C) ionization of cofactor
   D) Ionization of coenzyme
10. The catalytic region on enzyme recognizes and binds the substrate and carries the reaction. This region is called as:
    A) cofactor B) activator C) inhibitor D) active site

Short Questions

1. Write the difference between:
   (a) catalyst and enzyme (b) anabolism and catabolism
   (c) intracellular and extracellular enzymes.
2. Why enzymes are called biological catalyst?
3. What are the characteristics of enzymes?
4. Name the factors affecting enzyme activity.
5. How enzymes are named?
6. At what temperature human enzymes act the best?
7. Give examples of cofactor.
8. What happens to an enzyme when it is heated up to 100°C?
9. Which protein digesting enzyme functions in acidic medium?
10. Why is less energy needed for reaction to occur when an enzyme is present?
11. Why are enzymes required in small amounts?
12. Why are enzyme specific and why can't each one speed up many different reactions?

Extensive Questions

1. Define enzyme and describe their characteristics and specifications.
2. Explain metabolism with examples.
3. Prove that enzymes are proteins and are specific in function. Explain that specificity of enzyme is due to its shape.
4. Describe that enzymes require co-factor.

5. What is energy of activation? Explain with reference to enzyme.
6. What happens to enzymes when you increase or decrease:
   (a) temperature (b) pH (c) Substrate concentration.
7. Only the related key can open the lock. How this fact is true for enzyme? Explain with examples.

TERMS TO KNOW

- Activation energy
- Active site
- Amylase
- Anabolism
- Biocatalyst
- Catabolism
- Catalyst
- Coenzyme
- Cofactor
- Denaturation
- Induced fir model
- Optimum pH
- Optimum temperature
- Enzyme
- Lipase Lock and Key theory
- Metabolism
- Product
- Saturation
- Substrate

ANALYZING, INTERPRETING AND COMMUNICATION

1. Draw graphs showing the effects of temperature pH and concentration of substrate on the rate of enzyme catalysed reactions.
2. Illustrate through a diagram, the lowering of energy of activation by enzyme.

INITIATING, PLANNING AND INTERPRETING

Build or design model of enzyme to demonstrate the working of an enzyme.

USEFUL WEBSITES

1. users.rcn.com/jkimball.ma.ultranet/BiologyPages/E/Enzymes.html
2. ull.chemistry.uakron.edu/genobc/Chapter_20/
3. web.indstate.edu/thcme/mwking/enzyme-kinetics.html
4. www.lewport.wnyric.org/JWANAMAKER/animations/Enzyme-%20activity.html

7

BIOENERGETICS

All metabolic reactions involve energy transformations. Biological energy transformations obey the laws of thermodynamics. The study of energy relationships in biological system is called **bioenergetics**.

Because an organism can neither make nor destroy energy, it must have adaptations that allow it to capture energy from its environment, convert it to another form and use it for its own need. During photosynthesis the plant cells transform light energy to electrical energy and then to chemical energy stored in chemical bonds. Some of that chemical energy may later be used to carry out the life functions of the plant cells, or it may be transformed by an animal that eats the plant to the mechanical energy of muscle or some other needed form. As these transformations take place, some of the energy is converted to heat and dissipated into the environment.

7.1 MAJOR ROLE OF ATP

Oxidation — Reduction Reactions

When an atom or molecule loses an electron, it is oxidized and the process is called **oxidation.** When an atom or molecule gains an electron, it is reduced, and the process is called **reduction.** Because oxidation and reduction reactions are simultaneous, they are often called **redox reactions.**

Importance of Redox Reactions: Energy stored in chemical bonds can be transferred to new bonds, with electrons shifting from one energy level to another. Redox reactions play a key role in energy flow through biological system, because electrons that pass from one atom to another carry their potential energy. These electron transfers, which are equivalent to energy transfers,

are an essential part of cellular respiration, and photosynthesis etc. Thus, redox reactions play an important role for the flow of energy through the living system.

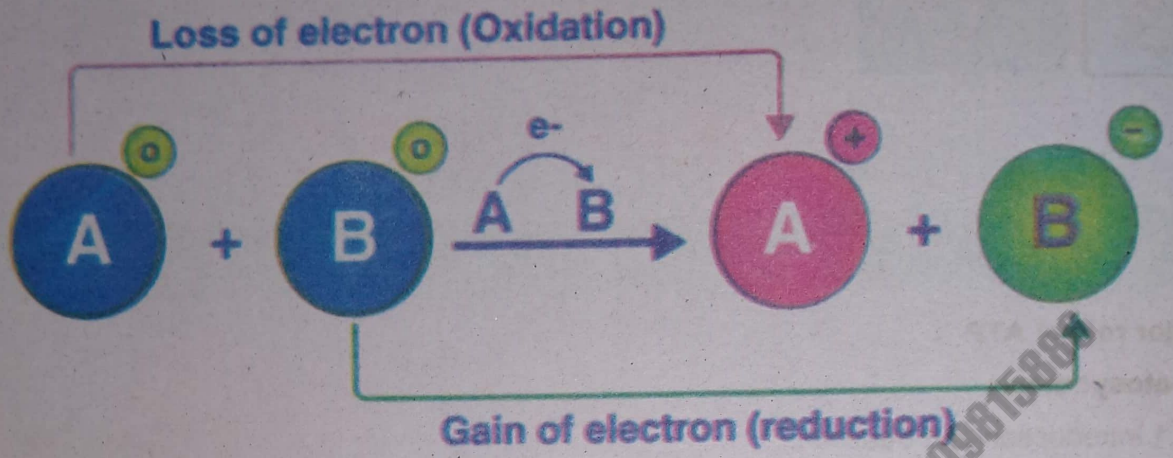


Fig. 7.1: Redox reaction

ATP — Energy Currency of the Cell

In many metabolic pathways in the body, complex substances are broken into simpler substances with the release of energy. The primary molecule used by cells to capture and supply energy, is **adenosine triphosphate (ATP)**.

Structure of ATP

ATP molecule is made up of three subunits: (1) A five-carbon sugar called **ribose**. (2) A double ringed molecule called **adenine**. (3) Three phosphate groups (PO_4) linked in a chain called a **triphosphate group.**

Together, the ribose sugar and the adenine rings are called **adenosine.** The "working end" of the ATP, however, is the triphosphate group. Attachment of one phosphate with adenosine form **adenosine monophosphate (AMP)**. When a phosphate is added to AMP it becomes **adenosine diphosphate** (ADP). By adding one more phosphate group to ADP, **adenosine triphosphate** (ATP) is formed.

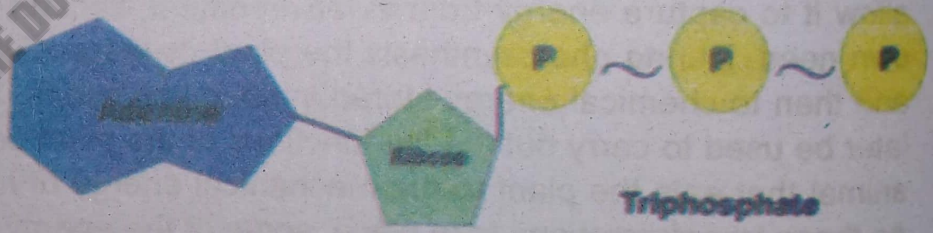


Fig. 7.1: Structure of ATP (high energy bonds indicated by wavy lines)

High Energy Bonds: The two covalent bonds linking the phosphate group together are shown by wavy lines. Such bonds were referred to as "high energy" or "energy-rich" bonds.

ATP — ADP Cycle: ATP can be converted to ADP and inorganic phosphate by hydrolysis. This reaction releases 7.3 Kcal of energy. The third phosphate group splits from ATP, and this phosphate remains in the cell in inorganic form. ADP and phosphate can be converted back to ATP by condensation. ATP is often referred to as the **energy currency** of the cell because it is used much like money. When cells breakdown molecules in metabolic reactions, the energy that

is released can be captured in molecules of ATP. The energy remains in the ATP until it is needed. ATP is made from oxidation of organic molecules during respiration. Most of the ATP in the cell is made in mitochondria. ATP can be used to make muscles contract, make nerve function, drive active transport and synthesis of proteins etc.

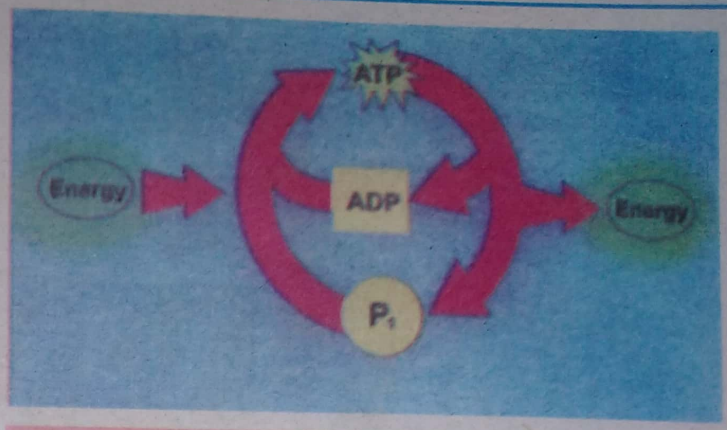


Fig. 7.2: ADP-ATP cycle

During cellular respiration glucose is broken down. What is so special about glucose? Glucose is important to cell because it contains much chemical energy. Chemical bonds hold the atoms of the glucose molecule together. When these bonds are broken, energy becomes available. The cell transfers the energy of glucose to the high-energy bonds of ATP.

7.2 PHOTOSYNTHESIS

Photosynthesis is a process in which plants use carbon dioxide and water to make glucose in the presence of light which is absorbed by chlorophyll. Oxygen is produced as a by-product during photosynthesis.

It is an important biochemical process performed by plants, algae and cyanobacteria. Nearly all life form depends on photosynthesis for food directly or indirectly. It involves a series of coordinated reactions. The following equation shows summary of photosynthesis process.

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

7.2.1 CARBON DIOXIDE AND WATER IN PHOTOSYNTHESIS

Intake of Carbon dioxide by Plants

Carbon dioxide is raw material of photosynthesis. It provides carbon and oxygen for the synthesis of glucose ($C_6H_{12}O_6$) molecule. Atmosphere contains 0.04 percent carbon dioxide. During photosynthesis carbon dioxide diffuses from the external environment through the stomata into the air spaces of the leaf. A thin layer of water always surrounds the surfaces of mesophyll cells. Carbon dioxide is dissolved in this water and diffuses into mesophyll cells.

Intake of Water by Plants

Water provides hydrogen which is used to reduce carbon dioxide to glucose. Water is present in soil. It is absorbed in root hair cells by osmosis process. It moves then to xylem of root and is transported up to the leaves.

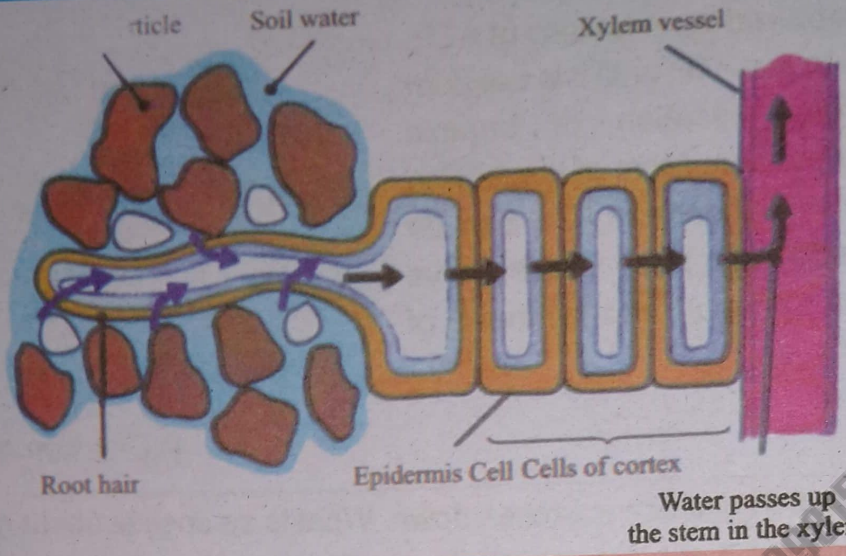


Fig. 7.3: Intake of water by plant

7.2.2 ROLE OF LIGHT AND CHLOROPHYLL IN PHOTOSYNTHESIS

Light

Photosynthesis utilizes only the portion of the electromagnetic spectrum, known as **visible light** which comes in discrete packets called **photons.** Light is the driving force for photosynthesis. Light absorbing molecules are called **pigments**. In the membranes of thylakoids mainly blue, red and orange wavelengths are absorbed. A leaf looks green because it reflects mainly green light.

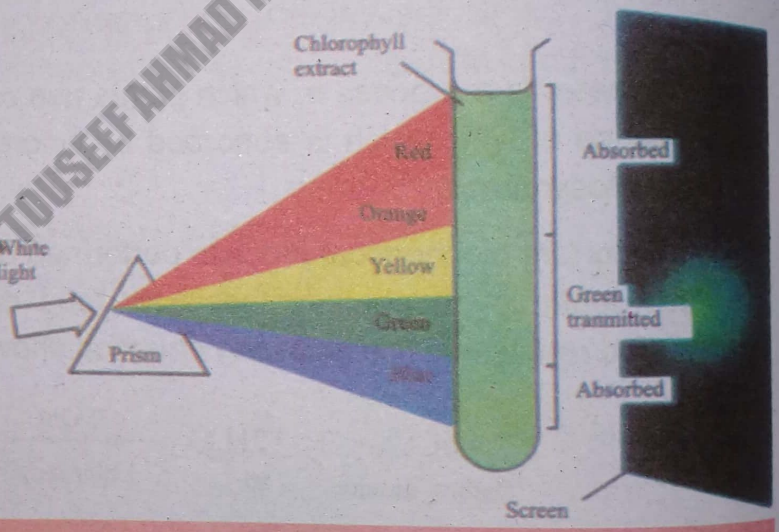


Fig. 7.4: The light colours absorbed by Chlorophyll

Chlorophyll

The chloroplast is the site of photosynthesis. The membranes of the thylakoids contain **chlorophylls** and other photosynthetic pigments. In green plants there are two types of chlorophyll i.e., **chlorophyll a** and **chlorophyll b.** Chlorophyll a is necessary for photosynthesis. It converts light energy to chemical energy. In thylakoid membranes photosynthetic pigments are arranged in clusters called photosystems.

MECHANISM OF PHOTOSYNTHESIS

Photosynthesis occurs in two phases. In the first phase, light energy is captured to produce ATP and NADPH. These reactions take place in thylakoid membranes of chloroplasts. These reactions occur only in the presence of light so are called **light dependent reactions.** During the second phase carbon dioxide is reduced by NADPH to form glucose molecule. This reduction requires energy which is provided by ATP. These reactions do not use light directly, they are known as **light independent reactions**.

Light Dependent Reactions of Photosynthesis

The reactions, which depend upon light, are called light dependent reactions of photosynthesis. These reactions take place in thylakoid membranes where photosynthetic pigments are arranged into clusters called photosystems. There are two types of photosystems: **Photosystem I** and **Photosystem II**. Process of light dependent reactions starts from photosystem II

1. Chlorophyll a of photosystem II absorbs light and a pair of electrons is emitted from it.
2. The emitted electron pair passes through electron transport chain and provides energy for ATP synthesis.
3. At the same time **photolysis** takes place. In this process light splits water into oxygen atom, two hydrogen ions (H^+) and two electrons. Oxygen is released out while electron pair is provided to chlorophyll of photosystem II to compensate its electron loss.
4. Light also acts on photosystem I which also gives out an electron pair. These electrons and two H^+ of water reduce $NADP^+$ to NADPH.

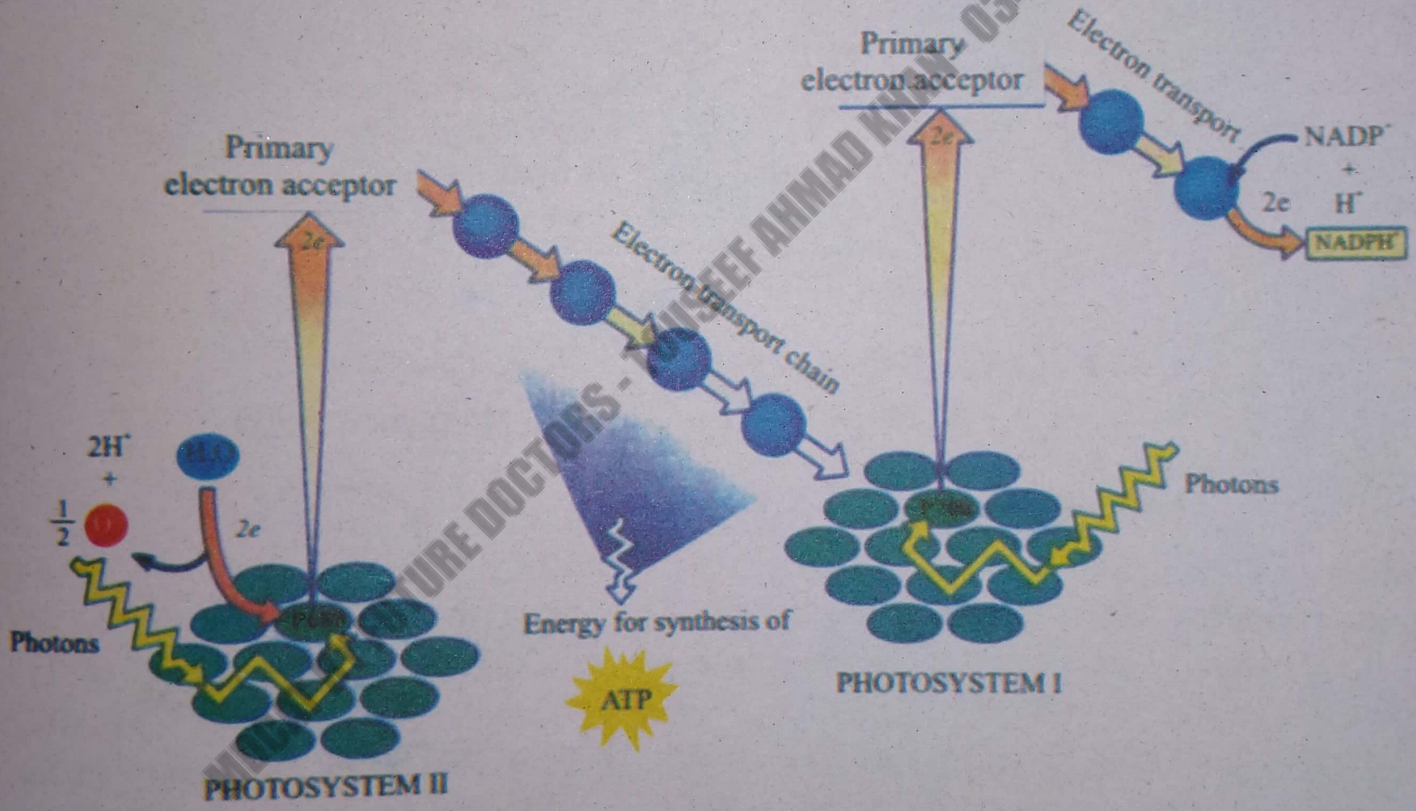


Fig. 7.5: Light dependent reactions of photosynthesis

Table 7.1: LIGHT REACTIONS OF PHOTOSYNTHESIS

Requirements	The immediate products
Light	Oxygen
Enzymes in the chloroplasts	ATP
Water	NADPH
$NADP^+$	
ADP and inorganic phosphate	

Light Independent Reactions of Photosynthesis

Once the light reactions produce ATP and NADPH, a photosynthetic cell can fix carbon dioxide to build sugar molecules. The pathway now followed does not depend directly on light that is why it is called **dark reactions** or **light independent reactions**. It takes place in stroma of chloroplast.

The sequence of reactions in this phase was discovered by Melvin Calvin and his colleagues so are known as **Calvin cycle**.

1. Carbon dioxide combines with an already existing 5-carbon compound to form a 6-carbon intermediate.
2. This 6-carbon compound is unstable and splits into two 3-carbon compounds.
3. Now 3-carbon compounds are reduced to 3-carbon sugar by NADPH by using ATP energy.
4. The 3-carbon sugar molecules are used to synthesize glucose and also to regenerate original 5-carbon compound.

