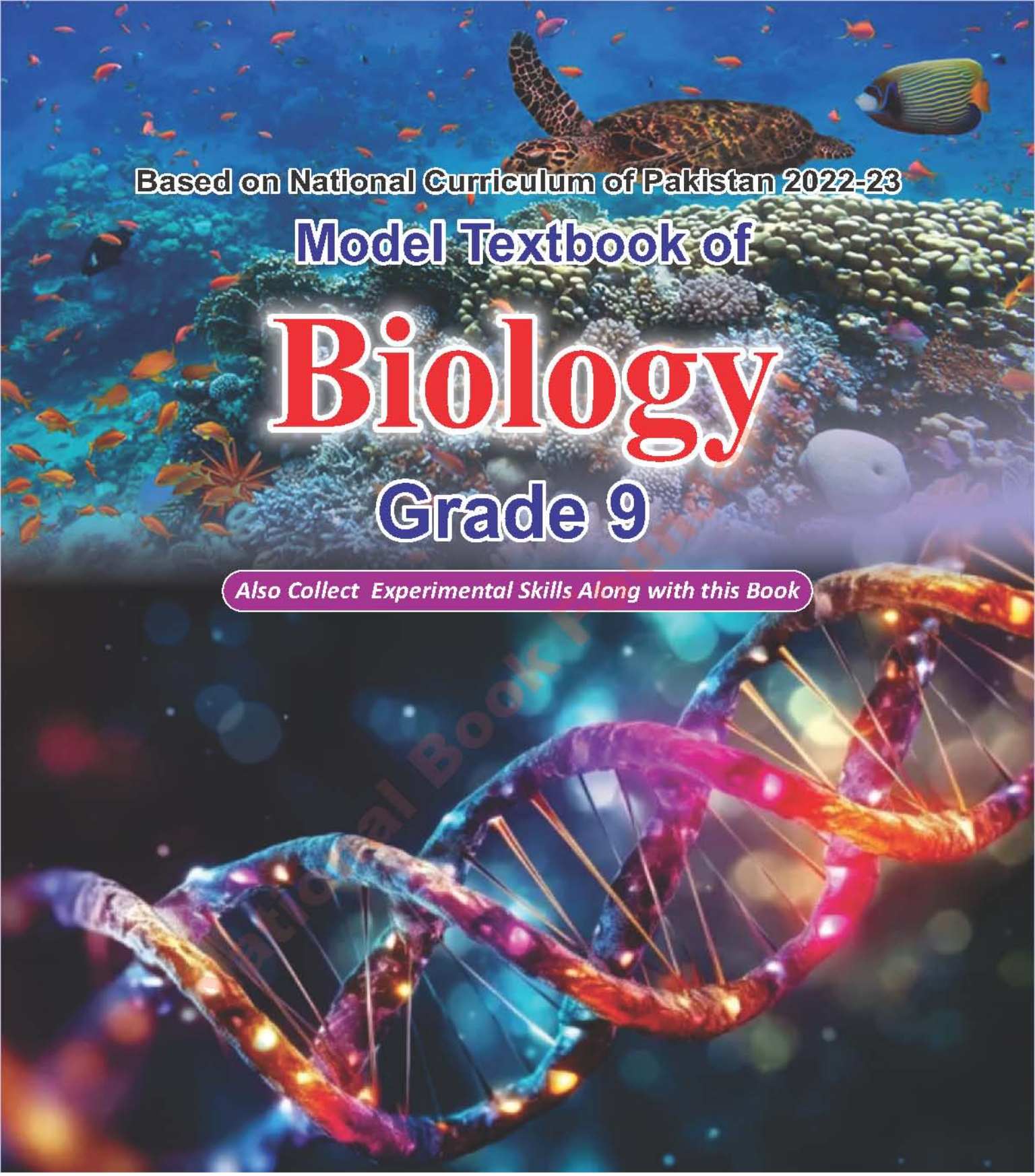

Based on National Curriculum of Pakistan 2022-23

Model Textbook of

Biology

Grade 9

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Model Textbook of **Biology**
for Grade 9

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Preface

This Model Textbook for Biology Grade 9 has been developed by NBF according to the National Curriculum of Pakistan 2022-2023. The aim of this textbook is to enhance learning abilities through inculcation of logical thinking in learners, and to develop higher order thinking processes by systematically building the foundation of learning from the previous grades. A key emphasis of the present textbook is creating real life linkage of the concepts and methods introduced. This approach was devised with the intent of enabling students to solve daily life problems as they grow up in the learning curve and also to fully grasp the conceptual basis that will be built in subsequent grades.

After amalgamation of the efforts of experts and experienced authors, this book was reviewed and finalized after extensive reviews by professional educationists. Efforts were made to make the contents student friendly and to develop the concepts in interesting ways.

The National Book Foundation is always striving for improvement in the quality of its textbooks. The present textbook features an improved design, better illustration and interesting activities relating to real life to make it attractive for young learners. However, there is always room for improvement, the suggestions and feedback of students, teachers and the community are most welcome for further enriching the subsequent editions of this textbook.

May Allah guide and help 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

Chapter 1

THE SCIENCE OF BIOLOGY

SLOs: After completing this lesson, the student will be able to:

1. Define biology
2. State Quran instructs to reveal the study of life.
3. Define major fields of biology as Botany, Zoology and Microbiology
4. Define with examples that biology has many sub-fields: Morphology, Anatomy, Physiology, Histology, Cytology, Genetics, Molecular biology, Embryology, Paleontology, Taxonomy, Ecology, Marine biology, Pathology, Immunology, Pharmacology.
5. Relate that biology connects with other natural sciences. Students should be able to distinguish in terms of the broad subject matter of the given fields: Biophysics, Biochemistry, Computational biology, Biogeography, Biostatistics, Biotechnology, Bio-economics.
6. Identify the careers in biology and explain with examples how biology is a subset of the natural sciences.
7. Justify with examples that science is a collaborative field that requires interdisciplinary researchers working together to share knowledge and critique ideas.
8. Describe the steps of the scientific method: Recognition, Observation, Hypothesis, Deduction, Experiments, and Results.
9. Evaluate the terms 'hypothesis', 'theory' and 'law' in the context of research in natural sciences.

Among all the living organisms human beings are the most intelligent ones. By using their intelligence human beings started learning and this learning lead to development of science.

1.1 INTRODUCTION TO BIOLOGY

What is science? When you look at the plants you observe leaves and flowers. You wonder 'why are the leaves green? Why are the flowers of various colours? Asking this type of question is the first step in doing science. Science is a process of collecting information about the world around us. Much of the time, the first step in collecting information is asking a question. Why do I feel pain when I touch a hot object? Making observations, asking questions and trying to find the answers is what science all about. The study of science helps us to answer the how, what, where and why of our surroundings.