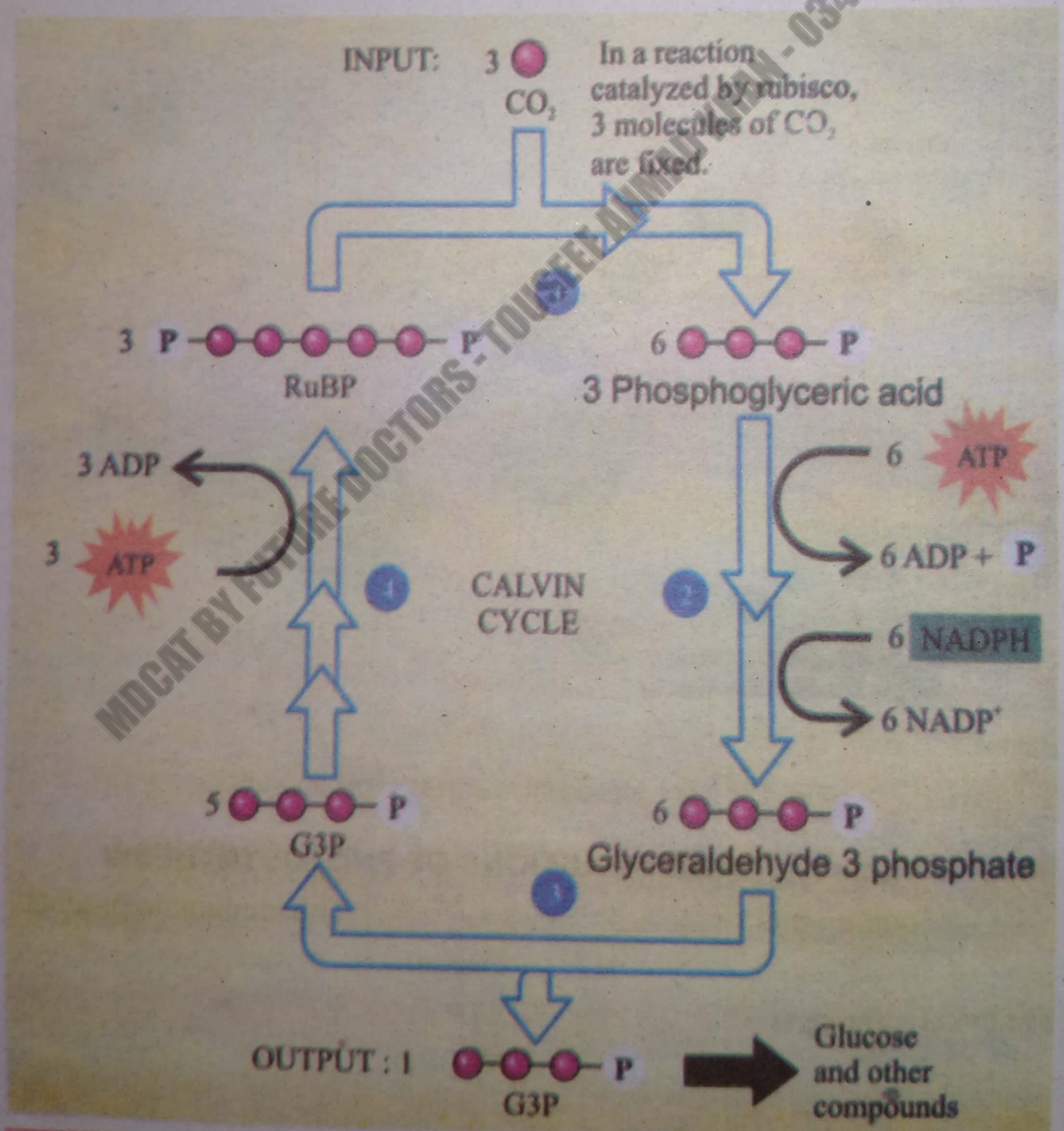


Fig. 7.6: Calvin cycle

Table 7.2: LIGHT INDEPENDENT REACTIONS OF PHOTOSYNTHESIS	
Requirements	The immediate products
ATP	ADP
NADPH	NADP
Carbon dioxide	3-carbon compound
5-carbon compound	Water
Enzymes in the chloroplasts	Inorganic phosphate

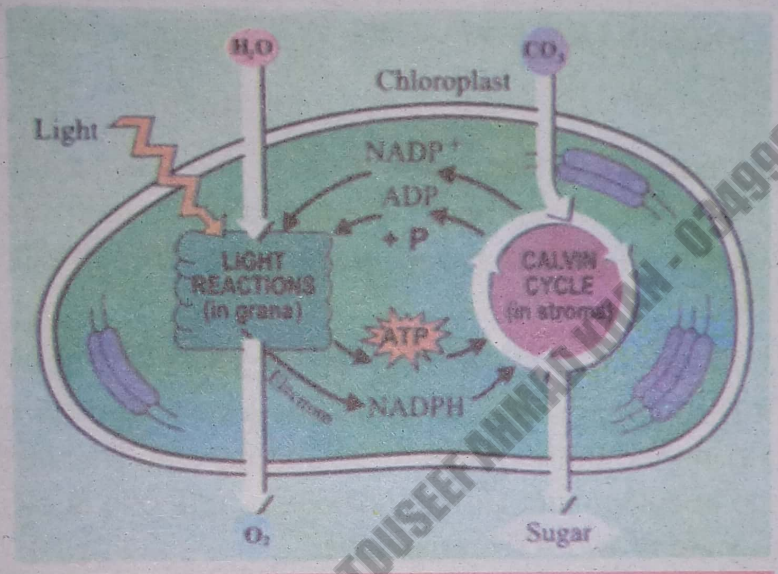


Fig. 7.7: An overview of photosynthesis

7.2.3 LIMITING FACTORS IN PHOTOSYNTHESIS

Any environmental factor that tends to restrict the process of photosynthesis is called a **limiting factor** of photosynthesis. The main external factors affecting the rate of photosynthesis are:

(a) light intensity (b) carbon dioxide concentration (c) temperature

Light Intensity

An increase in light intensity speeds up photosynthesis, but only up to a point. Beyond this point, any further increase in light intensity has no effect. As all available chlorophyll molecules are fully occupied in light absorption. So, no matter how much the light intensity increases, no more light can be absorbed and used.

Carbon dioxide Concentration

Since there is only 0.04 percent of carbon dioxide in the air, it might seem that shortage of carbon dioxide could be an important limiting factor. An increase in carbon dioxide concentration does allow a faster rate of photosynthesis. However, carbon dioxide concentration after a certain limit causes the closure of stomata which decreases photosynthesis.

Temperature

The light independent reactions and to a certain extent, the light dependent reactions are enzyme controlled and therefore temperature sensitive. So, a suitable temperature is essential for photosynthesis to take place at normal rate. For most plants the optimum

temperature is about 25°C. Temperature below or above the optimum will affect the rate of photosynthesis.

All Life Forms are Dependent on Photosynthesis

Two main products of photosynthesis are glucose and oxygen. Glucose is used to make cellulose, starch, proteins, fats and other organic compounds. Glucose is stored in stem, roots, fruits, and seeds in the form of glucose or starch e.g., grapes, mangoes, apples, carrots, turnips etc. All the heterotrophs directly or indirectly depend on food prepared by autotrophs by the process of photosynthesis. All aerobic organisms for respiration use oxygen gas released as a by-product during photosynthesis. Thus, all life forms are completely dependent on photosynthesis.

7.3 RESPIRATION

What happens when you burn a fuel like petrol? Energy is released in the form of light and heat. The same sort of things happens in our body. Our fuel is glucose from our food. The process by which energy is produced from food is called **respiration**. Respiration is a chemical process, which takes place in cells.

7.3.1. ANAEROBIC AND AEROBIC RESPIRATION

The two main types of respiration are: anaerobic respiration and aerobic respiration. The first phase of respiration is common both in anaerobic and aerobic respiration. This phase is called glycolysis. It takes place in cytoplasm. During glycolysis, glucose is oxidized into two molecules of pyruvic acid with the yield of two ATP molecules.

Glucose → 2 Pyruvic Acid + 2 ATP

a. Anaerobic Respiration

The word anaerobic means absence of oxygen. In anaerobic respiration glucose is not completely oxidized to carbon dioxide and water, but is converted into carbon dioxide and alcohol or lactic acid. This process is also called **fermentation**.

Alcoholic fermentation

In alcoholic fermentation, pyruvic acid produced during glycolysis is converted into ethyl alcohol and carbon dioxide. It occurs in yeast and some bacteria.

Pyruvic Acid → Ethyl Alcohol + Carbon dioxide+ ATP

Lactic acid fermentation

During vigorous exercise your heart and lungs cannot provide enough oxygen to skeletal muscles quickly enough. When this happens, muscles start to carry out anaerobic respiration. Bacteria which convert milk to yogurt also produce lactic acid. Each pyruvic acid molecule is converted into lactic acid.

Pyruvic Acid → Lactic Acid+ ATP

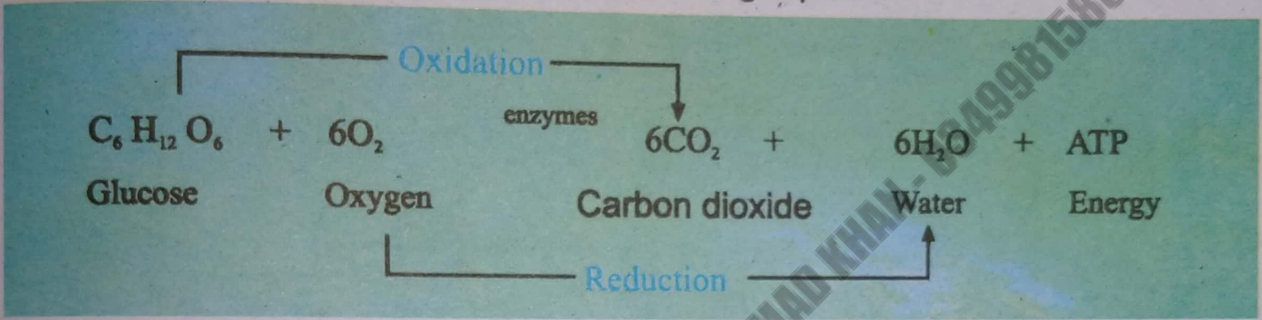
Importance of Anaerobic Respiration

Anaerobic respiration is important in following: (1) The very first organisms had to produce energy by anaerobic respiration because the early earth did not have an oxygen atmosphere. (2) Anaerobic respi ion by bacteria is used in cheese and yogurt making. (3) Fermentation by yeast is used in wine aking and baking. (4) Anaerobic respiration provides energy to muscle cells during vigoro s running or exercise by using lactic acid fermentation.

Aerobic Respiration

The word aerobic means presence of oxygen. Aerobic respiration, which requires oxygen, involves the complete breakdown of glucose to carbon dioxide and water.

Aerobic respiration can be summed up by the following equation.



7.3.2. MECHANISM OF AEROBIC RESPIRATION

The breakdown of glucose does not take place in a single step but in a series of chemical reactions. Energy released is stored in the form of chemical energy in ATP. The complete process of aerobic respiration is divided into three main phases; glycolysis, Krebs cycle and electron transport chain.

1. Glycolysis

Glycolysis takes place in cytoplasm outside the mitochondria. It occurs both in anaerobic and aerobic respiration. Glucose is broken down into two molecules of pyruvic acid. Two ATP molecules are produced as net energy gain. Two NAD^+ molecules are reduced to NADH.

Glucose → 2 Pyruvic Acid + 2 ATP + 2 NADH

2. Krebs Cycle

Each pyruvic acid molecule now enters a mitochondrion. Before the start of Krebs cycle pyruvic acid is oxidized to a two-carbon acetyl group which combines coenzyme A to form acetyl Co A. Carbon dioxide is removed and NADH is produced.

2 Pyruvic Acid + 2 CoA → 2 Acetyl CoA + 2 CO_2 + 2 NADH

Krebs cycle is a cyclic process which takes place in mitochondrial matrix. Coenzyme A is released and acetyl group is passed through a series of reactions. The products of this process are CO_2, NADH and $FADH_2$. Some energy is released to produce ATP directly.

2 Acetyl CoA → 4CO_2 + 2 ATP + 6 NADH + 2 $FADH_2$

3. Electron Transport Chain (ETC)

Electron transport chain is a series of electron carriers located in the inner membrane of mitochondria. The electrons that are removed by oxidation of food molecules during glycolysis and Krebs cycle are carried to ETC by NADH and $FADH_2$.When electrons coming through NADH

pass through ETC, they provide enough energy to synthesize three ATP molecules. Each $FADH_2$ gives two ATP. The final electron acceptor is oxygen atom which then combines with hydrogen ions to produce water.

Aerobic respiration produces 38 ATP molecules. 2 ATP are utilized so it gives 36 ATP as net energy profit.

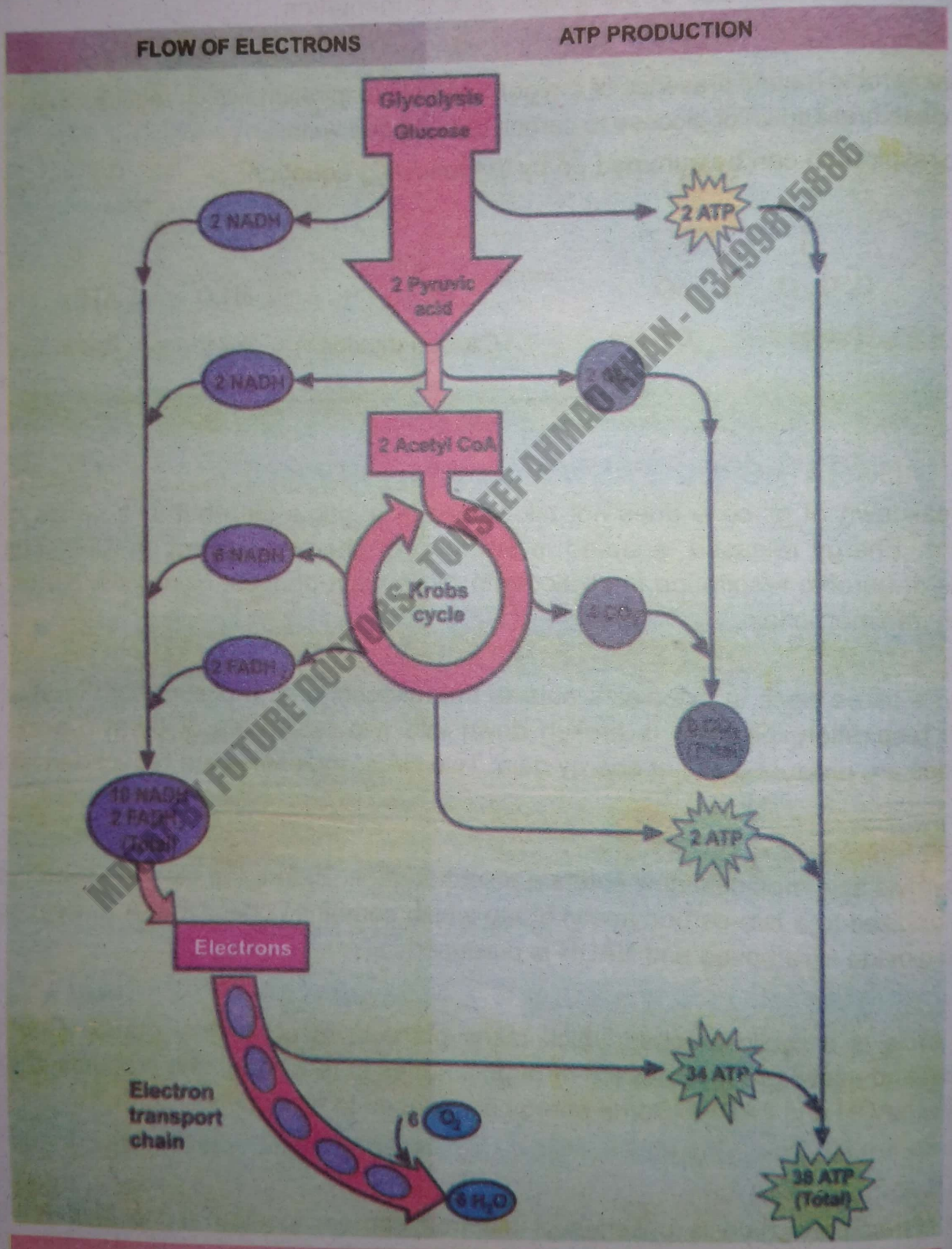


Fig. 7.8: An overview of aerobic respiration

Table 7.3: Comparison of Aerobic and Anaerobic respiration

	Anaerobic Respiration	Aerobic Respiration
Reactants	Glucose	Glucose and Oxygen
Products	• Ethyl alcohol in Alcoholic Fermentation • Lactic acid in Lactic Acid Fermentation	CO_2 and H_2O
Oxidation	Incomplete	Complete
Location	In Cytoplasm	In Cytoplasm and Mitochondria
Stages	1. Glycolysis 2. Fermentation	1. Glycolysis 2. Kreb's Cycle 3. Electron Transport Chain
Oxygen requirement	No	Yes
Energy yield	Low (2 ATP)	High (36-38 ATP)

Table 7.4: Comparison of Respiration and Photosynthesis

	Respiration	Photosynthesis
Type of Metabolism	Catabolism	Anabolism
Occurs in	All living things	Only green parts of plants
When it occurs	All the time	Only in day light
Organelle involved	Cytoplasm and Mitochondria	Chloroplast
Reactants	Glucose and Oxygen	CO_2 and H_2O
Products	CO_2 and H_2O	Glucose and Oxygen
Energy Conversion	Chemical energy is released in the form of Kinetic energy	Light energy is trapped in the form of chemical energy
Phases	Three Phases 1. Glycolysis 2. Kreb's Cycle 3. Electron Transport chain	Two Phases 1. Light dependent reactions 2. Light independent reactions

SUMMARY

1. In plants photosynthesis occurs in chloroplast.
2. During photosynthesis, light energy is captured by chlorophyll and converted to chemical energy in a way that ultimately results in carbohydrate synthesis.
3. During the light dependent reaction of photosynthesis, chlorophyll electrons become excited. These electrons reduce NADP, forming NADPH and some of their energy is used to phosphorylate ADP, forming ATP.
4. During dark reactions, energy of ATP and NADPH is used to chemically combine carbon dioxide with hydrogen.
5. Cell uses two different types of catabolic pathways to extract free energy from nutrients: aerobic respiration and anaerobic respiration.
6. Aerobic respiration is a redox process in which electrons are transferred from glucose (which becomes oxidized) to oxygen (which becomes reduced).
7. The chemical reactions of aerobic respiration occur in four stages: glycolysis, formation of acetyl CoA, the Krebs cycle and the electron transport chain.
8. During glycolysis, which occurs in cytoplasm, a molecule of glucose is degraded to form two molecules of pyruvate.
9. Pyruvate is converted into acetyl CoA, which enters the Krebs cycle.
10. Water is formed when oxygen combines with Hydrogen and with electrons from the electron transport chain.

Exercise

MCQs

Select the correct answer:

1) Glycolysis is the breakdown of
   A) fructose B) glucose C) lactose D) maltose
2) The mechanism of ATP synthesis is
   A) phosphorylation B) photosynthesis C) respiration D) glucose
3) Pyruvate is the end product of
   A) Krebs cycle B) plasmolysis C) photolysis D) glycolysis
4) In aerobic respiration pyruvic acid changes to
   A) glucose B) fructose C) Acetyl CoA D) citric acid
5) Which of these uses oxygen as the final acceptor?
   A) glycolysis B) electron transport chain C) Krebs cycle D) photosynthesis
6) Which of these produces carbon dioxide?
   A) Krebs cycle B) electron transport chain C) glycolysis D) photosynthesis

7) What are the products of light reactions in photosynthesis?
A) ATP, NADPH and oxygen B) ATP and NADP
C) ATP,PGA and oxygen D) PGA and oxygen

8) Which statement is false about the light dependent reactions?
A) oxygen is liberated B) ATP is formed
C) carbon dioxide is fixed D) water is split

9) The cells of green plants make starch from simple inorganic materials. What is the function of chlorophyll in this process?
A) to absorb carbon dioxide B) to release oxygen
C) to store starch D) to trap light energy

10) Which feature helps plants to make most food by the process of photosynthesis?
A) broad and flat leaves B) shiny surfaced leaves
C) spiky leaves D) variegated leaves

Short Questions

1. Name the constituents of ATP.
2. Write the equation of:
   a) photosynthesis b) fermentation c) aerobic respiration
3. Name the products of anaerobic respiration in muscle cells.
4. Why a part of photosynthesis is called dark reactions?
5. In light reactions of photosynthesis why photosystem II occurs before the photosystem I?
6. Differentiate between:
   (a) oxidation and reduction (b) ATP and ADP
   (c) respiration and photosynthesis (d) aerobic respiration and anaerobic respiration
   (e) anaerobic respiration in yeast and muscle cell
   (f) Light reaction and dark reaction of photosynthesis
   (g) stroma and granum (h) thylakoid and granum.

Short Questions

1. What are the immediate products of light reactions of photosynthesis?
2. Name the three phases of aerobic respiration.
3. What is the main function of glycolysis, Krebs cycle and electron transport chain?
4. Why are the majority of organisms so similar in their energy metabolism?
5. Only some plant cells have chloroplast but all living cells have mitochondria. Why?

Extensive Questions

1. Describe the structure and uses of ATP.
2. Describe the light reactions of photosynthesis.
3. Describe the dark reactions of photosynthesis.
4. Explain the factors affecting rate of photosynthesis.
5. What are the adaptations in leaf structure for photosynthesis?
6. Write an experiment to show that plant needs light in order to make starch.
7. Compare respiration and photosynthesis with examples.
8. What are the advantages and significance of anaerobic respiration and fermentation in your daily life?