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 Quranic Instructions to Reveal the Study of Life

What science is discovering 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. Some are quoted here;

1. Origin of Life in Water

وَجَعَلْنَا مِنَ الْمَآءِ كُلَّ شَيْءٍ حَيٍّ ۖ

"We made every living thing from water"

(Sura Ambia 21, Ayat-30)

As we know that living things consists of 60 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 الْإِنسَانَ مِن 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. Development

ثُمَّ خَلَقْنَا النُّطْفَةَ عَلَقَةً فَخَلَقْنَا الْعَلَقَةَ مُضْغَةً فَخَلَقْنَا الْمُضْغَةَ عِظٰمًا فَكَسَوْنَا الْعِظٰمَ لَحْمًا

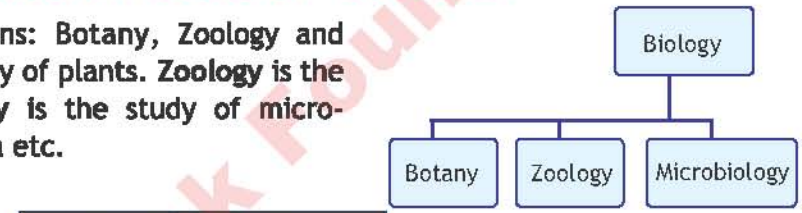
"Then fashioned we the drop a clot, then fashioned we the clot a little lump, then fashioned we the little lump bones, then clotted the bones with flesh,"
(Sura Al-mominoon, Ayat 14)

The sequence of developmental stages is described in Quran many times.

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

1.2 MAJOR FIELDS OF BIOLOGY

Biology has three main divisions: Botany, Zoology and Microbiology. **Botany** is the study of plants. **Zoology** is the study of animals. **Microbiology** is the study of micro-organisms e.g., viruses, bacteria etc.



Sub-fields of Biology

Morphology	Anatomy	Physiology	Histology	Cytology
Genetics	Molecular biology	Embryology	Paleontology	Taxonomy
Ecology	Marine biology	Pathology	Immunology	Pharmacology

By dividing biology into a number of sub-fields its study becomes convenient. Some of the sub-fields of biology are:

1. **Morphology:** The study of the size, shape, and structure of animals, plants, and microorganisms is called morphology. For example, the morphology of a flowering plant includes the roots, stem, leaves, flowers, and fruits. Dental structure in humans is an example of human morphology.
2. **Anatomy:** The study of the internal structure of the organisms is called anatomy. Anatomy is also called internal morphology. The examples of anatomy include human body parts such as muscles, heart, brain, and kidneys etc.
3. **Physiology:** The study of the functions of various organs of the organisms is called physiology. The examples of physiology are digestion, respiration, excretion, photosynthesis etc.

4. **Histology:** The microscopic study of tissues of organisms is called histology. The example is epithelial tissue that form a continuous layer covering the entire body surface.

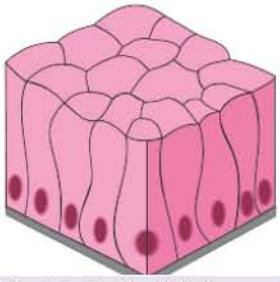


Fig 1.1. Epithelial tissue

5. **Cytology:** The study of the structure and functions of the cell is called cytology. It is also called cell biology. For example, the study of plant and animal cells.
6. **Genetics:** The study of genes, and heredity in organisms is called genetics. For example the plants having red flowers produce red flowerers. The white cats produce white kittens.

Fossils are remains of the living things preserved by natural process. Study of fossils help us to understand the life of past and process of evolution.

7. **Molecular biology:** Molecular biology is the study of biology at molecular level.
8. **Embryology:** Embryology is the study of the development of an organism from a fertilized egg.
9. **Paleontology:** It is the study of the history of life on Earth as based on fossils.

Fig 1.2: Fossils

10. **Taxonomy:** The classification and naming of organism is called taxonomy. For example humans are mammals. Its scientific name is *Homo sapiens*.
11. **Ecology:** The study of the interrelationship of organisms and their environment is called ecology. It is also known as environmental biology. For example the study of ecology of pond, lake, forest, desert etc.
12. **Marine biology:** The study of organisms that live in sea is called marine biology. For example the study of fish, whales, dolphins, and porpoises, sponges, crustaceans, and molluscs etc.
13. **Pathology:** Pathology: Pathology is a branch of science which deals with the study and diagnosis of diseases.
14. **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. For example, immunization is a process by which a person becomes protected against a disease through vaccination. The example of vaccine for diseases are polio, corona, dengue etc.
15. **Pharmacology:** The science that deals with the study of drugs is called pharmacology. In pharmacology, a drug is a chemical substance. For example, Aspirin is a pharm of drug often used to treat pain, fever, and inflammation. The other example of drugs is morphine, insulin, penicillin etc.

Computational biology has helped to sequence the human genome, created accurate models of the human brain, map the 3D structure of genomes and model of biological system.

The word pharmacology is derived from Greek word, pharmakon, meaning "drug" or "poison", together with other Greek word logia with the meaning of "study of" or "knowledge of"

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. So, biology is not an isolated science and is associated with other branches of science.

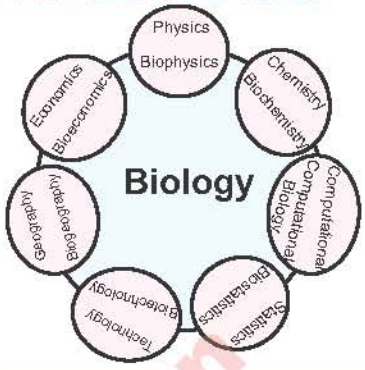


Fig. 1.3: Relationship of biology with other sciences

Table 1.1 RELATIONSHIP OF BIOLOGY WITH OTHER SCIENCES	
Biophysics	Biological organisms work on the principles of physics e.g., movement of muscles and bones. The study of biological phenomena according to the principles and laws of physics is called biophysics.
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 of carbon, hydrogen, oxygen, nitrogen, etc., and chemical reactions such as digestion of food, respiration, and photosynthesis takes place in the organism.
Biostatistics	Statistics is related to collecting and analysing various data or facts. The collection of biological data or facts through observations, experiments and analysing them according to statistical rules for biological study. It is also is called biometry.
Computational biology	The study of the use of data analysis, mathematical modeling, and computational simulations to understand biological system is called computational biology. The example of computational biology includes the process of locating fragments of DNA on chromosomes.
Biogeography	The study of distribution of plants and animals in different geographical regions of the world is called biogeography.
Biotechnology	The study of use of different techniques to manipulate the living organisms for the benefit of mankind is called biotechnology.
Bio-economics	The study of biology from economic point of view is called bio-economics. Production of wheat, fish, rice and studying their export value etc., are the examples of bio-economics.

1.4. CAREERS THAT REQUIRE A BACKGROUND IN BIOLOGY

After studying the basic courses in biology at secondary and higher secondary level a person has to select a career or profession. Pursuing a career in biology can be immensely rewarding and exciting. There are several applied fields in biology that you can select as a career e.g., medicine, surgery, fisheries, agriculture, animal husbandry, biotechnology, horticulture, farming and forestry etc.

Table 1.2 CAREERS THAT REQUIRE A BACKGROUND IN BIOLOGY	
Medicine and surgery	MBBS stand for bachelor of medicine and bachelor of surgery. Medicine is the diagnosis and treatment of different diseases. Surgery is the branch which treats diseases by removal, or replacement of the defective parts or organs. After MBBS a student can specialize in various fields of medicine and surgery.
Fisheries	The fisheries sector makes a significant contribution to the economy of Pakistan. Careers associated with it are fish farming, fishery management and related research.
Farming and Agriculture	Farming is the growth of crops and animals to provide food, wool and other products. The practice of agriculture is farming while agriculture is the science of improving farming methods. Careers associated with agriculture are food science, agricultural engineering, agricultural entomology (a person who studies insects) etc.
Animal Husbandry	Animal husbandry is the care and breeding of domestic animals. The careers associated with animal husbandry are veterinary science, animal breeding, animal training etc.
Biotechnology	Biotechnology is the use of living organisms or their components to make useful products. The careers associated with biotechnology are bacteriology, virology, molecular genetics etc.
Horticulture	Horticulture means the art of gardening. The careers involved are plant breeding, horticulture etc.
Forestry	It is the science of planting, managing and caring for forests. The careers related to forestry are forest ecology, environmental engineering etc.