THE TERMS TO KNOW

• Acetyl-CoA	• Chlorophyll	• Oxidation
• Adenine	• Coenzyme-A	• Photolysis
• ADP	• Electron transport chain	• Photosynthesis
• Aerobic respiration	• FAD	• Photosystem
• Alcoholic fermentation	• Glycolysis	• Pigments
• AMP	• Krebs cycle	• Pyruvic acid
• Anabolism	• Lactic acid fermentation	• Reduction
• Anaerobic respiration	• Light-dependent reactions	• Respiration
• ATP	• Limiting factors	• Stroma
• Autotrophic	• Mesophyll	• Thylakoid
• Bioenergetics	• Metabolism	• Z-scheme
• Calvin cycle	• NAD	

ANALYZING AND INTERPRETING

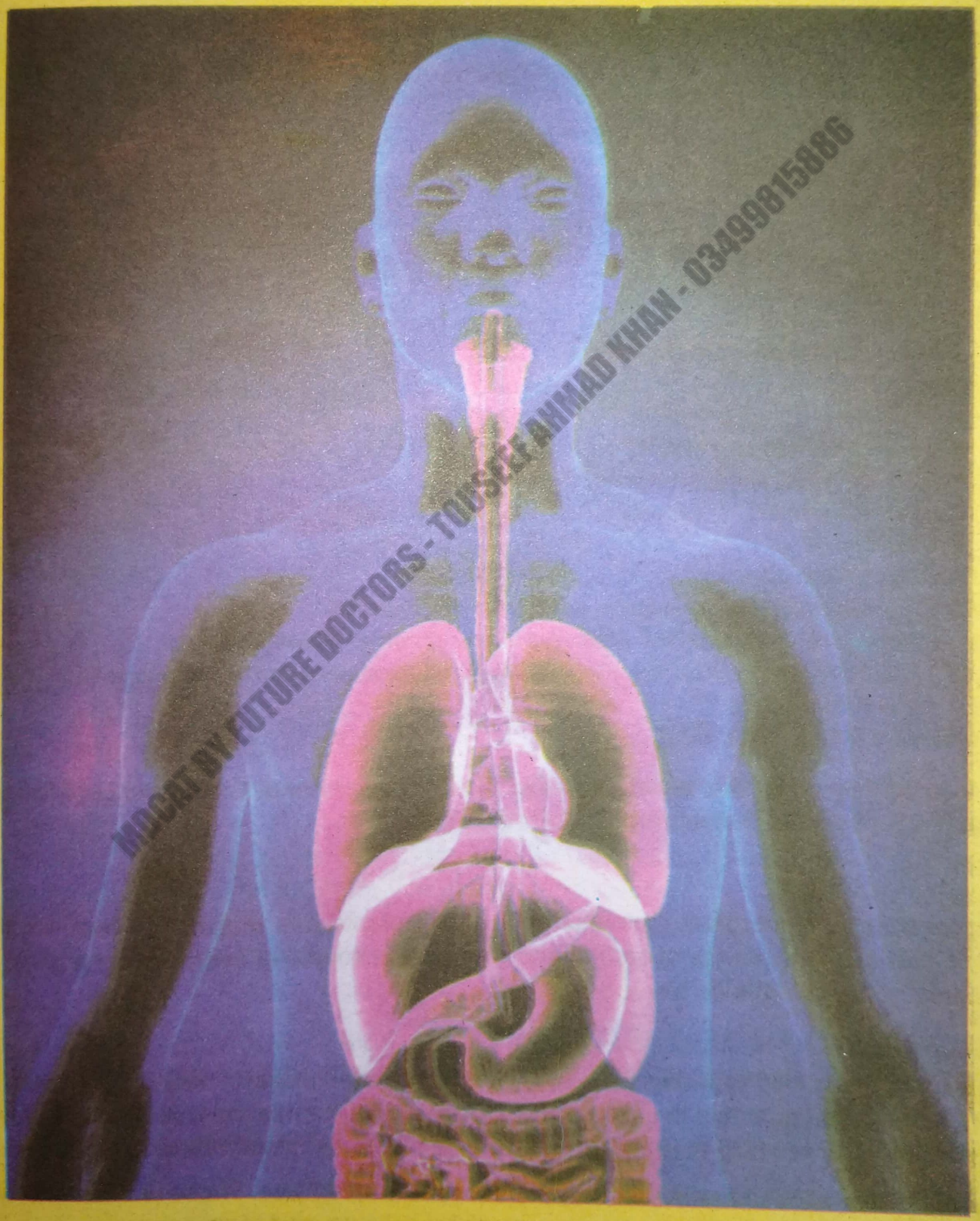
1. Design the molecular model of ATP using low cost materials, such as cardboard, empty cardboard boxes, clips, wire, used table tennis balls, egg shells etc., and label its components and high energy P bonds.
2. Design a model of light and dark reactions of photosynthesis materials. Use any sort of low cost /no cost materials such as cardboard, wire, packing material etc.
3. Identify and label the cellular and tissue structure in the cross section of a leaf through observation under microscope.

USEFUL WEBSITES

1. en.wikipedia.org/wiki/photosynthesis
2. photoscience.la.asu.edu/photosyn/education/learn.html
3. biology.clc.uc.edu/courses/bio104/photosyn.html
4. www.jphnkyrk.com/photosynthesis.html

SECTION 3

Life Process



8

NUTRITION

Major Concepts

The food contains chemical substances that the living cells need. Components of food required for normal growth and metabolism are called nutrients.

8.1 NUTRITION IN PLANTS

Plants require only inorganic nutrients so that the plants can make their own organic food. Carbon dioxide is the source of carbon and water is the source of hydrogen for a plant. Oxygen can come from atmospheric oxygen or water.

8.1.1 NUTRITION AND NUTRIENTS

Plants obtain inorganic elements from soil. These are called **mineral nutrients** and the mode of nutrition of mineral nutrients is called **mineral nutrition.** The mineral nutrients are of two types based on quantity in which they are required by the plants: (a) Macronutrients, (b) Micronutrients

Macronutrients: These are required by plants in larger quantities. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium, and magnesium.

Micronutrients: These are required by the plant in traces. These are often called **trace elements.** These are manganese, copper, molybdenum, zinc, boron, iron and chlorine.

8.1.2 MINERAL NUTRITION IN PLANTS

Here role of only nitrogen and magnesium will be discussed.

Nitrogen

Plants obtain their nitrogen requirements from soluble nitrates. Nitrogen is an important part of amino acids and nucleic acid. Deficiency of nitrogen causes: extremely stunted growth with small leaves and yellowing of leaves.

Magnesium

Magnesium is a constituent element of chlorophyll, so it takes part in the formation of chlorophyll. Deficiency of magnesium causes poor growth, yellowing of leaves followed by necrosis.

Importance of Fertilizers

There are two types of fertilizers: (a) Organic fertilizers. (b) Inorganic fertilizers.

a. Organic Fertilizers

Humus is an organic material formed by the decaying animals manure along with rotten leaves, fruits and vegetables. The humus when added to the soil enriches the soil with organic matter and minerals. The clay humus complexes are fundamental to almost every physical, chemical and biological process that occurs in the soil. They influence water and nutrients retention and aeration.

b. Inorganic Fertilizers

Usually the inorganic nitrogen, phosphorus and potassium are added to the soil, which are mostly depleted by the growing crops continuously. Nitrogen is usually added to the soil in the form of ammonium nitrate, ammonium sulphate and urea. Phosphorus is added in the form of super phosphate, rock phosphates. Potassium is added in the form of potassium chloride and potassium sulphate.

Chemical Fertilizers and Environmental Hazards

Phosphate containing fertilizer runs off into lakes and rivers and results in an overgrowth of algae and rooted aquatic plants. The result is **eutrophication** i.e., over enrichment, which can lead to an algal bloom. When algae die, decomposers use up all available oxygen during decomposition the result is a massive fish kill. Emission of the greenhouse nitrous oxide is caused by nitrogen fertilizers. Ammonia gas is emitted from inorganic fertilizers, which can also increase soil acidity.

8.2 NUTRITION IN MAN

Nutrients are the substance in food as energy source and for making structures. Nutrition is the process of taking in and using of food. All animals are **heterotrophs**.

8.2.1 MAJOR COMPONENTS OF FOOD

The major components of food are carbohydrates, proteins and fats.

Carbohydrates

The term carbohydrate means "hydrate (water) of carbon" reflects the 2:1 ratio of hydrogen to oxygen, the same ratio found in water (H_2O).

Sources of Carbohydrates: The main sources of carbohydrates are sugar, maize, barley, sweet potato, flour, rice, potato, honey, fig, grapes, sweets, and fruits. The carbohydrates we take, are in the form of sugar and starches. Except milk sugar all other sugars are obtained from the plants. One gram of carbohydrate on oxidation in the cells produce 4kcal of energy.

Metabolic Functions of Carbohydrates: After digestion carbohydrates are converted to glucose. It is absorbed and carried to the liver from where it is distributed to different parts of the body.

Proteins

The subunits of proteins are **amino acids**. The amino acids that animals cannot synthesize must be obtained from the diet are known as **essential amino acids**.

Sources of Proteins: Animal proteins are milk protein, egg protein and meat protein. Vegetable proteins are pulses, legumes, nuts, fresh fruits and dry fruits. One gram of protein produces 4 kcal of energy.

Metabolic Functions of Proteins: The metabolic functions of proteins are: (a) Many proteins act as structural proteins and take part in building and repairing of the body tissue. (b) Many proteins act as enzymes and hormones. (c) The protein haemoglobin found in red blood cells transports oxygen. (d) Actin and myosin are functional and structural proteins of the muscles and help in muscle contraction.

Lipids

Lipids consist mainly of carbon, hydrogen and little oxygen. A neutral lipid consists of glycerol joined to one, two or three fatty acids. Fats and oils together are called lipids. Fat comes from animals is **saturated** and solid at room temperature. Oil comes from plants is **unsaturated** and liquid at room temperature.

Sources of Lipids: Dairy products such as milk, butter, cheese, eggs, meat and fish are the examples of animal fats. Examples of vegetable oils are mustard seed, groundnut, coconut, linseed and dry fruits etc. One gram of fat gives9 kcal of energy.

Metabolic functions of Lipids: Lipids are used to form cell membranes and the sheath surrounding the neuron.

8.2.2 VITAMINS

Vitamins are organic substances. We need small amount of vitamins for good health. Vitamins come from food or made by the bacteria that live in our intestine. Vitamins play an important role in metabolism. Some vitamins are soluble in fat e.g., vitamin A,D, and some in water e.g., vitamin C.

Vitamin A

Vitamin A mainly occurs in carrots, papaya, mangoes, fish, milk, butter, eggs etc. It is needed for synthesis of visual pigments rhodopsin of rod cells and iodopsin of cone cells for eyesight. It is responsible for maintenance of healthy skin, hair and mucous membrane and for proper bone growth. **Deficiency of Vitamin A** leads to night blindness, retarded growth of bones, teeth and muscles.

2. Vitamin C or Ascorbic Acid

Vitamin C is widely distributed in citrus fruits e.g., oranges, lemons, grape fruit, black currents and leafy green vegetables, tomatoes, potatoes and cabbage. Milk contains very little vitamin C It is needed for forming collagen. Vitamin C helps to maintain capillaries, bones and teeth. It aids in absorption of iron and synthesis of hormones. **Deficiency of Vitamin C** causes scurvy.

3. Vitamin D

Mainly occurs in fish liver oil, milk, ghee, butter etc. It is also made in the skin when exposed to sunlight. Vitamin D regulates absorption of calcium and phosphorus by the intestine and their retention in the body and deposition in bones and teeth. **Deficiency of Vitamin D** causes increased loss of calcium ions in urine so no calcium is deposited in the bones. This causes rickets in children.

8.2.3 MINERALS

Minerals are inorganic elements. Only tiny quantity of **trace** elements is required in the daily diet. Man obtains minerals from food.

1. Calcium

Calcium is available in milk, cheese, egg yolk, beans, lentils, nuts, fig, cabbage etc. Calcium imparts strength and rigidity to bones and teeth. It is needed in muscle contraction and nerve conduction. Low level of calcium causes spontaneous discharge of nerve fibres resulting in tetany (painful muscular cramp). Bones become soft and cause osteomalacia (adult) and rickets (in children). The low level of calcium slows blood clotting and healing of wounds.

2. Iron

Iron occurs in liver, heart, kidney, spleen, egg yolk, whole wheat, fish, nuts, dates, figs, beans, spinach etc. Iron performs a wide range of functions. Many of these functions are connected with oxidation, reduction process by which energy is conserved in the body. It is a part of haemoglobin, so it is essential for transport of oxygen. The deficiency of iron causes anaemia (less haemoglobin), along with pale skin and fatigue.

8.2.4 EFFECTS OF WATER AND DIETARY FIBRES

1. Water

It is essential constituent of protoplasm. About 70% of the body weight is water. Sources of water are milk, juices, juicy fruit, vegetables, and natural water itself. The following are the functions of water:(1) Water is the medium of transport of nutrients, hormones and waste products. (2) Water serves as a solvent in which chemical reactions take place. (3) Water is the constituent of mucus in alimentary canal. (4) Evaporation of water from sweating cools the body and thus prevents overheating. **Deficiency Symptoms**: The condition of severe loss of water from the body is known as dehydration. Severe dehydration can damage brain, kidney and cardiovascular system. It can be fatal if 20% of body water is lost.

2. Dietary fibres

Fibre is material present in food, which we are unable to digest. It is mostly cellulose. It is not considered as nutrient.

Sources of Fibre: Dietary fibre comes from plant foods. It is of two types. Soluble fibre from fruit pulp, vegetables, oat bran etc. Insoluble fibres from the cellulose of plant cell walls and the bran husk that cover wheat, rice and other cereal grains. Whole meal bread contains much more fibre than white bread because it is made from whole meal flour i.e., flour made from the whole grain.

Functions of Fibre: Insoluble fibre does not dissolve, but holds water and swells up if mixed with water. Insoluble fibre adds bulk of food. The muscles of intestine can work against it and help to pass food quickly.

Deficiency Symptoms of Fibre: If proper peristaltic movements do not occur, the undigested matter in the large intestine cannot move along fast enough and too much water will be absorbed and cause constipation.

8.2.5 BALANCED DIET

The food we take each day is our diet. A diet containing the right amount of all nutrients is known as a balanced diet. A balanced diet must contain enough carbohydrates and fats to meet our energy needs. It must also contain enough protein of the right kind to provide the essential amino acids to make new cells and tissues for growth or repair. The diet must also contain vitamins and mineral salts, dietary fibre and water.

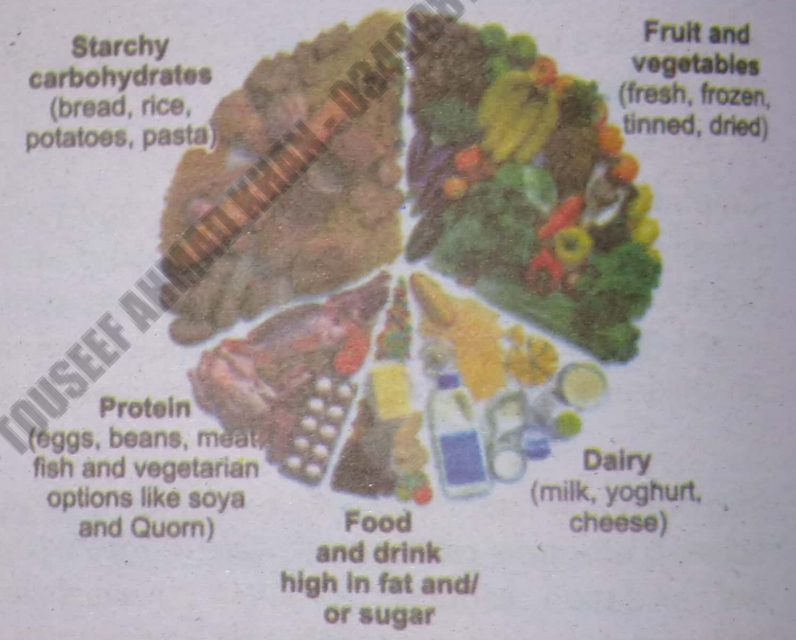


Fig. 8.1: Balanced diet

Relation of Balance diet with age, gender and activity

The composition of the balanced diet is affected by age, gender and activity.

a. Age

During growth period of the body there is higher basal metabolic rate. That is why at the age of one or two year it is highest, which decreases in the adults slowly throughout life. Children need extra calcium for growing bones, iron for their red blood cells, vitamin D to help calcify their bones and vitamin A for disease resistance.

b. Gender

Women of the same age, height and weight have less metabolic rate than men. This is due to difference in body. As the men have more muscular tissue and smaller amount of fatty tissue than women, so men need more energy for their normal body function.

c. Body Activity

People who use a lot of energy in their daily life such as athletes or people with energetic jobs, which involve a lot of moving around or carrying things need more energy. People who have sedentary jobs, such as office workers, will need less energy.

8.2.6 PROBLEMS RELATED TO NUTRITION

There are many nutritional problems, which affect a large number of persons. It may be under nutrition, over intake of nutrients, mineral diseases deficiency, anaemia etc. All of these are collectively called malnutrition.

8.2.6.1PROTEIN ENERGY METABOLISM

Protein energy malnutrition (PEM) is a major health and nutritional problem in the under developing countries of the world. It is caused by deficiency of both protein and calories in the diet. Example of diseases caused by PEM is Kwashiorkor and Marasmus.

Kwashiorkor: A growing child who does not get enough protein develops this disease. Growth is retarded and a child is weak.

Marasmus: The wasting of the body resulting from general starvation is called marasmus. Patient lose all their body fat and muscle strength. They acquire a skeletal appearance.

Kwashiorkor

Marasmus

Fig. 8.2: Protein energy malnutrition

8.2.6.2 MINERAL DEFICIENCY DISEASES (MDD)

Less sodium in diet causes loss of appetite, retard growth, and respiratory failure. Low level of calcium causes spontaneous discharge of nerve fibres resulting tetany. Iron deficiency causes anaemia. Low magnesium concentration causes irritability. Deficiency of iodine in human diet causes goitre. Deficiency of copper causes loss of body weight. Zinc deficiency causes retarded growth and skin wounds.

8.2.6.3 OVER INTAKE OF NUTRIENTS (OIN)

Over intake of nutrients can cause many health problems. Excess of carbohydrates and fats in food causes obesity, which may lead to high blood pressure. High dose of vitamin A may cause loss of appetite, cracking and bleeding lips, loss of hair, liver enlargement and pain in bone and joints. Excess dose of vitamin D are toxic causing deposition of calcium in soft tissues, arteries and formation of kidney stones.

Effects of Malnutrition

The effects of malnutrition are: starvation, obesity, heart diseases and constipation.

Starvation: Starvation occurs when a human or another animal does not receive energy in their diet. The body starts to use up its energy reserves stored as fat and glycogen. When these are

used up the body starts to use proteins i.e., body muscle, causing muscle wasting. It causes permanent organ damage that leads to death.

Obesity: Obesity means overweight. Obesity may lead to angina, heart failure, anaemia, arthritis, diabetes and hypertension. Obesity shortens life expectancy. The best way to control obesity is to lose weight by balanced diet, exercise and cut down on carbohydrates, fats, oils, and fried food.

Constipation: A lack of dietary fibre in the diet causes constipation. Constipation is a condition of the digestive system where a person experiences hard faeces that are difficult to eliminate.

Heart Diseases: The main cause is abnormally high blood cholesterol level and high blood pressure. Cholesterol deposition in the walls of blood vessels, makes them narrower and it leads to many heart diseases. Taking unsaturated oils in the diet can prevent heart disease.

8.2.6.4 FAMINE

Famine is the lack of enough food to feed all the people living in an area. The reasons of famine are unequal distribution of food, drought, flooding, increasing population etc.

a. Unequal Distribution of Food: The world as a whole produces more than enough food to supply everyone on Earth. However, this food is unequally distributed. In some parts of the world, there is more than enough for everyone. In other parts of the world, the food produced is not enough for its population.

b. Drought: The lack of rainfall is called drought, which stops crops from growing. Many areas are drought areas of world including Pakistan e.g., some areas in Balochistan and Sindh. As a result, population had to migrate as many animals and human beings died.

c. Flooding: Due to flood the land becomes muddy and marshy, so it is not possible to grow the crops immediately. People who rely on locally grown crops for their food will then have little to eat. They will not be able to save seeds to plant next year.

d. Increased Population: As human population continues to get larger, the problems of food shortage will become more and more intense. In parts of the world where soils are not fertile, or where water is in short supply, cause tremendous damage to the land. Eventually, the soil may become so dry and infertile that crops can no longer be grown and famine results.

8.3 DIGESTION IN MAN

A man like all other animals needs energy for the maintenance of his life processes. The energy comes from the metabolism of food substances. The food consists of carbohydrates, proteins, and fats. These are very large molecules. Every cell of the body needs these molecules for their proper functioning. Digestive system performs ingestion, digestion, absorption, assimilation and egestion.

8.3.1 INGESTION, DIGESTION, ABSORPTION, ASSIMILATION AND EGESTION

Taking in of the food is called ingestion. The breakdown of large food molecules, into small soluble food molecules with the help of enzymes is called **digestion**. When the food has been digested, the small molecules must pass out of digestive tube into the blood and the process is called absorption. From blood these molecules are taken into the cells and are used for various purposes by a process called **assimilation**. The process by which the undigested part of the

food is removed out of the body is called egestion. Digestive system cannot work alone. It is helped by transport system to take digested food from digestive tube to all parts of the body.

8.3.2 IDENTIFICATION AND FUNCTIONS OF THE MAIN REGIONS OF HUMAN ALIMENTARY CANAL

The organs, which take part in the process of digestion, make the digestive system. The human digestive system consists of two sets of organs.

1) The alimentary canal is concerned with ingestion, digestion, absorption and egestion of undigested food. The parts of the alimentary canal are mouth, oral cavity, pharynx, oesophagus, stomach, small intestine and large intestine.

2) The digestive glands are associated with the alimentary canal and help in digestion. The digestive glands are: salivary glands, gastric glands, intestinal glands, liver and pancreas.

1. Alimentary Canal

Alimentary canal is also known as gut or digestive tract or gastrointestinal tract. It is a continuous tube. The tube is about 9 meters long in adult. It is specialized at various points along its length, with each region designed to carry out a different role in the overall process of digestion, absorption and egestion. Alimentary canal begins from the mouth and ends at the anus. It is lined internally by mucous membrane.

Mouth: It is the external opening that leads into the oral cavity or mouth cavity.

Oral Cavity: Around the sides and front of the oral cavity are the upper and lower jaws. The upper jaw is fixed while the lower is movable. The oral cavity contains teeth and tongue.

1. Digestion in the Oral Cavity

Here food is tasted, smelled and felt. The food is chewed by crushing and grinding. The teeth, cheeks and tongue take part in these actions. As a result, food is physically and quickly broken down into smaller pieces. Food in the oral cavity stimulates the salivary glands to secrete saliva. The water and mucin in saliva moistens, soften and lubricate food. Saliva contains salivary amylase. This enzyme digests starch and maltose. The food is rolled by the tongue into small, slippery, spherical mass called bolus. The bolus is swallowed and enters the oesophagus through the pharynx.

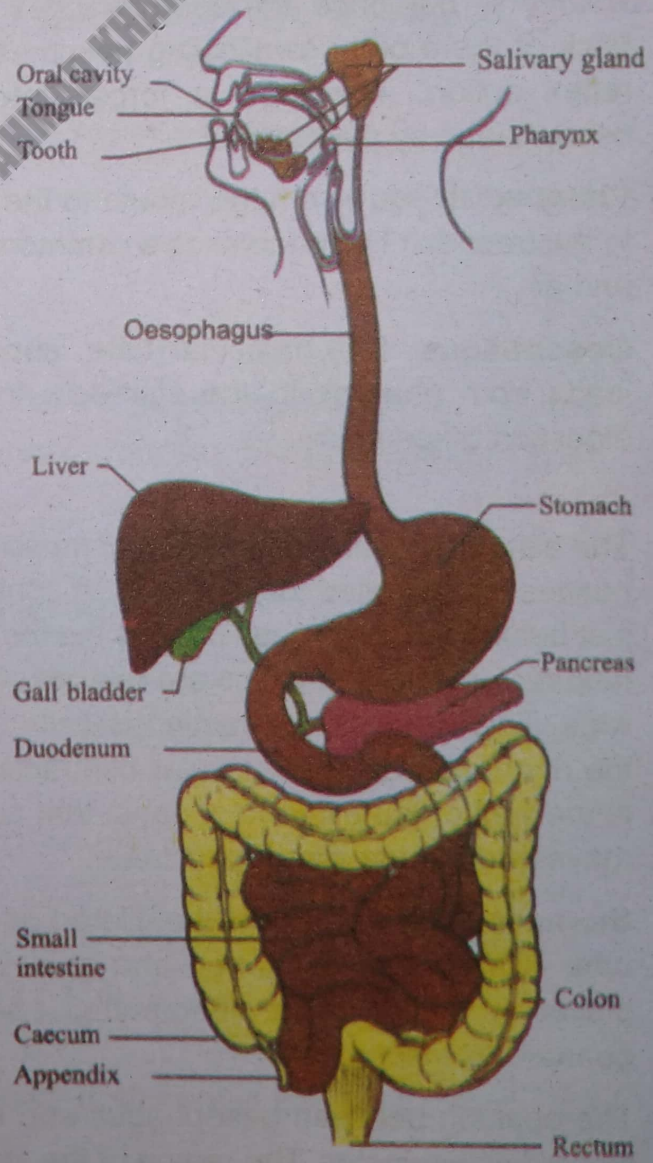


Fig. 8.3: The Human digestive system

Swallowing

In swallowing the following actions take place: (a) The tongue presses upwards and back against the roof of the mouth forcing a bolus, to the back of the mouth. (b) The soft palate closes the nasal cavity at the back. (c) The larynx cartilage around the top of the trachea is pulled upwards so that glottis (opening of trachea) lies under the back of the tongue. (d) The glottis is also partly closed by the contraction of a ring muscle. (e) The epiglottis (a flap of cartilage) helps to prevent the food from entering glottis instead of oesophagus.

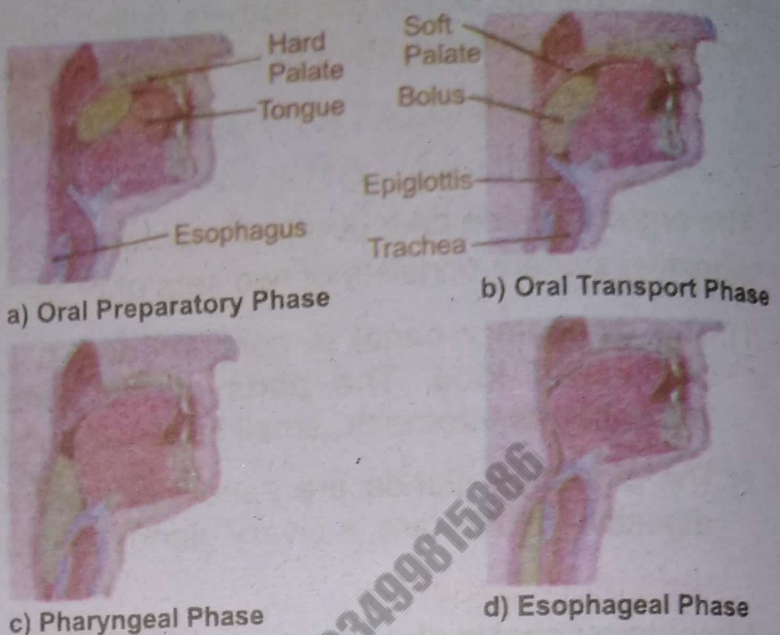


Fig. 8.4: The process of swallowing in man

The beginning of the swallowing action is voluntary, but once the food reaches the back of the mouth, swallowing becomes an automatic or reflex action. The food is forced into and down the oesophagus by peristalsis.

Pharynx: It leads from the mouth to the oesophagus and to the trachea. The pharynx is a common passage for food and air.

Oesophagus: It is muscular tube, about 25 cm long. It leads from pharynx to the stomach. In oesophagus no digestion takes place.

Peristalsis

The alimentary canal has layers of muscle in its wall which pushes the ingested food forward. A contraction of muscle just behind the food mass pushes the food forward into the next region where muscles are relaxed and oesophagus is wide. This wave of contraction is called **peristalsis**. It is the rhythmic wave of muscular contraction and relaxation in the wall of the alimentary canal that causes the food to move through the alimentary canal.

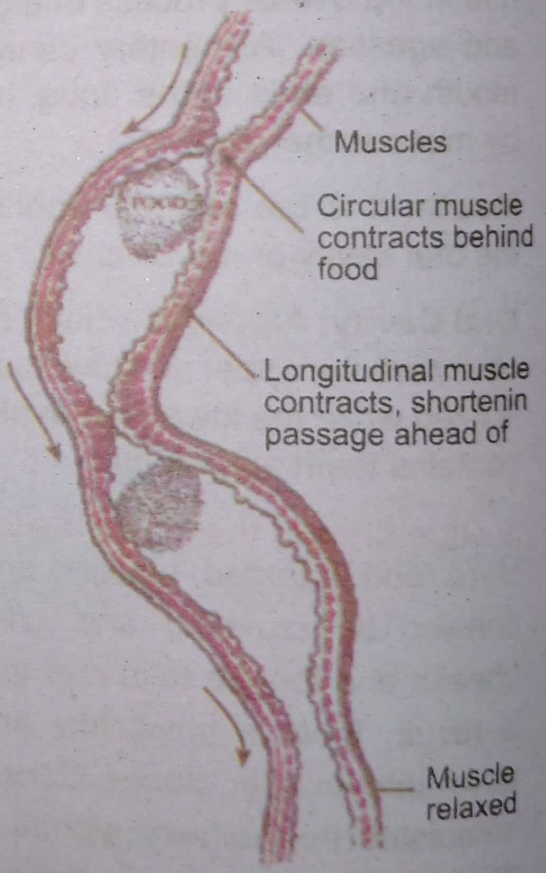


Fig. 8.5: Peristalsis

Stomach: The stomach is the dilated part of the digestive tube. It is roughly J shaped and somewhat transversely placed on the left of the abdomen just beneath the diaphragm. It has two openings, which are guarded by valves.

The opening between oesophagus and stomach is called **cardiac opening**, which is guarded by cardiac sphincter. The region of the stomach around the cardiac opening is the **cardiac end**.

The opening of stomach into the duodenum is called **pyloric opening** which is guarded by muscles called **pyloric sphincter**.

Digestion in Stomach

On the peristaltic reflex the cardiac sphincter relaxes to allow food in the stomach.

Gastric Juice: The food in the stomach stimulates the gastric glands to secrete gastric juice. It consists of mucin, HCl, pepsin and rennin.

Mucin: Mucin forms a coating over the stomach. It neutralizes the acid. It prevents the digestion of stomach wall by the enzyme pepsin.

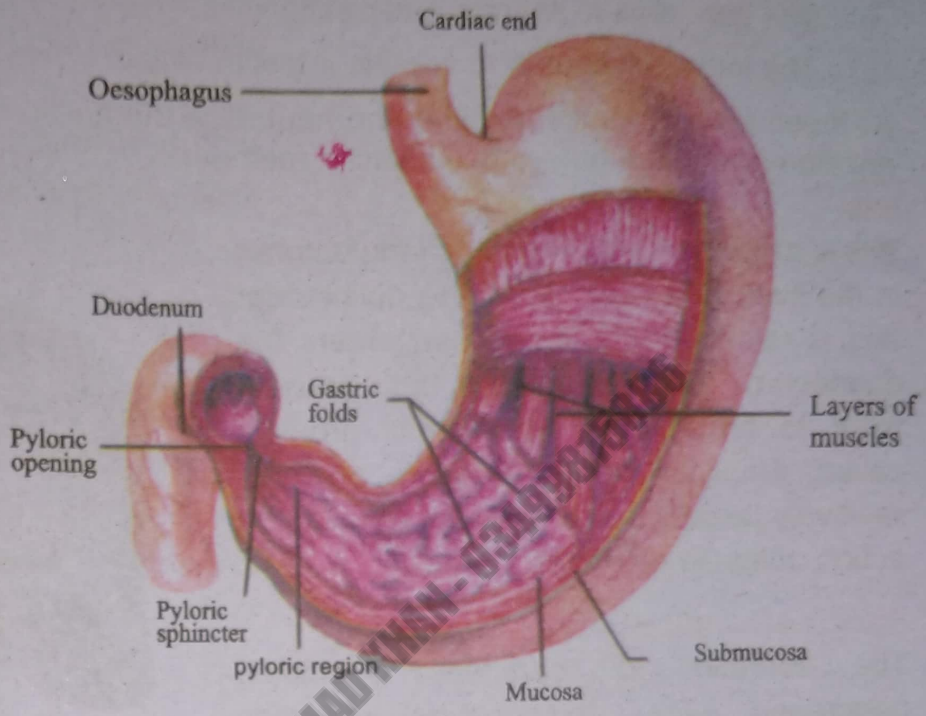


Fig. 8.6: Structure of Stomach

Hydrochloric Acid: HCl performs the following functions: (a) Stops the action of salivary amylase. (b) It converts the inactive form of enzyme (pepsinogen) to active form (pepsin). It provides acidic medium suitable for the action of enzymes. (c) It kills many microorganisms.

Pepsin

It is secreted as inactive pepsinogen. HCl or already present pepsin converts it to pepsin. Pepsin digests proteins to polypeptides (chain of many amino acids) and peptides (chain of few amino acids).

Rennin

Rennin is secreted only in infants. It helps in the digestion of milk protein.

By the churning action of stomach wall, the food mixed into a soupy mixture called chyme. When the chyme reaches a certain degree of acidity the pylorus relaxes and a little food passes into the duodenum.

Small Intestine: The small intestine is small in diameter. It is divided into three parts: duodenum, jejunum and ileum. **Duodenum** is about 20-25cmlong. Bile duct from gall bladder, hepatic duct from liver and pancreatic duct from pancreas empty its secretions, in the duodenum. Jejunum is about 2.5 meters long and ileum about 4 meters long.

Digestion in the Small Intestine

Starch, proteins and fats are all enzymatically broken down in the small intestine. When food enters the duodenum, the chyme stimulates:

(a) The gall bladder to release bile.

(b) The pancreas to secrete pancreatic juice.

(c) The intestinal glands to secrete intestinal juice.

All these secretions are alkaline and neutralize the acidic chyme. The pancreatic and intestinal enzymes can work only in this alkaline medium.

Bile

Bile is a greenish yellow liquid manufactured in the liver. Bile is stored in the gallbladder and is released whenever food enters the duodenum. Bile emulsifies fats causing them to break down into small droplets called emulsion. Emulsification provides relatively large surface areas of lipid for the action of lipase enzymes.

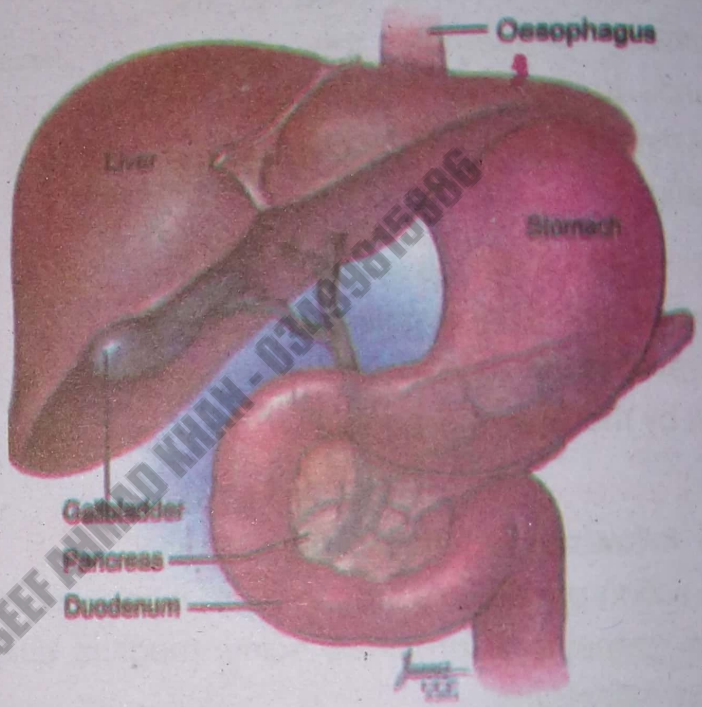


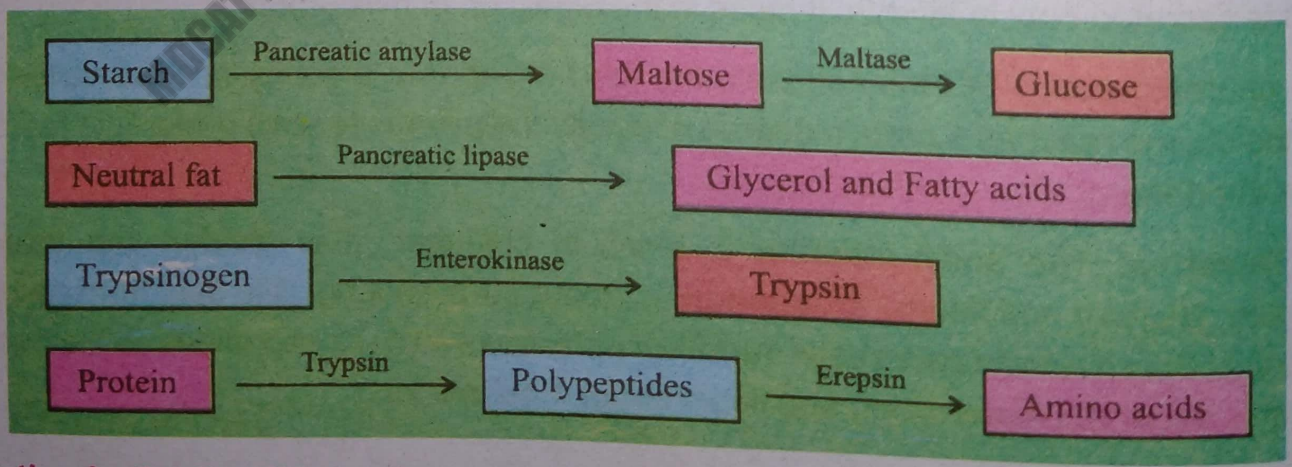
Fig. 8.7: Liver, Gall bladder and pancreas

Pancreatic Juice

The secretion of pancreas is called pancreatic juice. It contains enzymes amylase, lipase and trypsinogen. **Pancreatic amylase** is the starch-digesting enzyme. It converts polysaccharides to maltose and even to glucose. **Pancreatic lipase** converts neutral fats into glycerol and fatty acids. **Trypsin** converts proteins into polypeptides.

Digestion in Jejunum and Ileun

The lining of the jejunum and ileum secrete several enzymes such as **erepsin** converts peptides into amino acids. It secretes **Enterokinase** which activates pancreatic trypsinogen into its active form trypsin. **Lactase** converts lactose to glucose. **Maltase** converts maltose to glucose etc. In the ileum digestion process is complete.



Absorption in the Small Intestine

The internal lining of small intestine is modified to tiny finger like projections called **villi**. Each villus contains number of blood capillaries and a lymph vessel called lacteal. The villi increase surface area for absorption.

Simple sugar and amino acids pass through the wall of the villi into the blood capillaries of villi. Mineral salts and vitamins also pass in the blood capillaries of villi. Absorption occurs by a combination of diffusion and active transport. Glycerol and fatty acids are absorbed by the lacteal and ultimately poured into the blood.

The absorbed food in the blood capillaries of the villi passes into the blood stream. They are then carried away in the capillaries, which join up to form veins. These veins unite to form one large vein called the hepatic portal vein. This vein carries all the blood from the intestine to the liver, which may store and or alter any of the digestion products.

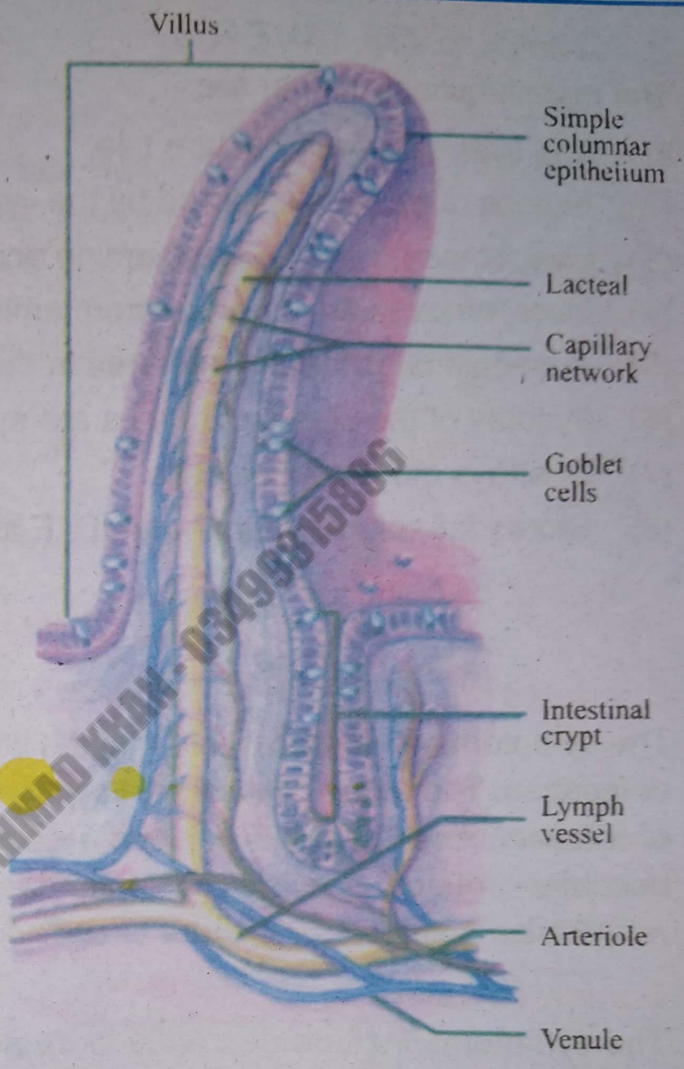


Fig. 8.8: Villus (L.S)

Assimilation

The products of digestion are carried round the body by the blood. These are absorbed by the body cells. The body cells use glucose, amino acids and fats. This uptake and use of food is known as assimilation. All the cells use glucose during cellular respiration to produce ATP.

Large Intestine: The large intestine is a tube leading from the small intestine to the anus. It is 1.5 meters in length. It is larger than the small intestine in diameter. It consists of caecum, colon and rectum.

Caecum is the first blind part of large intestine. The ileum enters it from side. It has a pouch like end and to its base **appendix** is attached which is 10 cm long. From **colon** water, salts and some vitamins are absorbed into the blood.

Rectum temporarily stores faeces.

Defecation: The semi solid waste, the faeces or stool is passed into the rectum by peristalsis and is expelled at intervals through the anus. The removal of undigested matter from the body is called **egestion** or **defecation**.

Liver: It is the largest gland, dark reddish in colour. The liver lies immediately below the diaphragm to the right side of the body. Liver secretes bile. It is collected by hepatic duct. In the gallbladder bile is temporarily stored. When the gallbladder contracts bile is poured into the duodenum.

8.3.3 ROLE OF LIVER

The main functions of liver are:

(1) The liver cells manufacture bile.
(2) Excess of glucose is stored by the liver as glycogen.
(3) Liver converts glycerol and amino acids to glucose molecules.
(4) Liver removes amino group from amino acids. It is called deamination.
(5) Ammonia is converted into urea in the liver.
(6) Majority of the plasma proteins are synthesized in the liver.
(7) Destroys old red blood cells.
(8) Stores fat-soluble vitamins (A, D, E and K) and mineral ions such as iron.

8.4 DISORDERS OF GUT

Diarrhoea

The symptoms of diarrhoea are that the stool becomes watery. There is increased frequency of defecation. The major causes are infection of the lower GI tract and nervous stimulation. In case of infection such as food poisoning caused by eating contaminated food the intestinal wall becomes irritated and peristalsis increases. Diarrhoea results in dehydration, so ORS (oral rehydration solution), or mixture of salt and sugar solution is given.

Constipation

The symptoms include decrease in frequency of stools daily, or difficulty in defecation, may result in abdominal pain. The faeces move too slowly along the large intestine. As a result, more water is absorbed from the faeces than usual. The faeces become hard so defecation become difficult and painful. For the treatment of constipation laxative is taken to make the faeces soft to be discharged easily. Constipation is called the mother of all diseases. As a preventive measure one should take plenty of water or fluids and fibrous food, fruits, vegetables etc.

Ulcer

An ulcer is an open sore in the wall of the gut caused by the gradual disintegration of the tissue. It may be gastric (stomach) ulcer or peptic (duodenal) ulcer. The main symptom of ulcer is stomach pain. The causes of ulcer are acidity, smoking, and bacterial infection. Medicines to be taken as prescribed by the physician. For the prevention of ulcer, (a) stop smoking, (b) avoid spicy food and food containing acids (c) avoid stress.