1.5 SCIENCE IS A COLLABORATIVE FIELD

Scientists from all around the world team up to share ideas and make progress in their research. Some are studying similar things, while others have different knowledge that can help.

When researchers from different fields work together to create new scientific knowledge, it's called interdisciplinary research collaboration. This is important because they can work on research, find solutions, and use what they learn to solve problems and discover new things.

For example, Cognitive Science combines knowledge from neurology, psychology, anthropology, linguistics, environmental, engineering, pharmacology and statistics. Women's Studies combines what we know about gender, history, literature, and biology. Public health combines information from medicine, sociology, and psychology.

Bioinformatics is a combination of biology and information technology. It helps to understand complex biological data. The new emerging careers of biology are bioinformaticians (apply their computer skills in solving problems in life science), biomedical engineers (develop new devices and equipment for improving human health), Astrobiologists (study effects of outer spaces on living organisms), Cryobiologists (study of effects of low temperature on living organisms) etc.

There was a special issue about research collaboration during the COVID era, showing how it was good for both science and society, when we work together across borders, cultures, and different fields of study.

One famous example of scientists working together is the International Space Station, where space agencies from Europe, the USA, Russia, and Japan all team up.

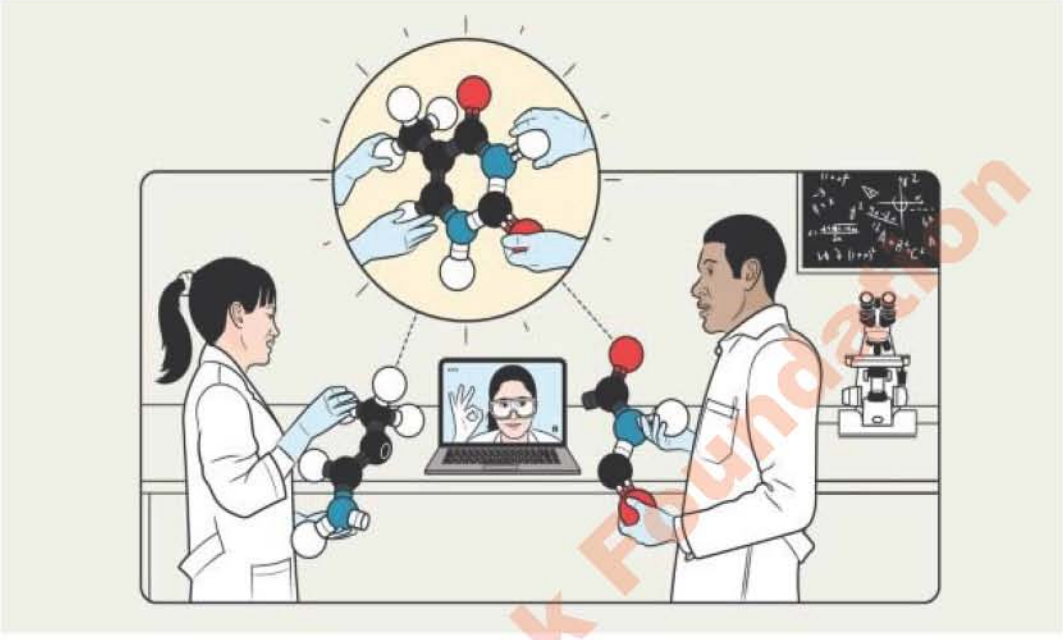


Fig.1.4. Collaboration in science

STEAM ACTIVITY 1.1

Topic: CLIMATE CHANGE

The teacher will divide the students into three groups. Each group may comprise of 3-5 students. And give each group different subtopics related to climate change. The students will investigate or research on the topics given.

Group 1: Causes of climate change.

Group 2. Effects of climate change.

Group 3. To overcome the problem of climate change.

The students will be given five days to prepare their research work.

Each group will read their research paper in the classroom before the students.

Then the teacher will ask each group to work together and prepare a joint research paper on 'Climate change' and submit.

1.6 BIOLOGICAL METHOD

There is nothing magical about science. You already have some of the qualities of a scientist e.g., 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 which he may use to solve different scientific problems.

Scientists, including biologists, employ an approach for solving scientific problem that is known as the **scientific method**. Biological problems are solved by a series of steps of biological 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

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 a 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.

1.7 HYPOTHESIS, THEORY AND LAW

A hypothesis is a tentative answer to a question. It is based on past experience and the available data. A scientific hypothesis makes prediction that can be tested by recording additional observations. In deduction-based science, deduction usually takes the form of predictions about what outcomes of experiments or observations. We should expect if a particular hypothesis is correct. We then test the hypothesis by performing the experiment to see whether or not the results are predicted. This deduction reasoning takes the form of 'if...then' logic.

Theory

What is a scientific theory and how it is different from a hypothesis? A scientific theory is much broader in scope than a hypothesis. Compared to any one hypothesis, a theory is generally supported by more evidence.

In spite of the body of evidence supporting a widely accepted theory, scientists must sometimes modify or even reject theories when a new research method produce results that do not fit.

A theory that has been verified and appears to have wide application may become biological law for example, Mendel's law of inheritance.

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.

1.8 MALARIA AN EXAMPLE OF BIOLOGICAL METHOD OF STUDY

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.

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*.

1. 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, but its cause was not known.

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 a malarial patient.

Hypothesis: Based on these observations and other information, following hypothesis was formulated by a French physician Laveran in 1882.

"*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 out 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. After few days those 07 healthy persons became ill with malaria.

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.

2. 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 important 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 marshy water. Problem in this study was to find that agent.

Observations: An American scientist A. F. A. King listed 20 observations in 1883 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. People 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 in 1897.

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 the sparrows suffering from malaria. He then allowed these mosquitoes to bite healthy sparrows. After few days these sparrows became ill with malaria.

In the end, the hypothesis was tested by direct experimentation on human beings. 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.

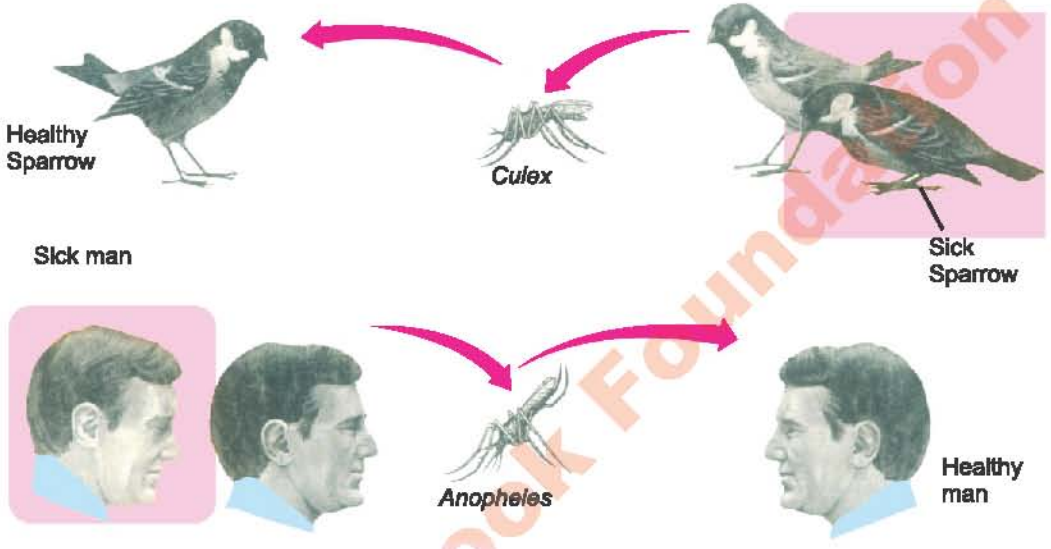


Fig. 1.5: Malaria in man is transmitted by *Anopheles* and in birds by *Culex*

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.