SUMMARY

1. Nutrients are the chemical substances in food that are used as energy source.
2. Plants obtain mineral nutrients from soil. There are two types of nutrients in plants: macronutrients and micronutrients.
3. The two types of fertilizers are organic fertilizers and inorganic fertilizers. Chemical fertilizers cause environmental hazards.
4. For balance diet humans require carbohydrates, proteins, fats, vitamins, minerals, water and dietary fibre.
5. Vitamins are organic compounds required in small amounts for many biochemical processes.
6. Minerals are inorganic nutrients ingested as salts dissolved in food and water.
7. Digestion of carbohydrates begins in mouth. As food is swallowed it is propelled through the pharynx and oesophagus.
8. A bolus of food is moved along through the digestive tract by peristaltic action.
9. In the stomach, food is mechanically digested by vigorous, churning.
10. Proteins are enzymatically digested by the action of pepsin in the gastric juice.
11. Most enzymatic digestion takes place in the duodenum which receives secretions from the liver and pancreas and produces several digestive enzymes of its own.
12. The liver produces bile, which emulsifies fats.
13. The pancreas releases enzymes that digest protein, carbohydrates, fats etc.
14. chains of glucose are digested to maltose by salivary and pancreatic amylases.
15. Maltase in the small intestine splits maltose into glucose.
16. Proteins are split by pepsin in the stomach and by enzymes in the pancreatic juice.
17. Most nutrients are absorbed through the thin walls of the intestine. The large intestine is responsible for the elimination of undigested wastes.
18. Diarrhoea, constipation, ulcer, are the disorders of the gut.

Exercise

MCQs

Select the correct answer:

1. This element is found in all proteins but not in carbohydrates:
   A) carbon B) oxygen C) hydrogen D) nitrogen
2. Which of the following vitamins is required for the formation of collagen?
   A) Vitamin A B) Vitamin B C) Ingestion D) Vitamin D
3. Emulsification of fat will not occur in the absence of:
   A) lipase B) bile C) pancreatic juice D) gastric juice

4. Process of conversion of simple absorbed food into complex compounds that become part of body is called:
   A) Digestion B) Assimilation C) Ingestion D) Absorption
5. Bile is formed in:
   A) liver B) gall bladder C) pancreas D) duodenum
6. The correct pair for deficiency cause is:
   A) vitamins A------ scurvy B) Vitamin C----- night blindness
   C) vitamin D------ rickets D) Vitamin D----- scurvy
7. The largest gland, in the human body is:
   A) gall bladder B) liver C) pancreas D) salivary gland
8. Glycogen is stored in:
   A) gall bladder B) spleen C) liver D) pancreas
9. Common passage for swallowing food and breathing is:
   A) pharynx B) glottis C) larynx D) mouth
10. Digestion of both starch and protein is carried out by:
    A) gastric juice B) saliva C) bile D) pancreatic juice
11. If the mucous lining covering the stomach breaks down and stomach tissues are damaged it is:
    A) appendicitis B) peptic ulcer C) constipation D) diarrhoea
12. When large intestine fails to absorb water from the undigested part of the food, it results in:
    A) constipation B) diarrhoea C) appendicitis D) vomiting
13. Part of the digestive system, which is not in contact with food, is
    A) small intestine B) liver C) caecum D) stomach
14. The diet component which prevent constipation is:
    A) fibre B) protein C) minerals D) vitamin

Short Questions

1. What is the importance of fertilizers?
2. What are the environmental hazards of chemical fertilizers?
3. Name the metabolic functions of carbohydrates.
4. Distinguish between:
   (a) carbohydrates and proteins
   (b) glucose and amino acid
   (c) macromolecules and micromolecule

(d) saturated and unsaturated fatty acids

(e) organic and inorganic fertilizers

(f) cardiac and pyloric sphincter

5. What do you think can be reasons or causes for famine.
6. Write the functions of: saliva, liver, gall bladder, pancreas, villus, bile, intestinal gland, gastric gland, pepsin, renin, goblet cells, HCl in stomach, amylase, lipase, trypsin, amino peptidase, entrerokinase, erepsin, lactase, maltase, sucrase, lacteal, vitamin A, vitamin C, vitamin D, hepatic portal vein.
7. Draw and label longitudinal section of villus.
8. What do you understand by balanced diet? Give its significance.
9. How is digested fat absorbed?
10. Why is digestion necessary?
11. Give one example of water soluble and fat-soluble vitamins.
12. Name the structures that secrete enzymes necessary for human digestion?
13. Why is pepsin formed in inactive form pepsinogen?
14. A man cannot digest cellulose but a cow can digest it. Why?
15. Why must digested food be distributed by blood in man and other animals?
16. How is chewing important to your digestion?
17. What would happen if pancreatic juice did not reach to your small intestine?
18. Why you cannot breathe while you are swallowing?
19. What are the causes of: a) Marasmus b) Kwashiorkor

Extensive Questions

1. Carbohydrates are major components of food for man. Explain.
2. What are proteins? What are the metabolic functions of proteins?
3. Write a note on fats.
4. Write the effects of vitamins A, C and D.
5. Write the effects of mineral calcium and iron.
6. How water and dietary fibre play important role for human health?
7. Scurvy, night blindness, obesity are due to some deficiency or excess? Explain.
8. Can you describe the structure of alimentary canal in your body?
9. Describe the process of swallowing food in man with diagram.
10. Describe peristalsis with diagram.
11. Describe the process of digestion. How it takes place in your body?
12. Write symptoms cause, treatment and prevention of the following disorder of gut:
    a) Diarrhoea b) constipation c) appendicitis d) ulcer
13. What role liver plays in your body?

THE TERMS TO KNOW

- Amylase
- Anemia
- Appendix
- Assimilation
- Balanced diet
- Bolus
- Cardiac sphincter
- Chyme
- Colon
- Constipation
- Diarrhea
- Dietary fibre
- Digestion
- Duodenum
- Emulsification
- Epiglottis
- Famine
- Fat-soluble vitamins
- Fertilizer
- Gastric juice
- Goiter
- Ileum
- Gastrin
- Oesophagus
- Intestinal juice
- Jejunum
- Kwashiorkor
- Lacteal
- Laxatives
- Lipase
- Liver
- Malnutrition
- Marasmus
- Mineral deficiency diseases
- Nutrition
- Oral cavity
- Over-intake of nutrients
- Pancreas
- Pancreatic juice
- Pepsin
- Pepsinogen
- Peristalsis
- Pharynx
- Protein-energy malnutrition
- Pyloric sphincter
- Rectum
- Saliva
- Starvation
- Stomach
- Swallowing
- Trace minerals
- Trypsin
- Ulcer
- Villus
- Vitamins
- Water solubie vitamins

SCIENCE, TECHNOLOGY AND SOCIETY CONNECTIONS

1. Explain why farmers use chemical fertilizers for better growth of their plants.
2. Describe ways in which research about nutrition has brought about improvements in human health (e.g., development of nutritional supplements and diets based on the needs of age, sex and activity).
3. Exemplify the societies suffering from famine due to unequal distribution of food and due to over population.
4. Explain how the customary food habits contribute to digestive tract disorders (e.g., diarrhoea, constipation)

USEFUL WEBSITES

1. www.esf.edu/efb/course/efb530/lectures/nutritio.html
2. www.hbci.com/~wenonah/min-def/index.htm

9

TRANSPORT

Major Concepts

Every cell depends on its environment. The environment is the source of necessary materials. The process by which the materials get into and out of the cells are diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis. In one-celled organisms and simple organisms, which are composed of only few cell layers, no cell is very far from its environment. Thus, the materials can be exchanged quickly between the organisms and environment.

Larger and complex organisms have specialized system to exchange materials between cells and their environment. In these organisms, individual cells cannot exchange materials directly with the environment. They are too far from the environment. The materials enter and leave the organisms only at specific points. These materials are carried to and from these points by a type of transport system.

9.1 TRANSPORT IN PLANTS

In plants oxygen and carbon dioxide are exchanged directly with the environment through stomata of leaves. A plant gets water, minerals and some oxygen from the soil. Plants use all the material to make sugars, chlorophyll etc. Plants have different channels for the distribution of water, minerals and sugars.

9.1.1 WATER AND ION UPTAKE

To understand how the uptake of water and ions (minerals) takes place in plant, we must know the internal structure of root and root hair.

Internal Structure of a Dicot Root

A thin transverse section of dicot root shows the following internal structure under microscope.

Epidermis is a single outermost layer of thin-walled cells having root hairs. **Cortex** consists of many layers of **parenchyma** cells. Inner to the cortex is the **endodermis**. **Pericycle** is a single ring like layer internal to the endodermis.

Vascular Bundles consist of xylem and phloem. Bundles of phloem tissue alternate with bundles of xylem tissue. **Pith** is a small area in the centre.

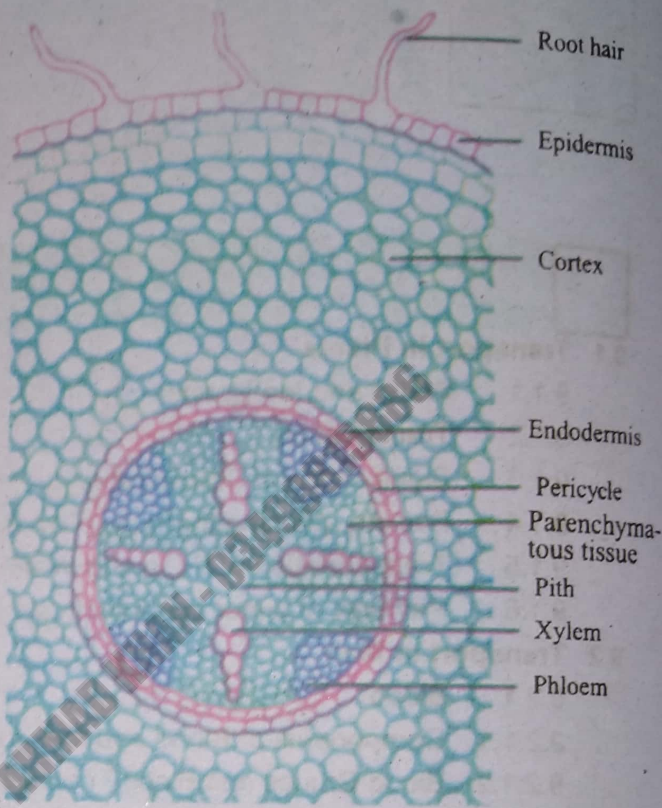


Fig. 9.1: T.S. of dicot root

Structure of Root Hair

Root hairs are projection of epidermal cells. Root hair are long and narrow. The root hair greatly increases the surface area of roots for absorption of water and minerals.

Uptake of water and Mineral Salts by Plants

Absorption of water and mineral salts takes place mainly through root hair. The cell sap is more concentrated than the soil solution. This results in water entering the root hair by osmosis. Water moves from cell to cell by osmosis and finally enters the xylem vessels and moves up the plant. Mostly mineral salts pass through by simple diffusion into the root hair and then through the cortex into the xylem vessels. However, when there is deficiency of minerals in the soil, the absorption of mineral salts by the root hair is done by active transport.

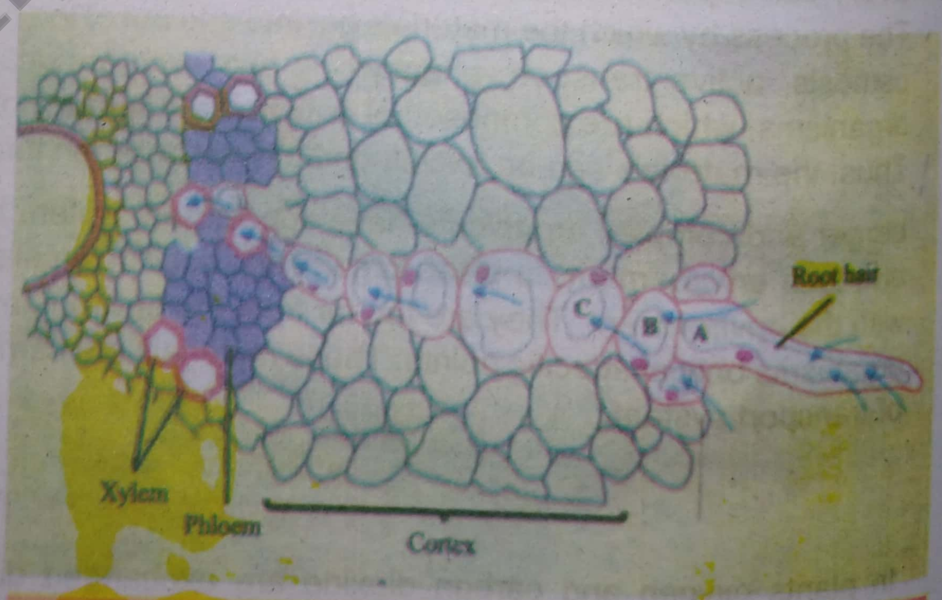


Fig. 9.2: Uptake of water and mineral salts by plants

9.1.2 TRANSPIRATION

A plant uses only little amount of water to perform its life processes. The excess of water has to be removed mainly by evaporation. The loss of water as vapours from the aerial parts of the plants is known as **transpiration.**

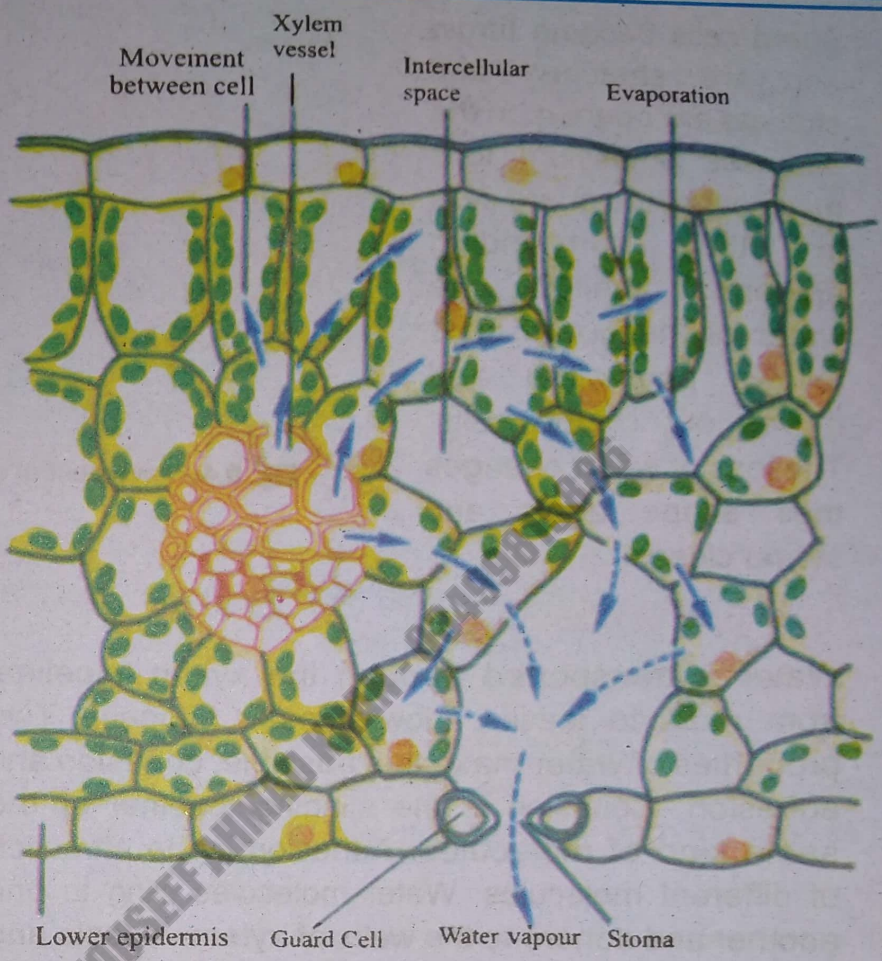


Fig. 9.3: Movement of water through a leaf

How transpiration takes place?

Transpiration and Surface Area: The cell wall soaks up water like blotting paper and water evaporates from the cell walls. The total surface area of all the cell walls is very large, so a lot of water can quickly evaporate and become water vapour inside the air spaces of mesophyll.

Transpiration and Stomata: The tiny pores on the leaf surface are called **stomata**, which is surrounded by two **guard cells**. The inner wall of each guard cell is thick and elastic. The outer wall is much thinner. The guard cell is surrounded by epidermal cell. The water vapours escape out of mesophyll air spaces through stomata.

Opening and Closing of Stomata

There are two hypotheses which may explain the opening and closing of stomata.

Starch Sugar Hypothesis

In the presence of light energy guard cells perform photosynthesis and produce sugar. As sugar concentration increases in the guard cell, water enters the guard cell. The guard cells become **turgid**. The thin outer walls bulge out and force the inner wall into a crescent shape. In this way a pore is formed between each pair of guard cells thus opening stomata. In the dark most of the sugar molecules are used by respiration or are converted into insoluble starch. As sugar concentration decreases water molecules diffuse out of the epidermal cells. When the guard cell loses water, it becomes **flaccid**. The inner thick walls move together until the pore between them is closed. Closing of stomata completely stops transpiration.

Influx of Potassium Ions Hypothesis

Day light stimulates potassium ions to enter guard cells from the surrounding epidermal cells by active transport. The accumulation of potassium ion increases concentration of the guard cells cytoplasm. Water (shown in blue arrows) enters the guard cells by osmosis. The

guard cells become turgid and are stretched and stomata are opened. In the darkness potassium ions move out of the guard cells in the surrounding epidermal cells. The water of the guard cells follows potassium and moves out of the cells. The loss of water changes their shape again and stoma closes.

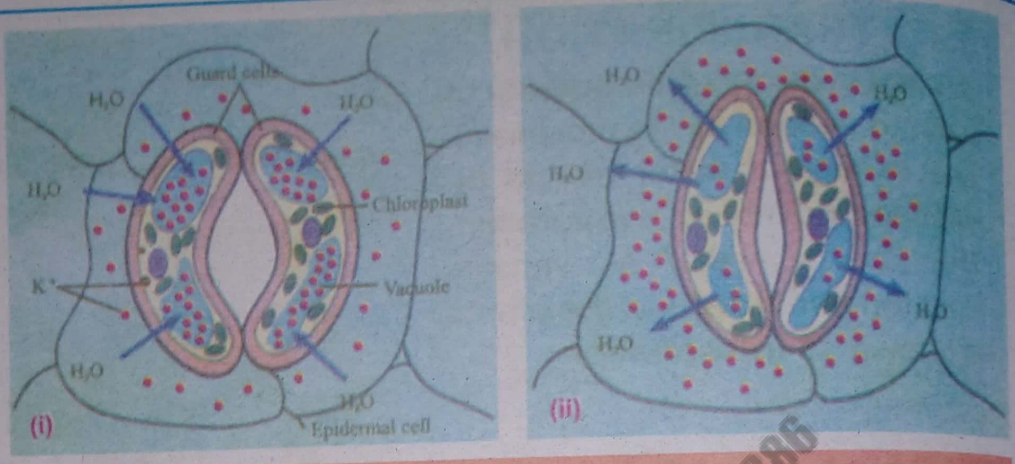


Fig. 9.4: Movement of water in xylem through TACT mechanism

Transport of Water

Water is transported through the xylem 'pipeline' from roots to leaves. How does it happen? Two properties of water make this possible, cohesion and adhesion. Cohesion is the clinging together of the same kind of molecules. Adhesion is the attraction of different molecules. Water molecules cling to one another and adhere to the walls of xylem vessels and tracheids. In the narrow tubes of vessels and tracheids, the combination of cohesion and adhesion form a continuous column of water from roots up to the leaves.

The evaporation of water from the leaves results in a suction force which pulls the water up the xylem vessels. This suction force due to transpiration is called **transpiration pull**.

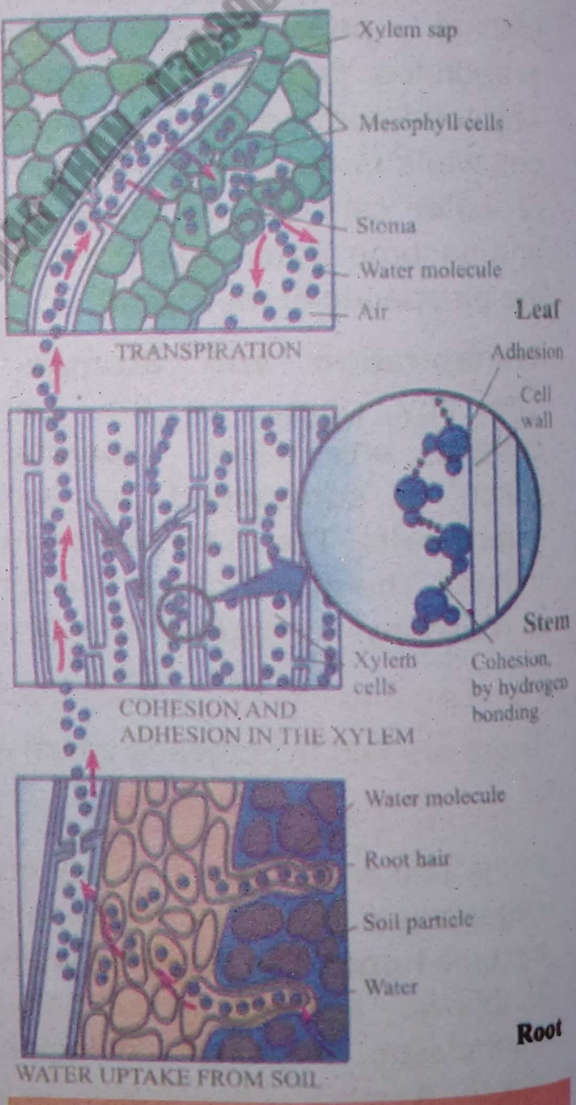


Fig. 9.5: Movement of Water in Xylem Through TACT Mechanism

9.1.3 Significance of Transpiration

Transpiration is of great importance to the plants. (1) Transpiration results in the transport of water and minerals from the soil to the leaves, where they form raw material of photosynthesis. (2) Evaporation of water has a cooling effect on plant.

Transpiration is a Necessary Evil

The stomata are primarily meant for absorption of carbon dioxide, but at the same time water vapours also escape through stomata. Thus, transpiration is a necessary evil because it is necessary but may become harmful. Loss of water can lead to wilting, serious drying up and often death of a plant, if there is shortage of water.

Transpiration and Wilting

During hot sunny days transpiration speeds up. Excessive transpiration causes cells to lose their water content and become flaccid. The flaccid cells give no support to the plant and wilting occurs so that the leaves, flowers and other non-woody tissue droop. Due to wilting the guard cells become flaccid and the stomata close and the rate of transpiration is reduced. The rate of photosynthesis is reduced, because amount of carbon dioxide is reduced as the stomata are closed.

9.1.4 Factors Affecting the Rate of Transpiration

Any change, which increases or reduces evaporation, will have the same effect on transpiration.

Temperature: The temperature warms the water inside leaves making it evaporate more quickly. An increase in temperature doubles the rate of transpiration, for every temperature rise of about 10^0C. If temperature exceeds 30^0C to 45^0C the stomata become closed.

Wind: In still air, the region round a transpiring leaf will become saturated with water vapour so that no more water can escape from the leaf. In these conditions, transpiration would slow down. In moving air, the water vapour will be moved away from the leaf as fast as it diffuses out. This will speed up transpiration.

Humidity: If the air is very humid i.e., contains lot of water vapour, it can accept very little water vapour from the plants and so transpiration slows down. In dry air rate of transpiration will be rapid.

9.1.5 TRANSPORTATION OF FOOD AND WATER IN STEM

The process of photosynthesis takes place in the leaves, during which glucose is made. Glucose is converted into other soluble products, which are sugar, amino acids and fatty acids. These are carried in solution to all parts of the plants by phloem. The process of movement of food from leaf to different parts of the plant is known as **translocation**.

Pressure Flow Mechanism

The most widely accepted hypothesis, explaining phloem transport is called pressure flow hypothesis. A location in a plant where sugar is being produced either by photosynthesis or by the breakdown of stored starch is called a sugar source e.g., green leaves and stem. A location in a plant where sugar is consumed or stored is called a sugar sink. e.g., young leaves, fruits etc.

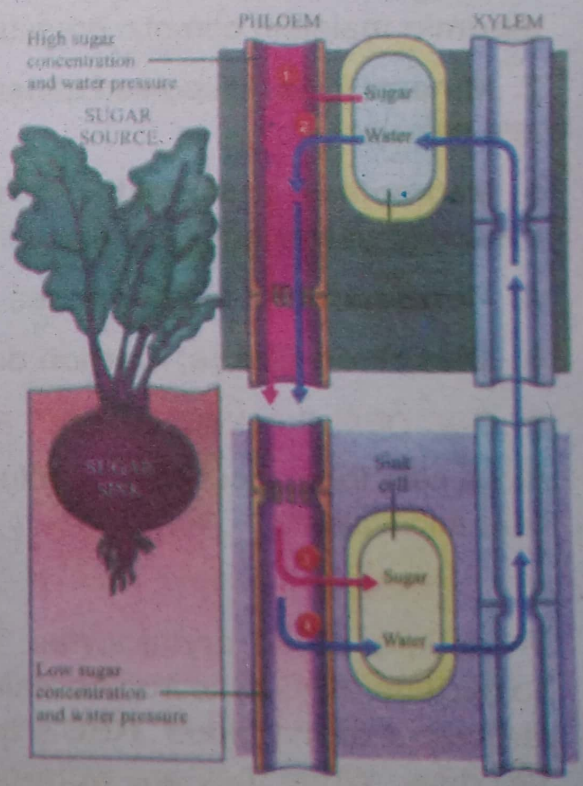


Fig. 9.6: Pressure flow mechanism through for phloem transport

According to pressure flow hypothesis water containing sugar in solution flows under pressure through the phloem. At source, sucrose is loaded into sieve tubes by using energy from ATP. So, the concentration of sugar increases in the phloem cells. Water enters the phloem cells from the surrounding xylem cells. The turgor pressure increases in phloem cells. It forces the sap through the phloem sieve tube to sink. Sugar is removed by the sink and is consumed or converted into starch. Thus, the concentration of the contents of phloem decreases. Remaining water enters xylem vessels.

9.2 TRANSPORT IN MAN

A specialized system has evolved in complex animals to distribute materials to all parts of the body. In mammals including man, the transport system consists of blood circulatory system, which contains the fluid called blood, pump called heart and pipes called blood vessels.

9.2.1 BLOOD

Blood is a type of special connective tissue with cells suspended in a fluid medium. The blood circulates in the blood vessels. Almost all the substances to be transported are present either dissolved or suspended in the blood.

9.2.1.1 Components of Blood and their Functions

PLASMA

The liquid part of the blood is called plasma. It constitutes about 55% by volume of blood in a normal person. Plasma contains 90% water and dissolved substances 10%.

1. **Plasma Proteins:** 7-9% of the plasma is made of different types of proteins e.g., **fibrinogen** take part in blood clotting, **immunoglobulins** defend against diseases and **albumin** maintain osmotic pressure.

2. **Mineral Ions:** Dissolved mineral salts e.g., chlorides, bicarbonates, sodium, potassium and calcium.

3. **Metabolites and Wastes:** Metabolites are amino acids, glucose, vitamins, lipids and metabolic wastes are urea, uric acid etc.

4. **Hormones:** All the hormones present in the plasma are to be carried by the blood.

5. **Dissolved Gases:** Carbon dioxide and oxygen in the plasma.

BLOOD CELLS AND CELL LIKE BODIES

Blood cells form about 45% by volume of the blood. These include red blood cells, white blood cells and platelets.

a) Red Blood Cells

These are called erythrocytes. R.B.C is a circular flattened, biconcave disc. It has no nucleus. RBC have iron-containing pigment haemoglobin in its cytoplasm, which gives red colour to the blood. RBC's are formed in bone marrow after birth. Their life span is 120 days. When they are worn-out, they are destroyed in spleen and liver. RBCs carry oxygen and also transport a small amount of carbon dioxide.

b) White Blood Cells

White blood cells are called leukocytes. Their life span is 3-4 days. Each white blood cell is irregular in shape and contains a nucleus. WBC's can be divided into two main types:

(1) Granular leukocytes (2) Agranular leukocytes

Granular Leukocytes

Their nucleus is variable in shape. Cytoplasm contains fine granules. These originate in bone marrow. Granular leukocytes are of three types, neutrophils, eosinophils and basophils.

Neutrophils: Neutrophils engulf pathogens during phagocytosis.

Eosinophils: Eosinophils are involved in the control of allergic reactions.

Basophils: Basophils release **histamine** in injured tissue and in allergic response.

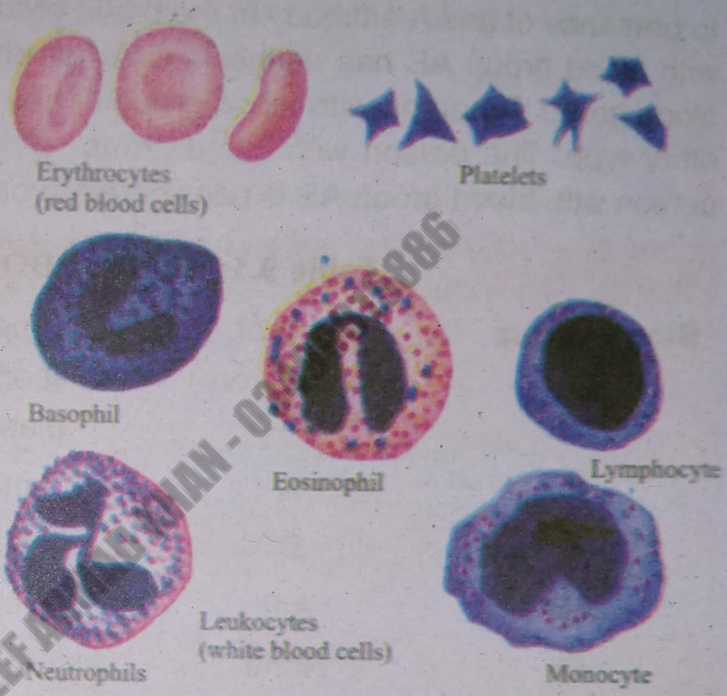


Fig. 9.7: Blood cells

Agranular Leukocytes

The cytoplasm is clear. These are of two types i.e., monocytes and lymphocytes. **Monocytes:** These are phagocytic and ingest bacteria and dead cells at the damaged tissue region.

Lymphocytes: There are two types of lymphocytes. B Lymphocytes protect us by producing antibodies. T lymphocytes directly destroy any cell that bears antigens.

c) Platelets

Platelets are known as **thrombocytes**. Bone marrow cells called **megakaryocytes** form fragments called platelets. **Platelets** play an important role in blood clotting.

9.2.1.2 Blood Groups and Blood Transfusion

There are 30 blood group systems. Only two are discussed here ABO and Rh.

Blood group — ABO system: Red blood cells have antigens on their membrane. The plasma has antibodies. An antigen is a substance, which promotes the formation of antibodies. Antibody is a protein that has been formed in response to antigen. Agglutination or clumping of red blood cells occurs due to antigen - antibody reaction. According to ABO system in humans blood groups are A, B, AB, and O. What is your blood group?

Some people were found to have antigen A, some had B, and some had both A and B and some has neither A nor B antigen. Those with A type blood do not carry the corresponding anti A antibody, but they carry anti B antibody in their plasma. B type people carry anti A but not anti B antibody, persons with AB type blood have both A and B antigens associated with red blood

cells, but no anti A antibody or anti B antibody in their plasma. O type individuals have no A and B antigens but carry both anti A and anti B antibodies.

Blood Transfusion

If a person with blood A gives blood to a person with type B there will be clumping of blood due to presence of anti A antibody in the blood group B and the recipient will probably die. A person with blood group AB has neither anti A nor anti B antibody and can safely receive A, B or O blood group. A person with blood group O has no cell antigen and can safely give blood to any other type. The person with blood group "O" is therefore known as universal donor, and the person with blood group AB is considered to be universal recipients.

Table 9.1: Human ABO Blood Group System

Blood Group	Type of Antigen on RBCs	Type of antibodies in plasma	Compatible Can receive from	Can donate to
A	A	anti B	A,O	A, AB
B	B	anti A	B,O	B, AB
AB	A,B	None	A,B,AB,O	AB
O	None	anti A, anti B	O	A, B, AB, O

Rh Blood Group

Rh blood group is due to antigen, called Rh factor, named after Rhesus monkey. If Rh factor is present on the red blood cell membrane the blood is said to be Rh positive and if the red blood cells lack Rh factor, the blood is called Rh negative.

Antibody against Rh Antigen

Normally no one has Anti Rh antibody in the plasma. If the Rh-negative person is given Rh-positive blood, it will stimulate the plasma to produce antibody. If the same Rh-negative person is given Rh positive blood, the antibody already formed in the plasma against Rh positive will react with donated blood. The person can even die.

9.2.1.3 Disorders of Blood

There are many disorders of blood, but we will discuss only leukaemia and thalassemia.

Leukaemia

The symptoms of leukaemia are fatigue, weight loss, repeated infection, anaemia, nose bleeding, bone pain etc. It is due to uncontrolled production of leukocytes. As a result, white blood cells greatly increase in the circulating blood. **Chemotherapy** is the most effective method of treating leukaemia.

Thalassemia

The symptoms of thalassemia are severe anaemia, fatigue, bleeding gums, larger spleen etc. It is transmitted genetically due to a recessive gene. If a single recessive gene is

present, this condition is called **thalassemia minor**. Two recessive genes give severe disease called **thalassemia major**. The treatments of thalassemia are blood transfusion and bone marrow transplant.

Prevention: You know that prevention is better than cure. Genetic counselling can help to reduce the chances of disease. Marriage between thalassemia minor persons should be avoided.

9.2.2 HUMAN HEART

The human heart is a hollow pumping organ. It is somewhat conical in shape. It is about the size of a man's fist. The heart is enclosed in a thin tough transparent sac, the **pericardium**. There is a fluid between the heart and the pericardium called **pericardial fluid**. It is lubricating fluid, which reduces friction between the pericardium and heart. The major portion of the heart is called **myocardium**. It consists largely of cardiac muscle tissue.

Internally, the heart is divided by a vertical partition into two halves, the right and left. The vertical partition is called **septum**. Each half is again divided into an upper thin-walled **atrium** and a lower thick-walled **ventricle**. Thus, the heart consists of four chambers, the right and left atria and the right and left ventricles.

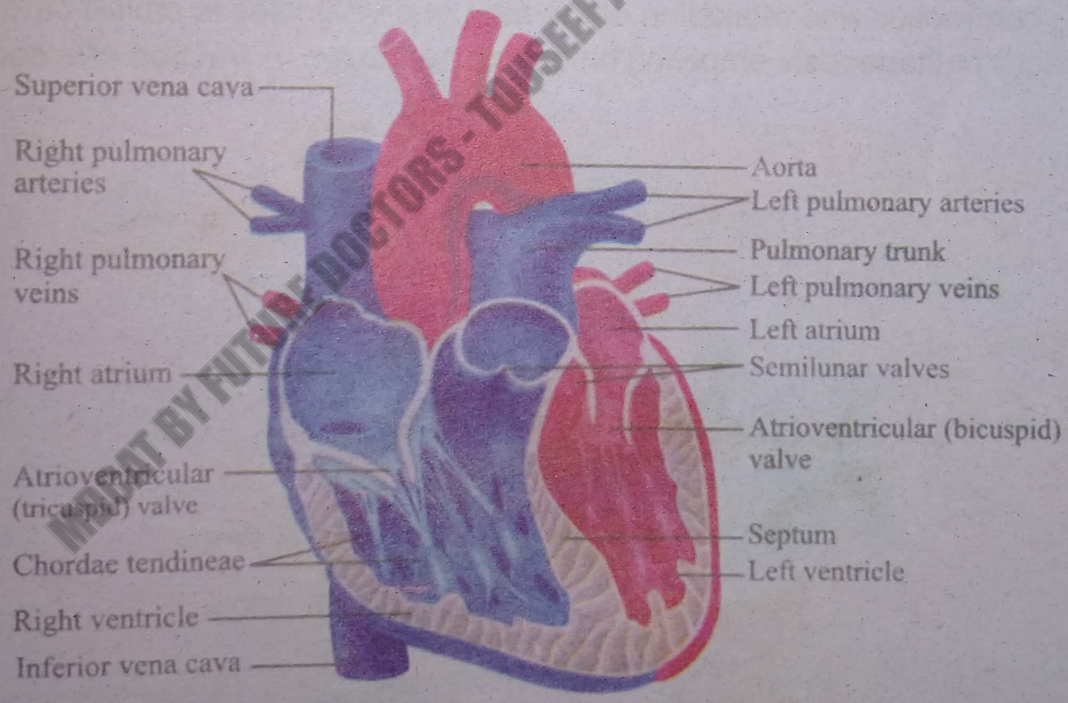


Fig. 9.8: Dissection of a human heart, as seen from the front, with the ventral part of both atria and both ventricles removed.

The atria receive blood and the ventricles distribute it. Blood from the head, neck and arms is returned to the right atrium by superior vena cava. Blood from lower parts of the body is brought back by the inferior vena cava to the right atrium. Thus, the right atrium receives deoxygenated blood from the two-vena cava. When the right atrium contracts, the blood flows into the right ventricle through the tricuspid valve.

When the right ventricle contracts the blood pressure closes tricuspid valve. This prevents back flow of blood into the atrium. The blood leaves the right ventricle by pulmonary trunk. The pulmonary trunk divides into two pulmonary arteries one to each lung. Return of blood into the ventricle is prevented by semilunar valves in the pulmonary trunk. Oxygenated blood from the lungs is brought back to the heart by way of the pulmonary veins, which open into the left atrium. When the left atrium contracts the blood enters the left ventricle through bicuspid valve.

When the left ventricle contracts, blood leaves by a large artery, the aorta. From the aorta blood is distributed to all parts of the body except lungs. Aorta also has semilunar valves to prevent back flow into the left ventricle.

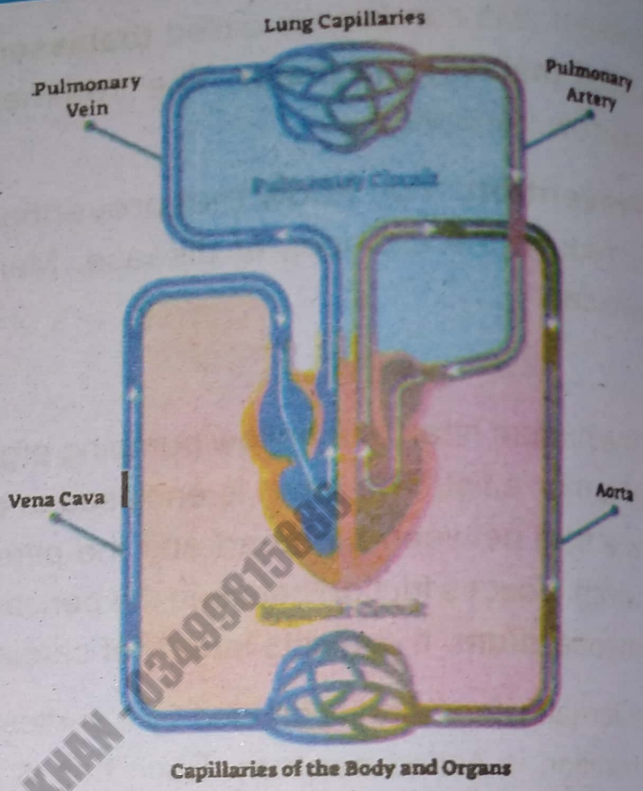


Fig. 9.9: Circulation of blood

Heartbeat

The alternating contraction and relaxation of the atria and ventricles is called cardiac cycle. The two atria contract simultaneously emptying blood into ventricles. A fraction of a second later, the

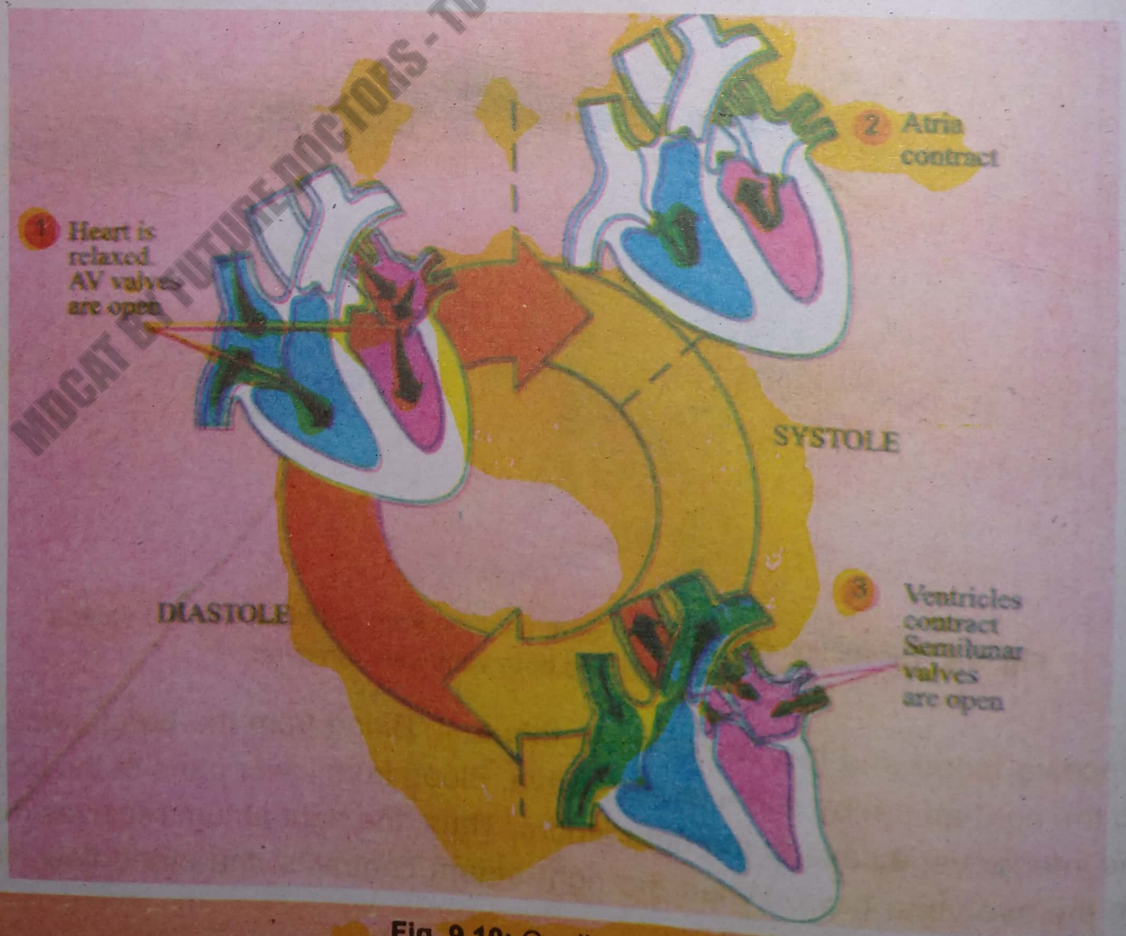


Fig. 9.10: Cardiac cycle

two ventricles contract simultaneously, forcing blood into arteries leaving the heart. Both the ventricles then relax for less than a second before the cycle is repeated. The period of contraction is called systole and the period of relaxation is called diastole. A heartbeat includes one systole and one diastole.

Pulse Rate

The beating of the heart is also felt in the arteries as pulse. Pulse is the vibration felt in arterial walls due to expansion of the aorta following ventricular contraction. If you place fingers on an artery on the wrist you will feel the pulse. A normal adult pulse rate can vary from 60-100 times per minute. Normally it is 68-72. The rate of heartbeat is indicated by the pulse rate.