Dengue Fever

It is caused by a Dengue virus and is transmitted by mosquito *Aedes aegypti*, which has zebra like white and black stripes on its body. Typical case of Dengue haemorrhage fever is characterized by high grade 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.

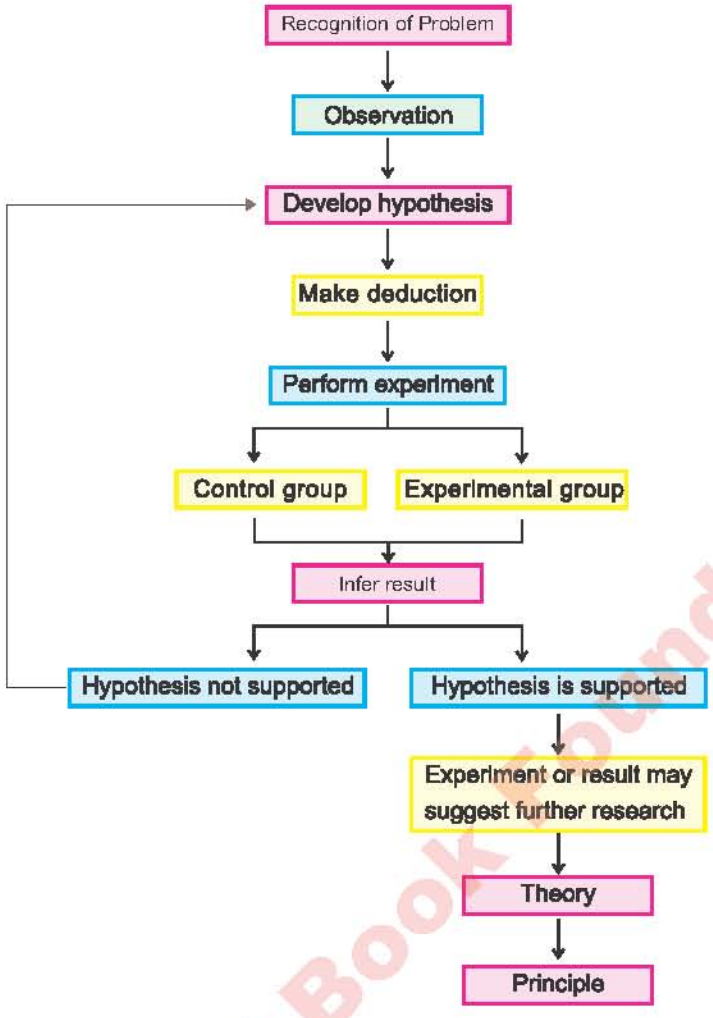


Fig 1.6: Scientific method of study

SUMMARY

1. Science is the study of world around us.
2. Biology is the study of living organisms.
3. The Holy Quran instructs us to study life.
4. Biology has many divisions and subfields. Biology is related to physics, chemistry, statistics, geography, technology and economics.
5. Medicine, surgery, fisheries, agriculture, animal husbandry, biotechnology, horticulture and forestry are dependent directly or indirectly on the study of biology.
6. Science is a collaborative field.
7. 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.

8. Data is the collection of facts.
9. A hypothesis is a possible explanation for a group of related observations.
10. Deduction is the logical explanation of hypothesis.
11. A scientific hypothesis is a tentative, testable explanation for a phenomenon in the natural world.
12. A scientific theory is an explanation of some aspect of the natural world. It is based on the facts that have been repeatedly confirmed through observation and experiments.
13. A scientific law is a statement that describes an observable occurrence in nature that appears to always be true.

EXERCISE

Section I: Multiple Choice Questions

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. Paleontology 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. 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
7. The starting point of scientific investigation is:
   A) hypothesis B) theory C) observation D) data
8. Information that is gathered as a result of an experiment is called:
   A) hypothesis B) data C) theory D) Observation
9. 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

10. 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
11. Malaria is caused by:
    A) mosquito B) stagnant water C) swamp D) *Plasmodium*
12. Malarial patient has *plasmodium* in his blood. What would be the possible explanation if a healthy person who is not having any malarial symptoms shows plasmodium in his blood?
    A) *Plasmodium* are dead B) *Plasmodium* are in incubation period
    C) *Plasmodium* are not mature D) *Plasmodium* are inactive
13. 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
14. Which option has correctly matched disease and vector mosquito?

	Malaria in humans	Malaria in birds	Dengue fever
A	*Anopheles*	*Aedes*	*Culex*
B	*Aedes*	*Culex*	*Anopheles*
C	*Anopheles*	*Culex*	*Aedes*
D	*Culex*	*Anopheles*	*Aedes*

Section II: Short Answer Questions

1. Define the following branches of biology and give at least one significance of studying these branches
    a) Molecular biology b) Physiology
    c) Palaeontology d) Pharmacology
2. Can you distinguish between?
    a) Anatomy and Morphology b) Cytology and Genetics
    c) Biotechnology and Immunology d) Marine Biology and Ecology
3. Healthy life of a person depends on healthy life choices. How study of biology is going to help you to live a healthy life.
4. What is the contribution of the following scientists?
    a) A.F.A King b) Ronald Ross c) Laveran
5. Observations are mainly of two types i.e., qualitative and quantitative. Sort the following observation according to these two types. Colour of cat, Height of giraffe, Weight of mango fruits, Body temperature of birds, Volume of blood in humans, Shape of leaves, Climate of desert, Speed of tiger, Song of a bird.

6. A Noble prize winner gave a hypothesis about effects of COVID-19 vaccine. Can it be wrong? Why? Develop deduction from this hypothesis, "Vaccination of COVID-19 can reduce the severity of complications in case of infection."
7. Why it is impossible to eradicate malaria?
8. The diagram shows one insect. Answer the following questions related to it.

i. Why do we use word vector for mosquito?

ii. What is name of organism which transmit malaria disease in man and birds?

iii.. What was the main purpose of experiment by Ronald Ross?

9. Why Ross did not allow the infected mosquitoes to bite a healthy person?
10. A student wants to investigate the effect of different factors on the activity of salivary amylase. He will design an experiment in order to reach conclusion. What would be the most appropriate first step to initiate?
11. Hepatitis B virus was found in blood of 10 persons. Only 6 of them were suffering from Hepatitis B disease. Why?

Section III: Extensive Answer 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. Explain that science is a collaborative field.
4. Why is biology important for the welfare of human beings? Give reasons.
5. Give at least ten examples of farming of animals which can improve economy of Pakistan. Describe the products and benefits of each example as well.
6. Discuss biological method of study and its application.
7. How biological method is applied to find the cause of malaria?
8. Explain use of biological method to understand the spread of malaria.

BIODIVERSITY

SLOs: After completing this lesson, the student will be able to:

1. Define biodiversity and classification.
2. Describe advantages of classification.
3. Discuss the history of classification schemes.
4. List the three distinct domains into which living organisms are broadly classified into.
5. List the taxonomic ranks of classification.
6. Define species
7. Outline the binomial nomenclature system.
8. Describe the complications of classifying viruses.