9.2.3 BLOOD VESSELS

Blood moves through a system of three types of vessels, the arteries, veins and capillaries.

Arteries

Arteries carry blood away from the heart. Artery consists of three layers. **Endothelium** is the inner most layer. The **middle layer** consists of smooth muscle and elastic fibres or tissue. The outer most layer consists mainly of the connective tissues. **Arterioles** are the smallest arteries which transport blood. The arteries undergo elastic recoil and contract, to produce thumping vibrations called **pulse**.

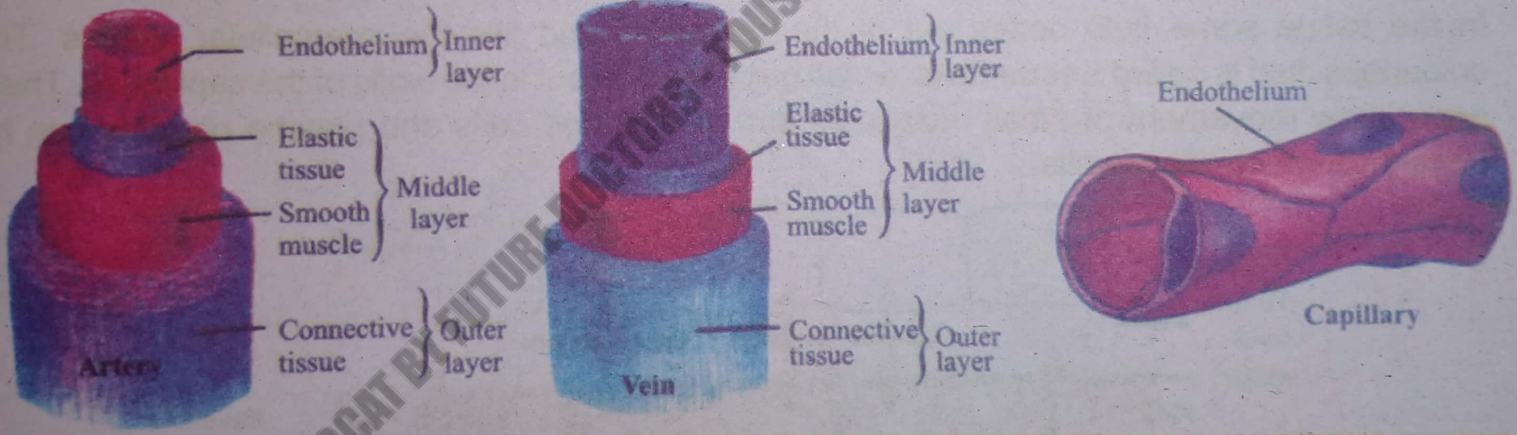


Fig. 9.11: Blood Vessels

Capillaries

Capillaries form a vast network of vessels in all parts of the body. The walls of capillaries are very thin, consisting of only a single layer of cells, the endothelium. The lumen of the capillaries is very narrow, so the RBCs can move through them only in a single row. In the capillaries the exchange of materials takes place by diffusion.

Veins

The blood vessels that bring blood back to the heart are called veins. A vein consists of three layers, i.e., inner layer, middle layer and out layer. The walls of the inner layer are thin and almost inelastic. The lumen of the vein is large. Semilunar valves are present.

Table 9.2: Comparison of arteries, veins and capillaries

Arteries	Veins	Capillaries
Transport blood away from the heart to the various part of the body through capillaries.	Collect blood from body through capillaries and transport it towards heart	Link arteries with veins
All arteries carry oxygenated blood except pulmonary arteries	All veins carry deoxygenated blood except pulmonary veins	These have a mixed oxygenated and deoxygenated blood.
There are no valves in them except at the base of pulmonary trunk and aorta.	Valves are present only below the heart region of the body. These prevent the back flow of blood.	There are no valves
Have a high blood pressure	Have a low blood pressure	Blood pressure falls in these.
Can be detected	No pulse	No pulse.
Have smaller lumen and thick wall.	Have larger lumen with thin walls.	Narrower lumen, wall with one cell thickness.
Thick muscle layer	Thin muscle layer	No muscles.
No exchange of materials takes place	No exchange of materials takes place	Responsible for exchange materials.

Tissue Fluid

In the tissue some fluid oozes out of the capillaries and fills the intercellular spaces. This colourless fluid is called **tissue fluid**. Small gaps are present in the walls of the capillaries. These gaps allow movement of small molecules and ions. Blood cells and plasma proteins can not pass-through capillary walls.

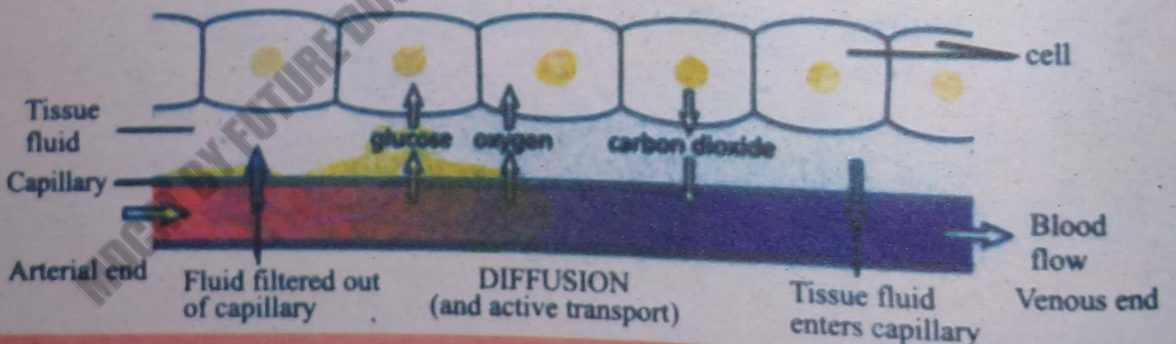


Fig. 9.12: Tissue fluid

9.2.4 GENERAL PLAN OF HUMAN BLOOD CIRCULATORY SYSTEM

The human blood circulatory system includes pulmonary circulation, which circulates blood through the lungs and the systemic circulation, which serves the needs of the body tissue.

Pulmonary Circulation

The pulmonary circulation consists of pulmonary trunk, pulmonary arteries and pulmonary veins. Pulmonary arteries carry deoxygenated blood to the lungs. After oxygenation, pulmonary veins bring back oxygenated blood to left atrium.

Systemic Circulation

The systemic circulation includes all of the other arteries and veins. The largest artery in the systemic circuit is the aorta, which branches into arteries leading to the organs. The following major arteries are:

1. **Coronary arteries:** Supply blood to the heart itself.
2. **Carotid arteries:** Supply blood to the head and neck.
3. **Subclavian arteries:** Supply blood to arms.
4. **Dorsal aorta:** It curls backward and continues downwards as the dorsal aorta.

From the dorsal aorta, the following arteries are given off: (a) **Hepatic artery**: Supplies blood to the liver. (b) **Mesenteric arteries**: Supply blood to the intestine. (c) **Renal arteries**: Supply blood one to each kidney. (d) **Common iliac arteries**: Supply blood one to each leg. This artery divides into femoral artery.

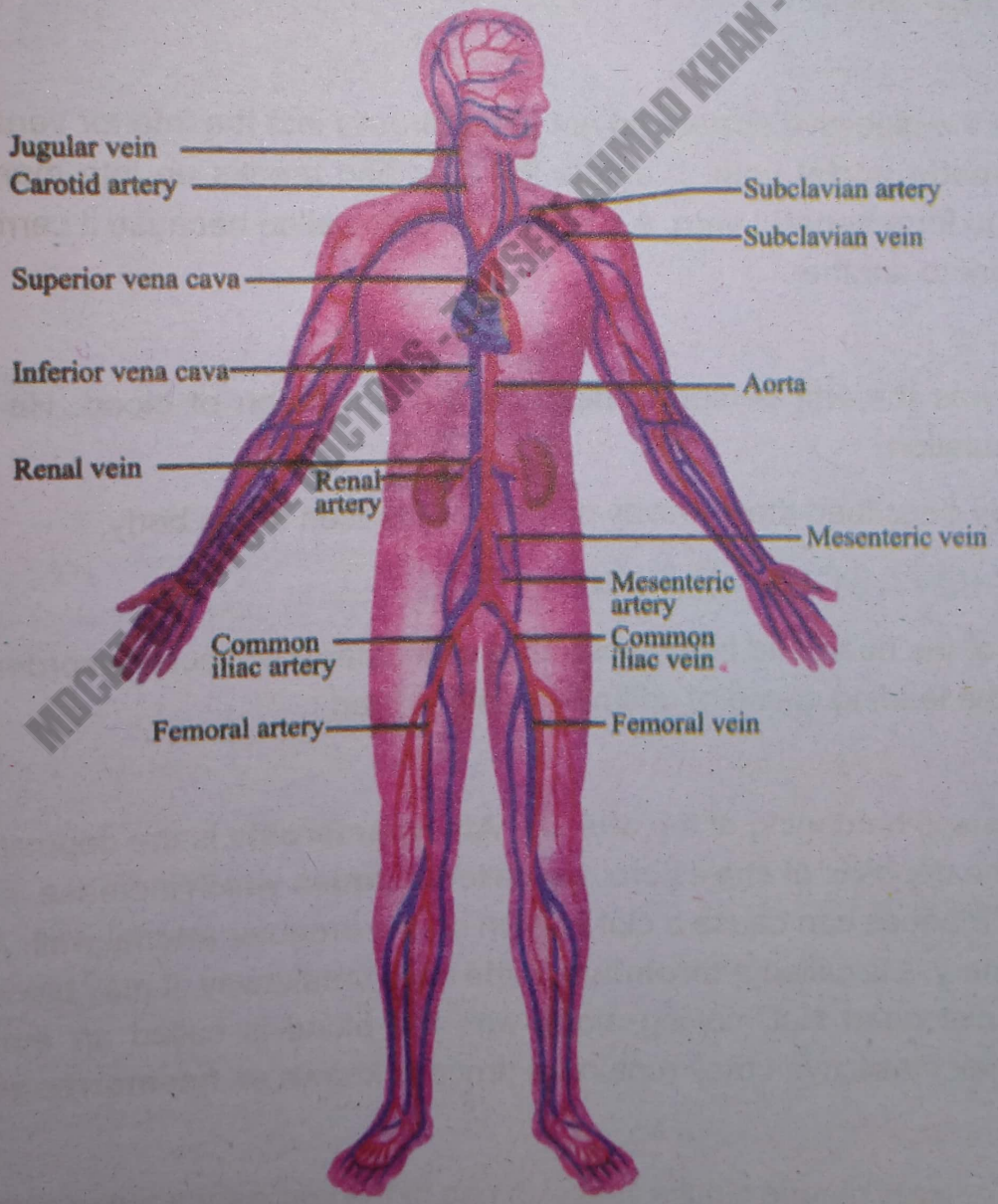


Fig. 9.13. artery and veins system of men

Main Veins

Blood is returned to the heart by the main veins as follows:

(1) **Jugular veins**: Bring blood from head and neck.

(2) **Subclavian veins**: Bring blood from the forelimbs.

(3) **Superior vena cava**: Jugular and subclavian veins unite to form the superior vena cava which opens into the right atrium of the heart.

(4) **Common iliac veins** and femoral vein brings blood from the lower limbs.

(5) **Renal veins:** Bring blood from the kidneys.

(6) **Hepatic veins:** Bring blood from liver and digestive system.

(7) **Inferior vena cava:** Iliac, renal and hepatic veins join to form inferior vena cava. It opens into the right atrium of the heart.

Hepatic Portal Vein

The veins from the digestive system do not open directly into the inferior vena cava. They unite to form the **hepatic portal vein**. It enters the liver and breaks up into many capillaries. The capillaries join to form **hepatic vein**. A **portal vein** is so called because it carries blood form one capillary network to another.

Contributions of Ibn-al-Nafees and William Harvey

Ibn-e-Nafees was the first person to describe the circulation of blood. He discovered blood pulmonary circulation.

William Harvey described the pathway of blood circulation in the body.

9.3.5 CARDIOVASCULAR DISORDERS

The disorders of the heart and blood vessels is called cardiovascular disorders. Cardiovascular disorders are the leading cause of untimely death in man.

Atherosclerosis and Arteriosclerosis

Arteriosclerosis is hardening of the arteries. **Atherosclerosis** is the deposition of materials in the arteries. The deposits of cholesterol are called **plaques** which increase in size and begin to block arteries. Plaques can cause a clot to form on the irregular arterial wall. As long as the clot remains stationary, it is called a **thrombus**. If the clots breakaway, it may block artery at another location. The dislodged clot moving along with the blood is called an **embolus**. Hardened arteries lose their elasticity. It may rupture, a process known as **haemorrhage.**

Myocardial Infarction

If the embolus or large plaque blocks vessel in one of the coronary arteries of the heart, a portion of the heart muscle will not get supply of oxygen. Due to lack of oxygen, this portion of heart

muscle dies. Infarction means death due to lack of oxygen. The whole process is called **myocardial infarction**.

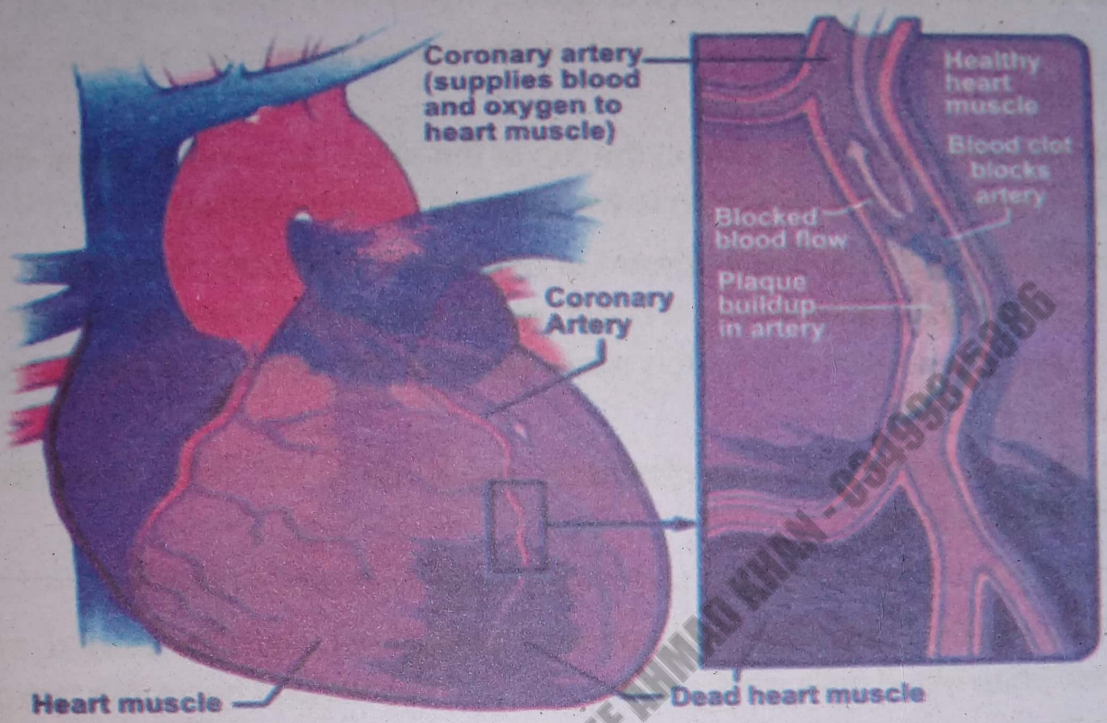


Fig. 9.14: Myocardial Infarction

Treatment

1. Medical treatment includes the use of an **enzyme** that dissolves blood clot.
2. **Coronary bypass surgery** is done to treat blocked arteries. In this surgery blood vessel from elsewhere in the patient body are grafted to coronary arteries to improve blood supply to heart muscles.
3. **Angioplasty** is the mechanical widening of a narrow or totally blocked coronary artery.

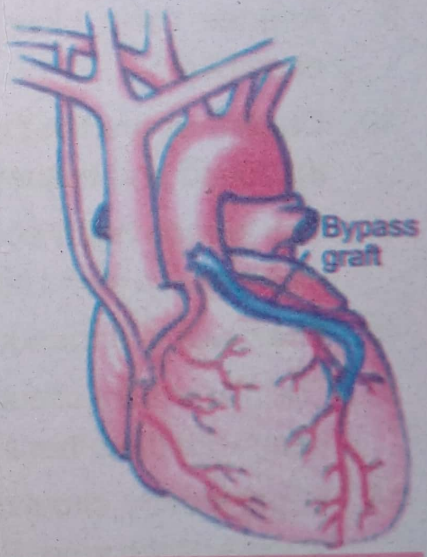


Fig. 9.15: Coronary artery bypass graft operation

Prevention

1. Avoid food rich in salt and fats.
2. Maintain healthy body weight.
3. Control blood pressure.
4. Regular walk and exercise.
5. Avoid smoking 6. Avoid stress.

SUMMARY

1. Water and dissolved minerals move upward in xylem from roots to stem and leaves.
2. Water moves from an area of higher water concentration to an area of lower water concentration.
3. Transpiration pull causes te: sion at the top of the plant. As a result, water moves from the soil to root xylem to stem xylem, to leave xylem to the atmosphere.
4. Dissolved sugar is translocated upward or downward in phloem. Sucrose is a predominant sugar translocated in phloem. As a result, water moves into these sieve tubes by osmosis. Sugar is actively unloaded from the sieve tubes at the sink. As a result, water leave the sieve tube.
5. Human blood consists of liquid plasma in which red blood cells, white blood cells and platelets are suspended.
6. Red blood cells transport oxygen and small amount of carbon dioxide.
7. White blood cells defend the body against diseases. Lymphocytes and monocytes are agranular white blood cells while neutrophils, eosinophils and basophils are granular white blood cells.
8. Platelets patch damaged blood vessels and release substances essential for blood clotting.
9. Arteries carry blood away from the heart chambers; veins return blood to the heart chambers.
10. Capillaries are the thin-walled vessels through which materials pass back and forth between the blood and tissues.
11. The human heart consists of two atria, which receive blood from veins and two ventricles, which pump blood into the arteries.
12. The heart is enclosed by pericardium and has valves that prevent backflow of blood.
13. The pulmonary circulation connects heart and lungs. The systemic circulation connects the heart with the other body organs.
14. In pulmonary circulation, the right ventricle pumps blood into pulmonary arteries, one is going to each lung. Blood circulates through pulmonary capillaries in the lungs and is then conducted to the left atrium by a pulmonary vein.
15. In the systemic circulation, the left ventricle pumps blood into the aorta, which branches into arteries leading to the body organs. After flowing through the capillary networks within various organs, blood flows into vein that conducts it to the right atrium.
16. The coronary circulation supplies blood to the heart muscles.
17. The hepatic portal system carries nutrient-rich blood from intestine to the liver.
18. The disorder of the heart and blood vessels is called cardiovascular disorder *e.g.*, atherosclerosis, arteriosclerosis and myocardial infarction

Exercise

MCQs

Select the correct answer:

1) Food is transported in plants in the form of:

A) proteins B) glucose C) starch D) lipids

2) Stomata close when guard cells:

A) lose water B) gains chloride ions B) become turgid B) gain potassium ions

3) The principle tissue for transpiration is:

A) cortex B) spongy mesophyll C) epidermis C) xylem

4) The large number of stomata are present on:

A) upper epidermis B) lower epidermis C) root epidermis D) stem epidermis

5) Guard cells differ from epidermal cells in having:

A) mitochondria B) vacuoles C) cell wall D) chloroplasts

6) Which of the following is not a leukocyte?

A) Lymphocyte B) Monocyte C) Eosinophil D) Thrombocyte

7) The normal pH of human blood is:

A) 7.1 B) 7.2 C) 7.3 D) 7.4

8) The source of sugars and other organic solutes in sap is:

A) root B) photosynthesising cells C) xylem D) phloem

9) The left half of the human heart:

a) is responsible for systemic circulation

b) is responsible for pulmonary circulation

c) circulates blood to the lungs.

d) passes blood through the right ventricle

10) The pulmonary arteries carry blood to the:

A) brain B) heart C) liver d) lungs

Short Questions

1. Write the function of: xylem, phloem, root hairs, palisade cells, stomata, epidermis, pericardium, left atrium, left ventricle, right atrium, right ventricle, tricuspid valve, bicuspid valve, semilunar valve, septum, aorta, pulmonary artery, pulmonary vein, guard cells, stomata, mesophyll cells, plasma, red blood cells, white blood cells, platelets.
2. Differentiate between:
   (a) Evaporation and transpiration (b) Serum and blood
   (c) Artery and vein (d) Tricuspid and bicuspid valve
   (e) Systole and diastole (f) Sink and source
   (g) Xylem and phloem (h) Pith and cortex
   (i) Cohesion and adhesion (j) Antigen and antibodies
   (k) Guard cells and epidermal cells (l) Pulmonary artery and pulmonary vein
   (m) Red blood cells and white blood cells
3. How does water enter a plant?
4. How do guard cells control opening and closing of stomata?
5. How do rise in temperature and wind velocity affect transpiration?
6. Why a person having blood group "O" is called "universal donor" and "AB" a universal recipient?
7. How are the valves of human heart important?
8. What are the types of white blood cells?
9. What would happen if a person with type B positive blood receives a transfusion of A positive blood?
10. What would happen if a person with Rh-positive blood receives a transfusion of Rh-negative blood?
11. Write the contributions of Ibn-al-Nafis and William Harvey.
12. In what way does pulmonary artery differ from all other arteries in the body?
13. Name the blood vessels that supply blood to:
    (a) head (b) liver (c) kidney (d) hind limb (e) heart.
14. Suggest why an injury that cuts open an artery is much more dangerous than an injury to vein.
15. Why are valves present in veins but not arteries?
16. Why are the walls of the atria thinner than the walls of the ventricle?
17. Why is the muscle of the left ventricle thicker than that of the right ventricle?

Extensive Questions

1. What are guard cells? How do they regulate transpiration?
2. Why transpiration is considered as necessary evil?
3. Describe the process of uptake of water and minerals by plants.
4. Describe the structure, and mechanism of opening and closing of stomata. Name the activities which take place in stoma during day and night.
5. Describe movement of water from roots to leaves.
6. Explain the factors affecting rate of transpiration?
7. What is the importance of transpiration?
8. Define translocation? Describe pressure flow mechanism of translocation in plants.
9. Write in detail the structure and functions of components of blood?
10. Describe ABO-blood group system.
11. Write a note on: (a) leukaemia(b) thalassemia
12. Describe the external and internal structure of human heart.
13. Write the differences between artery, vein and blood capillaries?
14. Describe pulmonary and systemic circulation?
15. Define cardio-vascular disorders. Discuss arteriosclerosis and myocardial infarction.

THE TERMS TO KNOW

- ABO system
- Agglutination
- Agranulocytes
- Albumin
- Angina pectoris
- Anti- A antibody
- Anti-B antibody
- Antigen
- Antigen A
- Antigen B
- Anti-Rh antibody
- Diastole
- Dorsal aorta
- Embolus
- Endodermis
- Eosinophils
- Erythrocytes
- Fibrin
- Fibrinogen
- Granulocytes
- Guard cell
- Haemoglobin
- Pulmonary artery
- Pulmonary circulation
- Pulmonary vein Pulse
- Red blood cells
- Rh factors
- Rh-blood group system
- Root hair
- Semilunar valve
- Stoma
- Systemic circulation
- T lymphocytes

- Aorta
- Aortic arch
- Arteriole
- Arteriosclerosis
- Artery
- Atherosclerosis
- Atrial systole
- Atrium
- B lymphocytes
- Basophils
- Bicuspid valve
- Blood group system
- Cohesion-tension theory
- Coronary artery
- Cortex
- Heart rate
- Lenticels
- Leukaemia
- Lymphocytes
- Lymphogenous cell
- Megakaryocytes
- Monocytes
- Myocardial infarction
- Neutrophils
- Pericardial fluid
- Pericardium
- Pericycle
- Phloem
- Plasma
- Platelets
- Thalassemia
- Thrombocytes
- Thrombus
- Transpiration
- Transpirational pull
- Tricuspid valve
- Vein
- Vena cava
- Ventricle
- Ventricular systole
- Venule
- White blood cells
- Wilting
- Xylem

PERFORMING AND RECORDING

1. Identify red and white blood cells as seen under light microscope (or in diagrams and photomicrographs).
2. Study of Human Heart
3. Identify the main arteries and veins in charts, diagrams, models

SCIENCE, TECHNOLOGY AND SOCIETY CONNECTIONS

1. State vascular surgery as one of the major fields in the careers.
2. Explain the social as well as personal factors that contribute to cardiovas-cular disorders in Pakistan.

USEFUL WEBSITES

1. www.geocities.com/emruf4/romance.html
2. www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1243355
3. www.stjohnsmercy.org/healthinfo/adult/digest/diarhea.asp
4. digestive.niddk.nih.gov/diseases/pubs/appendicitis/index.html

GLOSSARY

A

Acetyl CoA: A compound combining the two – carbon acetyl fragment removed during the oxidation of pyruvate with the carrier molecule coenzyme A

Active site: A particular portion of an enzyme molecule, which fits substrates.

Active transport: The transport of a substance across a cell membrane with the expenditure of energy, often against a concentration gradient.

Adhesion: Attraction between unlike molecules.

Aerobic respiration: Respiration, which occurs in the presence of oxygen.

Agglutination: Process in which blood cells clump together.

Amino acid: Compound which are the building blocks of proteins.

Anabolism: The building up complex substances from simpler ones.

Antibody: A protein that is produced by Blymphocytes and binds specifically to a particular antigen.

Antigen: A substance, which promotes the formation of antibodies.

Apoptosis: Cell death by cell destruction

Appendix: A pouch that hangs from the beginning of the large intestine.

Aster: In animal mitosis, an array of microtubules that radiates outward from the centrioles, when the centrioles reach the polls of the cell.

B

Balance diet: The diet containing the right amount of all food substances.

Bile: Secretion of the liver that is temporarily stored in the gall bladder before being released into the small intestine where it emulsifies fat.

Binomial nomenclature: System of naming a species by the combination of the genus name and specific epithet.

Bioelements: The elements found in all living organisms.

Biodiversity: The richness and variety of species on Earth.

Biogeography: The study of the geographical distribution of organisms.

Blood: A fluid circulating connective tissue that transports nutrients and other materials through the body of many types of animals.

C

Calvin cycle: Cyclic series of reactions in the chloroplast stroma in photosynthesis fixes carbon dioxide and produces carbohydrates.

Cardiac cycle: One complete heart beat.

Cartilage: The type of connective tissue having cells within lacunae separated by flexible matrix.

Catabolism: The breakdown of complex substances to simpler substances in a cell with release of energy.

Cell body: Portion of a nerve cell that includes cytoplasmic mass and a nucleus.

Cell cycle: Repeating sequence of events in eukaryotic cells consisting of interphase, when growth and DNA synthesis occurs, and mitosis, when cell division occurs.

Cell theory: Concept, which applies to all living things, the cell is the basic unit of a structure and

function and all cells are luced from other cells.

Centrioles: Short cylinder that contains microtubules in a 9 + 0 pattern; associated the formation of basal bodies and possibly the meiotic spindle.

Centromere: Constructed region of a chromosome where sister chromatids are attached to one another and where the chromosomes attaches to a spindle fibre.

Chiasma: In meiosis the point of crossing over where parts of chromosomes have been exchanged during synapsis; under light microscope a chiasma appears as an X-shaped structure (Pl: Chiasmata)

Chloroplast: Cellular organelle on autotroph which contains chlorophyll.

Chromatids: One of the two identical parts of chromosomes.

Chromatin: Thread like network in the nucleus that is made up of DNA and proteins.

Chromosomes: Thread like structures in the nucleus, which carry the genes.

Co-enzymes: Non-protein organic molecule that aids the action of the enzyme to which it is loosely bound.

Cohesion: Clinging together of the same kind of molecules.

Colon: Large intestine that extends from the caecum to the rectum.

Compact bone: Hard bone, consisting of osteons cemented together by a matrix.

Contractile vacuole: Organelle which pumps excess water from many protozoans.

Crossing over: Exchange of corresponding segments of genetic material between nonsister chromatids of homologus chromosomes during synapsis of meiosis-I.

Cytokinesis: The physical division of the cytoplasm of eukaryotic cells into two daughter cells.

D

Data: Fact derived from observations and experiments pertinent to the matter under study.

Daughter cell: The two new cells formed from a parent cell that has undergone division.

Defaecation: Discharge of faeces from the rectum through the anus.

Deforestation: Removal of trees from a forest in a way that it ever reduces the size of the forest.

Denaturation: Loss of normal shape by an enzyme so that it no longer functional caused by a less than optimal pH and temperature.

Dengue fever: A viral disease transmitted by a mosquito, *Ades aegypti*.

Diffusion: The net movement of molecules from a region where they are in higher concentration to a region where they are in lower concentration, down a concentration gradient.

Digestion: The process whereby large food molecules are broken down into small soluble and diffusible molecules that can be absorbed into the body cells.

Diploid (2n): Number of chromosomes in the body cells, twice the number of chromosomes found in gametes.

Disaccharide: Sugar that contains two units of a monosaccharide e.g., maltose.

Division of labour: Organization of parts for a specific function.

Dorsal: Top side of an organism.

Duodenum: Portion of a small intestine closest to the stomach.

E

Electron transport chain: Chain of electron carriers in the cristae of mitochondria. The electron release energy as they pass down the chain and this is used to produce ATP

Endangered species: A species whose numbers are so severely reduced that it is in imminent danger of extinction throughout all or part of its range.

Endocytosis: The active transport of substances into the cell by the formation of inviginated regions of the plasma membrane that pinch off and become cytoplasmic vesicles.

Endoplasmic reticulum: Interconnected network of internal membranes in eukaryotic cells enclosing a compartment, the ER lumen. Rough ER has ribosomes attached to the cytosolic surface; smooth ER, a site of lipid biosynthesis, lacks

Energy: The capacity to work can be expressed in kilo joules or kilo calories.

Enzymes: Organic catalyst usually a protein that speeds up a reaction in cell due to its particular shape.

Eukaryotic cell: A type of cell more complex than a prokaryote that makes up the bodies of plants, animals, protists and fungi, a plasma membrane encloses that cytoplasm which contains organelles and the nucleus.

Exocytosis: The active transport of materials out of the cell by fusion of cytoplasmic vesicles with the plasma membrane.

Extinction: The elimination of a species occurs when the last individual member of a species dies.

F

Facilitated diffusion: The passive transport of ions or molecules by a specific carrier protein in a membrane. As in simple diffusion, net transport is down a concentration gradient, and no additional energy has to be supplied.

Fertilization: The union of male gamete and a female gamete.

Filtration: The movement of a material through a membrane as a result of hydrostatic pressure.

Flagellum: Long whip like moveable structure extending from the cell and used in locomotion.

Fluid mosaic model: The modern picture of the plasma membrane in which protein molecules float in phospholipids bilayer.

Fungus: A heterotrophic eukaryotes with chitinous cell walls and body usually in the form of a mycelium of branched, thread like hyphae or unicellular. Most fungi are decomposers, some are parasites.

G

Gall bladder: In human beings, a sac attached to the under side of the liver, where excess of bile is stored and concentrated.

Gamete: A sex cell; the female gamete is the egg, the male gamete is the sperm.

Gametogenesis: Formation of gametes.

Gametophyte: The haploid phase of a plant life cycle that alternates with the diploid phase.

Glycolysis: The breakdown of glucose during cellular respiration, which results in the formation of ATP and pyruvate.

Golgi apparatus: The delivery system of eukaryotic cell, it collects modifies, packages and distributes molecules that are made within the cell.

H

Haemoglobin: Iron contains protein in red blood cells that combines with oxygen and transports oxygen.

Haploid: Half the diploid number; the number of chromosomes in the gamete.

Hepatic portal system: The portion of the circulatory system that carries blood from the intestine through the liver.

Homologus chromosomes: Similarly constructed; with chromosomes, the same appearance and containing genes for the same trait.

Humus: Rich layer of soil containing decayed remains of organisms.

Hybrid: The offspring of the cross between two different varieties or species.

Hybridization: Inter-breeding between members of two different parents.

Hydroponics: Growing plant in an aerated solution of dissolved inorganic minerals.

Hypertonic: Containing a higher concentration of solute and lower concentration of water than the cell.

Hypothesis: Statement that is capable of explaining present data and is to be tested by future observations and experimentations.

Hypotonic: Containing a lower concentration of solute and a higher concentration of water than the cell.

I

Ileum: The third and final part of the small intestine following the jejunum.

Ingestion: Process of taking food into the body.

Jejunum: The second portion of the small intestine extending from duodenum to the ileum.

K

Knock knee: A deformity in which the knees are abnormally closed together and the space between the ankles is increased.

Krebs cycle: The series of reactions during which pyruvate the end product of glycolysis enters the cycle to form citric acid and is finally oxidized to carbon dioxide also called citric acid cycle.

L

Lacteal: A lymphatic vessel within a villus in the small intestine that helps pass nutrients into the lymph and blood during absorption.

Liver: A large complex organ lying just under the diaphragm that performs over five hundred function in the body, including aiding in the digestion of lipids.

M

Macromolecules: A large organic molecule having many functional groups.

Meiosis: The two stage process of nuclear division in which the number of chromosomes in cells is halved during gamete formation.

Metabolism: All the chemical reactions that take place within a living organism.

Mitochondrion: An oval, sausage shaped or thread like organelle, bounded by double membrane, breakdown fuel molecules for cell work.

Mitosis: A process of cell division that produces two identical cells from an original parent cell.

Monera: The kingdom that consist of bacteria, cyanobacteria and Archaea.

N

Necrosis: A type of cell death.

Nucleus: The double membrane organelle of a eukaryotic cell that contains the hereditary material.

Nutrients: Raw material of food, the classes of nutrients is, carbohydrates, fats, proteins,

vitamins, minerals, dietary fibres and water, inorganic materials a plant needs to grow such as hydrogen, oxygen and nitrogen.

O

Oesophagus: Tube that transport food from pharynx to the stomach.

Oogenesis: Production of female gametes (eggs, oo) by meiosis.

Osmosis: A special form of diffusion in which water molecules move from an area of higher concentration across a differentially permeable membrane.

Osteomalacia: Softening of bones by absorption of their calcium salts.

Oxidation: The loss of an electron by an atom or a molecule.

Oxidation-reduction: A chemical reaction in which one atom or molecule gains an electron while the other atom or molecule involved in the reaction losses an electron.

Oxidative phosphorylation: Process by which ATP production is tied to an electron transport system that uses oxygen as the final acceptor, occurs in mitochondrion.

P

Pancreas: A long gland that lies beneath the stomach and is surrounded on one side by the curve of the duodenum, it secretes a number of digestive enzymes and the hormones insulin and glucagon.

Peristalsis: The rhythmic wave of contraction by the muscles of the oesophagus that moves food toward the stomach and of the small intestine that moves food being digested along its length to the large intestine.

Phagocytosis: A type of endocytosis in which a cell ingests an organism or some other fragment of organic matter, macrophages and neutrophils are phagocytes.

Phloem: Cells, which transfer food materials synthesized by the leaf to other parts of the plant.

Photolysis: The photochemical splitting of water in the light dependent reactions of photosynthesis.

Pinocytosis: A type of endocytosis in which a cell ingests liquid material containing dissolved molecules.

Plasma membrane: A thin structure that encloses the cell and through which all materials entering or leaving the cell must pass.

Plasmolysis: The shrinkage of cytoplasm and the pulling away of the plasma membrane from the cell wall when a plant cell losses water usually in a hypertonic environment.

Plastids: Membrane bonded organelles occuring in photosynthetic eukaryotic cells, include chloroplast, chromoplast and leukoplast.

Polymer: A molecule built up from repeating sub units of the same general type (monomers) such as protein, nucleic acid or polysaccharides.

Prions: An infectious agent that consists only of protein.

Prokaryotic cell: Cell that lacks a nucleus and other membrane-bonded organelles includes bacteria.

Proteins: A large complex organic compound composed of amino acids.

Pseudopodium: A temporary extension of an amoeboid cell that is used for feeding and locomotion.

Pulse: Alternate expansion and recoil of an artery.

R

Resolving power: The ability of a microscope to show fine detailed, defined as the minimum distance between two points at which they can be seen as separate image or referred to as resolution.

Rh factor: Red blood cells antigens first identified in *Rhesus* monkeys. Person possessing these antigens is Rh positive those lacking them are Rh negative.

Ribosomes: A minute round structure found on endoplasmic reticulum or the places where proteins are manufactured.

Ribulose bisphosphate: A five carbon phosphorylated compound with a high energy potential reacts with carbon dioxide in the initial step of Calvin cycle.

Rubisco: Common name of ribulose bisphosphate, carbooxylase, the enzyme that catalysis the reaction of carbon dioxide with ribulose bisphosphate in the Calvin cycle.

S

Spermatogenesis: The production of sperm by mejosis.

Spongy bones: A type of bone in the human skeleton that is composed of an open latticework of thin plates of bone.

Sporophyte: In the life cycle of a plant, the diploid (spore-plant) generation that alternates with haploid (gamete plant).

Synapsis: The lining of homologous chromosomes during prophase I of meiosis, initiating the process of crossing over.

T

Tissue fluid: Filtrate, containing all the small molecules of blood plasma that baths all the cells of the body.

Translocation: The movement of organic material (dissolved food) in the phloem of a plant.

Transpiration: The process by which water vapours leave a leaf.

V

Vein: A blood vessel that brings blood to the heart.

W

Water potential: Free energy of water, water potential of pure water is zero and that of solutions is a negative value.

X

Xylem: The vascular tissue that conducts water and dissolved minerals in plants.

Z

Zygote: A cell produced by the fusion of the haploid nuclei of a sperm and egg: the fertilized ovum.

About the Content Authors

Prof.Jawaid Mohsin Malik

Prof. Jawaid Mohsin Malick was born on 8th February 1945 in the province of Bihar. Malik is the title given to his ancestor Syed Ibrahim by the King Muhammad Tughlaq. Syed Ibrahim was a saint, the commander in chief of the army and conqueror of Bihar. Syed Ibrahim is the descendent of Hazrat Ghos-e-Azam, Syed Abdul Qadir Jilani (رحمة الله عليه) at the seventh generation. The ancestors of Syed Ibrahim migrated from Iraq to Afghanistan and settled in the village 'But Nagar' near Ghazni. Prof. Jawaid is a former head of the department of Zoology, F.G. Postgraduate College, H-8,Islamabad where he served for more than twenty five years. He is also a former Principal, Federal Government College, H-9 , F-10/4 Islamabad, and Director Colleges and Director Administration, Federal Directorate of Education, Islamabad. He did his post-graduation in Zoology with specialization in Entomology form Dhaka University, East Pakistan (former). He taught various classes for more than fortyfive years in various capacities. He has also worked as Education Officer, in Nigeria for four years. He has successfully completed the 61st advance course in administration and development held in 1996 at National Institute of Public administration (NIPA), Karachi. In 1995, he was awarded a shield by the honourable Mr. Rafiq Tarrar, the then President of Pakistan, for his services to humanity. He published four research papers in Science Journals of Pakistan on Butterflies of Pakistan. He has contributed articles on science and sports in Urdu and English dailies of Islamabad. He is co-author and managing author of more than forty five textbooks on General Science and Biology as well as Biology Practical Notebooks. He has travelled to Singapore, Thailand, Indonesia, India, Bangladesh, UAE, Saudi Arabia, Egypt, Italy, Holland, UK, Qatar, USA and Nigeria. He has also served as a National Consultant, Science Education, JICA sponsored project for the promotion of Student Centred and Inquiry Based (SCIB) learning, National Institute of Science and Technical Education, Ministry of Education, Islamabad.

Ms. Ruqayya Shaikh

Ruqayya Shaikh did her M.Sc and M.Phil in Animal Sciences from Quaid-i-Azam University, Islamabad. She started her professional career as a Zoology lecturer at Islamabad College for girls, F-6/2, Islamabad. At present she is working as associate professor in the same institute. She has been teaching General Science to secondary school classes, Biology to SSC and HSSC classes for the last two decades. Recently she certified in instructional leadership, College of Education, University of Massachusetts, USA.

She was the part of the General science Curriculum development team, Grade 4-8, under National Curriculum council. She worked as text book reviewer for General science Grade 4, General Science Grade 5, Biology HSSC I and Biology HSSC II. She served as FBISE Biology course committee member. The author conducted a number of teacher training programs. She is the author of General Science 6 & 7. Her video lectures of General Science and Biology are available on youtube channel Ruqayya Shaikh ICG.

Dr. Sarwat Jawaid

Dr. (Mrs.) Sarwat Jawaid is the daughter of Prof. J. M. Malik. She has served as Medical Officer (Burn Centre) in Pakistan Institute of Medical Sciences, Islamabad. She did her graduation in Medicine from Isra University Hyderabad (2005) and Master in Public Health from Sarhad University, Peshawar (2009). She is a co-author of Biology textbooks of grade 9, 10, 11 and 12 as well as practical notebooks. She has also written a thesis on "Effect of health awareness programme in the reduction of burn injuries incidence among the community of Islamabad territory".

Ms. Neelofar Shaheen

Ms. Neelofar Shaheen is a retired senior science teacher from Islamabad Model College for Girls, Islamabad. She did her M.Sc. in Chemistry from Karachi University, B.Ed. from Punjab University and M.Ed. Allama Iqbal Open University, Islamabad. She is a co-author in biology textbooks of grade 9 and 10 published by NBF and co-author of biology 11 published Balochistan Textbook Board. She has served as head examiner in Federal Board of Intermediate and Secondary Education, Islambad for a few years. She has travelled to India, Dubai, Saudi Arabia, Italy, London, Qatar, Nigeria, Irland and USA.

Sajid Ali Shah

Sajid Ali Shah is serving as Associate Professor of Biology in Islamabad College for Boys G-6/3, Islamabad. he started his teaching career as lecturer from IMCB G-10/4, Islamabad. He also served as lecturer in FG degree college for Men H-9, Islamabad. he has honour to successfully complete FPSC competitive examination four times. Conducted for recruitment of college faculty. He is author of 2nd year biology textbook of Khyber Pakhtunkhwa Textbook Board, and reviewed many books of science & biology. He is M.Phil from Quaid-i-Azam University, Islamabad.

Mrs Nasreen Fatima

Mrs Nasreen Fatima is Head of Biology Department in Fazaia inter college, Nur Khan. She has teaching experience of more than 25 years with excellent results in Federal Board Examination. She served as Biology course Committee member of FBISE and review committee member for various books at NBF. She was selected as mentor among Fazaia teachers according to Mentoring series 2020.

Approved by Government of Pakistan
Ministry of Education, Curriculum Wing
vide letter No. F.3-1/2007-Bio, Dated: January 19, 2011

قومی ترانہ

پاک سَر زمین شاد باد! کشورِ حسین شاد باد!
تو نِشانِ عزمِ عالی شان ارضِ پاکستان
مرکزِ یقین شاد باد!

پاک سر زمین کا نِظام قُوّتِ اُخوّتِ عوام
قوم ، مُلک ، سلطنت پائندہ تابندہ باد!
شاد باد منزلِ مُراد!

پرچَمِ سِتارہ و ہِلال رہبرِ ترقی و کمال
ترجُمانِ ماضی، شَانِ حال جانِ اِستقبال
سایۂ خُدائے ذُوالجلال!

National Book Foundation
as
Federal Textbook Board
Islamabad