In the previous chapter we have learned that biology is the study of living organisms. The living organisms have been divided into major groups so that they can be studied easily.

2.1 DEFINITION AND INTRODUCTION TO BIODIVERSITY

The similarity among living organisms 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 is enormous.

2.1.1 Biodiversity

If you look around you will find variety of various kinds of organisms. The term biodiversity comes from 'biological diversity'. Biodiversity has ecological and economic importance. It provides us with nourishment, housing, fuel, clothing etc. Biodiversity is defined as "the variety of living organism on earth".

2.1 Biodiversity

STEAM ACTIVITY 2.1

Take a chart paper. Cut pictures of various plants and animals from old newspapers or magazines and paste on the chart paper. You have placed all the organisms together at one place. What is it? This is biodiversity.

The natural biodiversity provides us oxygen, clean water and air. They help carbon cycle and fix nutrients. They enable the plants to grow. Pests are controlled by organisms such as by insects, birds and fungi. They help protect against flooding and regulate climate. They help in pollination and crop production. Biodiversity provides our food stuff and medicines derived mainly from plants. The industrial materials such as building materials, fibres, dyes, resins, gums, adhesives, rubber and oil etc., are derived directly from plants.

2.2 CLASSIFICATION

Classification is the grouping of related facts into classes. It is a process which brings together like things and separates unlike things.

STEAM ACTIVITY 2.2

Write the names of the organisms in their respective groups on the basis of having similar characteristics.

Rose, guava, fowl, pigeon, mango, sparrow, snake, crocodile, sunflower, lizard, cat, tiger, cow, tortoise, goat, dove. For example, rose, fowl, snake and goat have been placed in separate groups.

Group 1	Groups 2	Group 3	Group 4
Rose, ...	Fowl, ...	Snake, ...	Goat, ...

Why did you put rose and mango in one group whereas, fowl and pigeon in another group?

You placed the organisms of similar characteristics in groups. For example, you made a group of flowering plants with Rose, mango, guava and sunflower. You made another group of fowl, pigeon, dove, and sparrow. All of them have the similar characteristics in each group.

You have separated the organisms into groups on the basis of similarities and differences. Thus, you have classified the organisms.

To put organisms into separate groups on the basis of similarities and differences is called classification.

2.2.1 Advantages of Classification

Biologists have devised ways of grouping organisms. The grouping of organisms is called **classification. Taxonomy** is the branch of biology concerned with identification, naming and classification 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 **systematics.**

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.

2.3 HISTORY OF CLASSIFICATION

The Greek philosopher Aristotle was the first person who classified the living organisms. In 700s, Abu Usama Aljahiz described 350 species of animals. In the end of 15th century many biologists have worked on classification method.

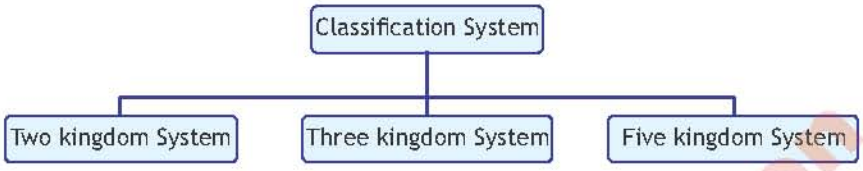
Andrea Caesalpino (1519-1603): He divided plants into fifteen groups and called them genera.

John Ray (1627-1705): He published important works on the classification of plants.

Tournefort (1656-1708): He introduced the taxa of class and species

Carolus Linnaeus (1707-1778): He grouped species according to similar physical characteristics.

According to earlier classification system, organisms were classified into two kingdoms, then three-kingdom and then five-kingdom system.



1. Two-kingdom classification system: It is the oldest system and classifies organisms into two kingdoms, the Plantae and Animalia. The kingdom Plantae includes the autotrophs. Bacteria, fungi and algae were also included in the kingdom. The organisms which depend on autotrophs or other heterotrophs are included in the kingdom Animalia.

Many unicellular organisms like *Euglena* have both plant like (presence of chlorophyll) and animal like (heterotrophic mode of nutrition in darkness and lack of cell wall) characteristics. So separate kingdom was introduced for such organisms.

2.Three-kingdom classification system: The German Scientist Ernst Haeckel proposed a third kingdom, Protista to accommodate *Euglena* like organisms and to separate unicellular microscopic organisms from multicellular ones.

3.Five-kingdom classification system: In 1937 E-Chatton suggested the terms 'Procariotique' to describe bacteria 'Eucariotique' to describe plant and animal cells. In 1967 Robert Whittekar introduced five-kingdom classification system. The five kingdoms are: Monera, Protista, Fungi, Plantae and Animalia. In the five kingdom system bacteria and archaea were combined in a single kingdom Monera, because they shared the prokaryotic form of cell structure.

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

2.4 CLASSIFICATION- THE THREE DOMAINS SYSTEM

In biology, a domain means the largest of all groups in the classification of life. **Domain** is group of kingdoms or taxonomic category above the kingdom.in 1990 Carl Woese introduced a three domains system of classification. The three domains of life are Archaea, Bacteria and Eukarya.

Classification into three domains is based on difference in the sequence of nucleotides in the rRNA (ribosomal Ribonucleic acid) of the cell, the cell's membrane lipid structure and its sensitivity to antibiotics.

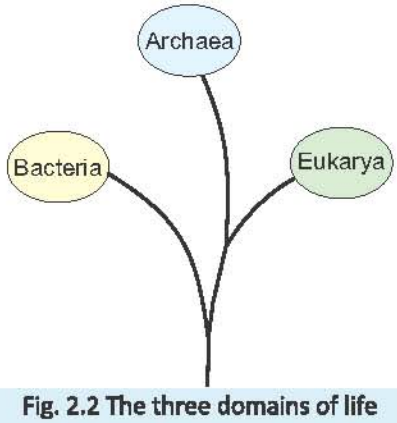


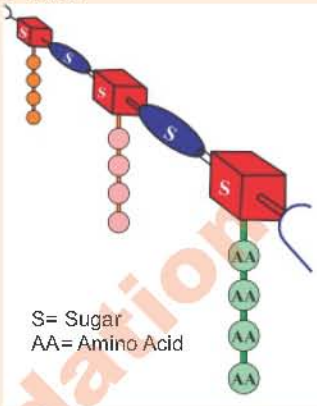
Fig. 2.2 The three domains of life

1. The Domain Archaea

The domain Archaea have the following characteristics:

a. Archaea are prokaryotic cells.
b. The cell walls of Archaea contain no peptidoglycan.
c. The rRNA (ribosomal RNA) are not found in Bacteria and Eukarya.
d. Archaea are not sensitive to some antibiotics that affect bacteria. They are sensitive to some antibiotics that affect the Eukarya.
e. Archaea often live in extreme environmnet.
f. Archae membrane can withstand higher temperature and stronger acid concentration.
g. Archaeal creatures include : Methanogens, Halophiles, Thermoacidophiles.

Peptidoglycan or murein is a polysaccharide, consisting of sugar and amino acids that form a layer outside the rig Animalia id cell wall.



2. The Domain Bacteria

The domain bacteria have the following characteristics:

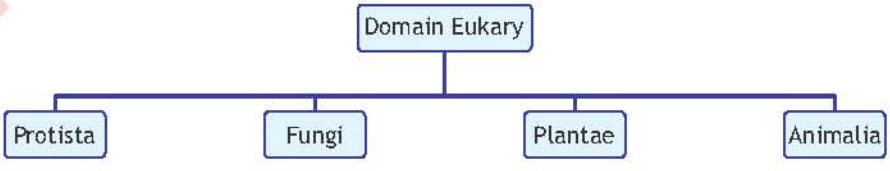
a. Bacteria are prokaryotic cells.
b. The cell walls of bacteria contain peptidoglycan.
c. They contain rRNA that is unique to bacteria.
d. Bacteria are sensitive to traditional antibacterial antibiotics but are resistant to most antibiotics that affect eukarya.

1. Microorganisms that produce methane as a metabolic byproduct is called methanogens.
2. Microorganisms that live in high salt concentration are called halophiles.
3. The microorganisms that can live in high temperature and high acidity are called thermoacidophiles.

3. The Domain Eukarya

The domain Eukarya (also spelled Eucarya) have the following characteristics:

a. Eukarya have eukaryotic cells.
b. Not all Eukarya have cells with a cell wall. Their cell wall contains no peptidoglycan.
c. Eukarya contains rRNA that is unique to Eukarya.
d. Eukarya are resistant to traditional antibacterial antibiotics but are sensitive to most antibiotics that affect eukaryotic cells.



The domain Eukarya are divided into four kingdoms: Protista, Fungi, Plantae and Animalia.

1. **Protista:** Protists include eukaryotic organisms with unicellular or colonial organization. These are mostly aquatic. It is a diverse group of organisms. It includes: Animal like protists called protozoa e.g., *Amoeba*. Plant like protists called algae e.g., *Euglena*. Fungi like protists e.g., slime molds.

2. **Fungi:** Fungi are eukaryotic organisms which have chitin in their cell wall. Fungi are saprotrophic decomposers. Mostly fungi are multicellular. Some fungi are unicellular. The examples of fungi are black bread mold, yeast, mushroom, etc.
3. **Plantae:** The members of kingdom plantae are eukaryotic multicellular and autotrophic with chloroplasts containing chlorophyll. Their cell wall is made up of cellulose e.g., moss, mustard.
4. **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, starfish and vertebrates e.g., fish, frogs and man.

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. These are producers.

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

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

2.5 TAXONOMIC RANKS OF CLASSIFICATION

The group into which organisms are classified are known as taxonomic categories or taxa (singular 'taxon'). The taxa form a ladder, called **taxonomic hierarchy**. There are eight main taxonomic ranks: kingdom, phylum or division, class, order, family, genus and species. In addition **domain** is now usually used as a fundamental rank.

The kingdom is the largest taxon or rank. Each kingdom is further divided into smaller taxa in the following way:

Phylum (Division: for plants and fungi): A phylum is a group of related classes.

Class: A class is a group of related orders.

Order: An order is group of related families.

Family: A family is a group of related genera.

Genus: A genus is a group of related species.

Species: A species is a group of similar organisms.

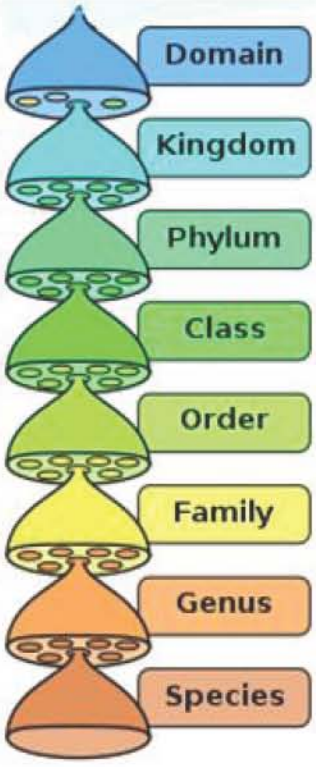


Fig2.3: Taxonomic ranks of classification

Table 2.1: Simple classification of human and pea			
Taxa	**Human**	**Taxa**	**Pea**
Kingdom	Animalia	Kingdom	Plantae
Phylum	Chordata	Division	Magnoliophyta
Class	Mammalia	Class	Magniopsida
Order	Primate	Order	Fabales
Family	Homonidae	Family	Fabaceae
Genus	*Homo*	Genus	*Pisum*
Species	*Homo sapiens*	Species	*Pisum sativum*

2.6 SPECIES

Species is a group of similar organisms individuals capable of interbreeding or exchanging genes among themselves and producing fertile offspring.

Cross between a male donkey and a female horse produces mule. It is infertile, because of the odd number of chromosomes, they can't reproduce. So, it is not a species. Species is the most basic unit of classification, as well as a taxonomic rank.

Fig 2.4: Infertile mule

2.7 BINOMIAL NOMENCLATURE

Carolus Linnaeus introduced a naming system to give each organism a name consisting of two Latin names. The first name is genus name and the second name represents the particular species. The genus name begins with a capital letter but 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 names 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 organisms 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.

2.8 COMPLICATIONS OF CLASSIFYING VIRUSES

Viruses show characteristics of both living and nonliving things. The living characteristics of viruses are:

1. They occur in different varieties.
2. They have their own genetic material in the form of either RNA or DNA.
3. They reproduce using the material of the host cell they infect.
4. They enter the cells of living organisms and cause diseases.

Prions are composed of proteins only. Viroids are composed of circular RNA only. Both causes infectious diseases in certain plants. Both are acellular particles. They are not included in any kingdom of classification system.

The non-living characteristics of viruses are:

1. They lack cellular structure and enzyme system.
2. They can be crystallized and store in bottle.
3. They do not respire.
4. Viruses behave as non-living, inert infectious particles outside the host.

Viruses are at the borderline of living and non-living. So, they are not included in any domain and kingdom under modern classification.

SUMMARY

1. Biodiversity is the variety of organisms on Earth.
2. The grouping of organisms is called classification.
3. Taxonomy is concerned with identification, naming and classification of organisms.
4. The scientific study of diversity of organisms and their evolutionary relationship is called systematics.
5. Aristotle was the first person who classified the living organisms.
6. According to earlier classification systems organisms were classified into two kingdoms, three kingdoms and then five kingdom system.
7. Two-kingdom classification system classifies organisms into two kingdoms the Plantae and Animalia.
8. Three system classification system introduced the third kingdom Protista to separate unicellular microorganisms from multicellular ones.
9. Five-kingdom classification system includes the kingdoms Monera, Protista, Fungi, Plantae and Animalia.
10. Domain is a group of kingdoms or taxonomic category above the kingdom.
11. The three domains of life are domain Archaea, domain Bacteria and domain Eukarya.
12. Classification into three domains is based on sequence of nucleotides in the rRNA of the cell.
13. The four kingdoms of domain Eukaya are Protista, Fungi, Plantae and Animalia.
14. The group into which organisms are classified are known as taxonomic categories or taxa.

15. The kingdom is largest taxon or rank. Each kingdom is further divided into smaller taxa which are: Phylum, Class, Order, Family, Genus and Species.
16. Species is a group of organisms that consist of similar individuals capable of interbreeding.
17. Binomial nomenclature is the biological system of naming the organisms. In it the name is composed of two terms. The first term indicates the genus and the second term indicates the species of the organism.
18. Viruses are at the borderline of living and nonliving. There are not included in any domain or kingdom under modern classification

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

1. Into which kingdom you place a multicellular land organism that performs 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) animalia 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 is universally accepted.

5. Binomial nomenclature was introduced by:

   A) Aristotle B) Carolus Linnaeus

   C) Ernest Haeckel D) R.H Whittaker

8. The organisms that feed on dead, decaying matter are called:

   A) saprotrophs B) autotrophs C) heterotrophs D) parasites

10. Viruses are assigned to the kingdom:

    A) Plantae B) Protista

    C) Fungi D) Not included in any kingdom

11. The common characteristic of viruses, prions and viroids is:

A) Respiration B) Movement C) Infectious nature D) Excretion

12. Colonial organization is the unique feature of kingdom:

A) Animalia B) Protista C) Fungi D) Plantae

13. Which option is correct regarding the mode of nutrition of following organism?

	Animal	Prokaryote	Fungi	Plant
A)	heterotrophic	heterotrophic	ingestive	autotrophic
B)	ingestive	absorptive	autotrophic	heterotrophic
C)	ingestive	heterotrophic	absorptive	photosynthetic
D)	absorptive	autotrophic	ingestive	autotrophic

14. Viruses are not included in any domain or classification as:

A) they are poorly understood.

B) they are too large.

C) they are of various colours.

D) they are not considered as organism.

15. A related groups of genera consists of:

A) a phylum B) a class C) an order D) a family

16. In which of the following the first letter is capitalized in binomial nomenclature?

A) genus B) class C) species D) family

17. If humans and cats belong to the same class, they must belong to the same:

A) phylum B) order C) family D) genus

Section II: Short Answer Questions

1. Why are the following scientists famous for?

(a) Aristotle (b) Carolus Linnaeus (c) Carl Woese

2. Define:

(a) Biodiversity (b) Classification (c) Taxonomy (d) Systematics

(e) Domain (f) Taxa (g) Species.

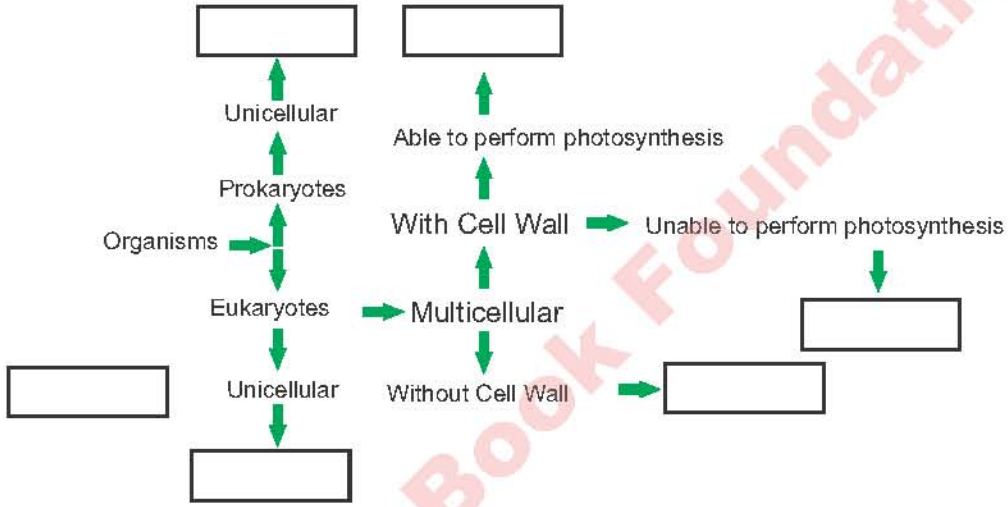
3. What is domain? Name the three domains of life.

4. What are basis of classification of life into domains?

5. Can you differentiate between? :

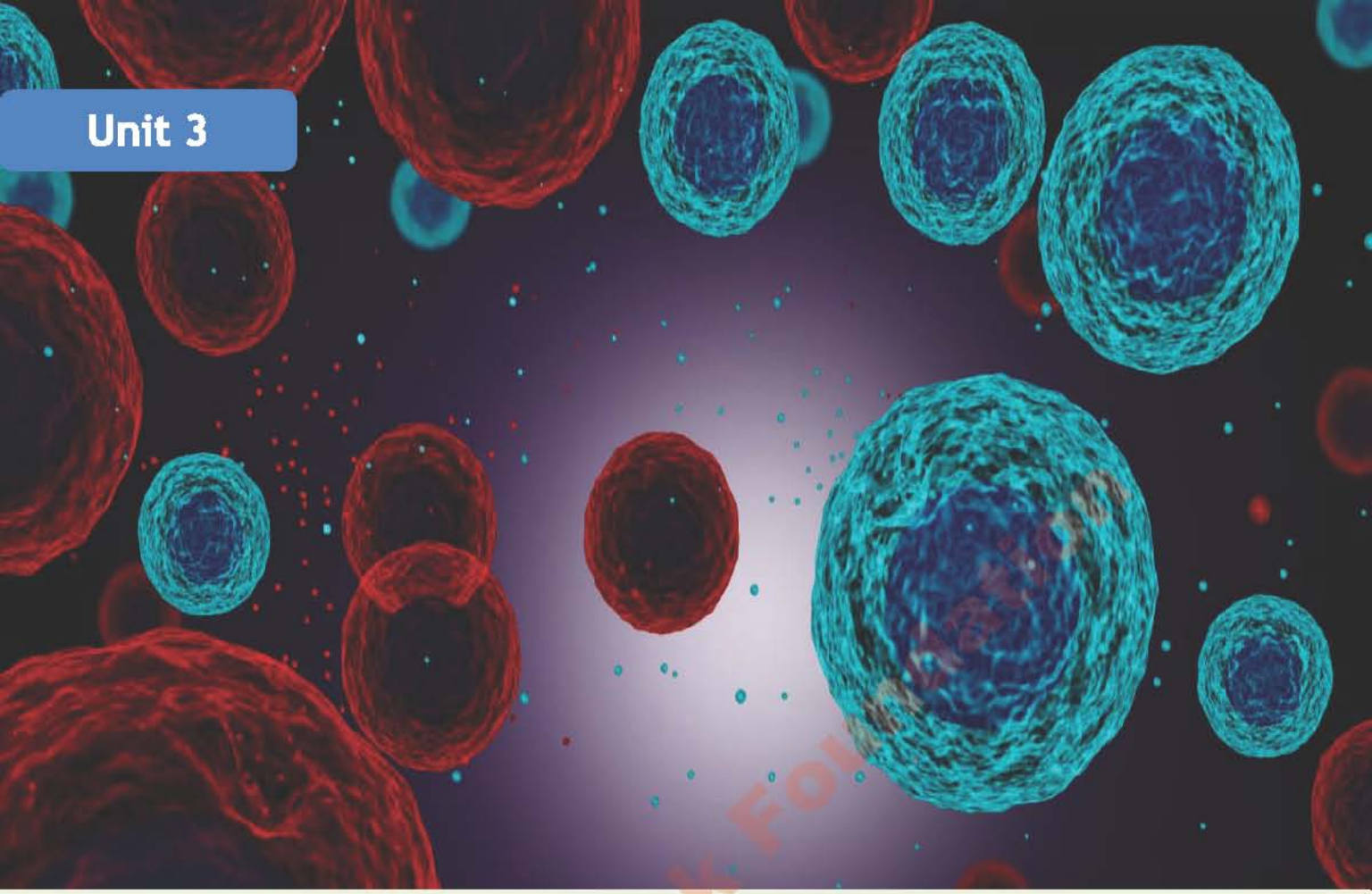
(a) Bacteria and Protists (b) Fungi and Plants (c) Plants and Animals.

6. Answer the following with supportive reasons.
   (a) Which the simplest domain?
   (b) Which is the complex domain?
   (c) Are most bacteria harmful?
   (d) Which domain/s can flourish or survive in most adverse conditions?
7. Compare the two-kingdom, three kingdom and five-kingdom system of classification.
8. Compare the three-domain system of classification.
9. Why mule is not regarded as a species.
10. Complete the following chart:



Section III: Extensive Answer Questions

1. What is biodiversity? Write the importance of biodiversity in the natural ecosystem.
2. Describe classification. How are the organisms classified?
3. What are the main aims and objectives of classification?
4. Give an account of history of classification.
5. What are the characteristics of the domain Archaea?
6. What are the characteristics of the domain (a) Bacteria (b) Eukarya ?
7. What are the diagnostic characteristics of the four kingdoms of domain Eukarya?
8. Describe the taxonomic ranks of classification.
9. Write a brief note on species.
10. What is Binomial nomenclature? Describe aims, principles and importance of Binomial nomenclature using local examples.
11. State the complications of classifying viruses.



Unit 3

The Cell

SLOs: After completing this lesson, the student will be able to:

1. Describe cell as the basic unit of life
2. Compare with diagram the structure of animal and plant cell.
3. Sketch different subcellular organelles nucleus, mitochondria, cell membrane etc. and outline their roles.
4. Outline structural advantages of plant and animal cells.
5. Identify different types of cells mesophyll, epidermal cells, neurons, muscles, red blood cells, liver cells and sketch their structures
6. Describe the concept of division of labour and how it applies to
7. Within cell across subcellular organelles
8. Multicellular organisms across cell
9. Describe cell specialization
10. Define stem cells as unspecialized cells

3.1 CELL

Earth is a living planet. It is home of a huge variety of life from microscopic organisms to magnificent blue whales and giant redwood trees. Irrespective of their size and shape all life forms are made up of units called cells. The functions performed by the living organisms are also performed at the cell level. So cell is the basic unit of structure and function of all living organisms.

3.1.1 Structure of cell

In 1665, Robert Hooke discovered cell when he examined a thin slice of cork tissue under a compound microscope. He observed cells as empty chambers with thick outer coverings. However, the quality of microscope lenses improved greatly in the nineteenth century which lead to the discovery of cell nucleus in 1831 and many cytoplasmic organelles in coming years.

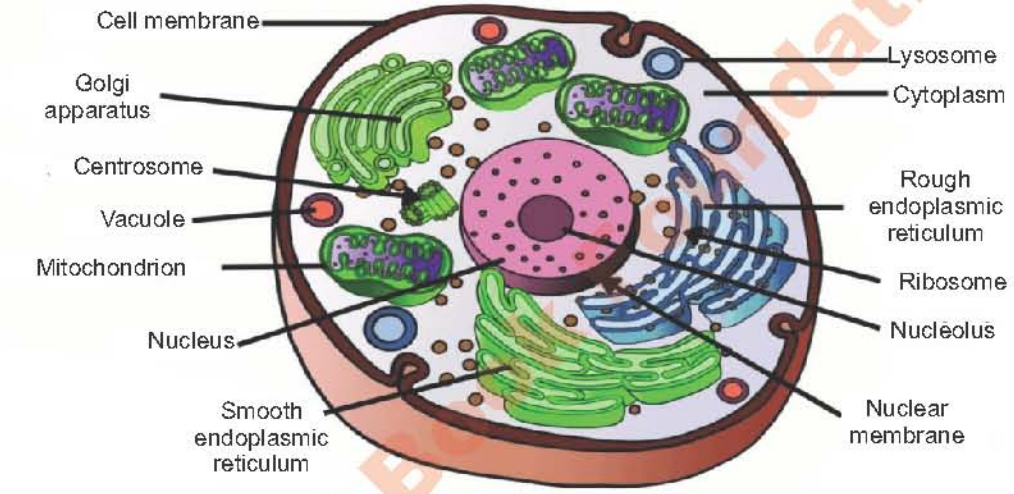


Fig 3.1: Animal cell

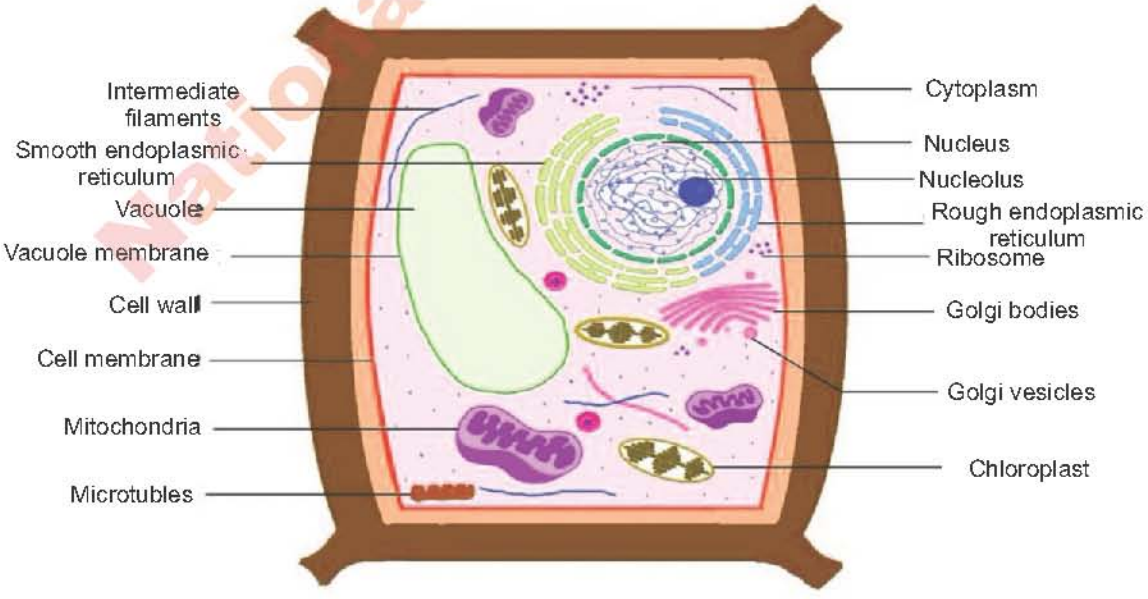


Fig 3.2: Plant cell

Cell wall

The cell wall surrounds the plasma membrane of plant cells. It is rigid, inert covering secreted and deposited outside the cell membrane. It consists of three layers namely middle lamella, primary wall and secondary wall.

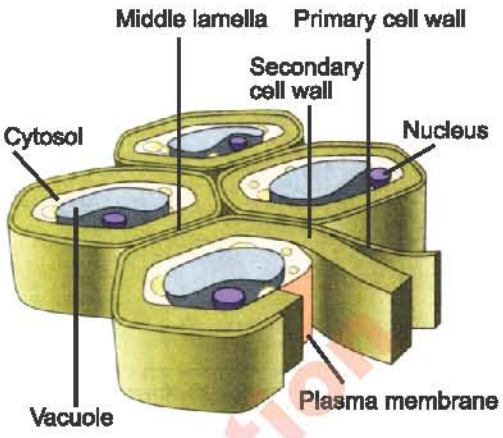


Fig 3.3: Plant cell wall

Middle lamella is a made up of magnesium and calcium salts of **pectin**. It is sticky in nature that holds the neighbouring cell walls together. **Primary wall** contains cellulose fibres arranged in a criss-cross fashion. It is thin and flexible. Some plant cells like xylem vessels form **secondary wall** inside the primary wall. It is very thick and rigid structure due to presence of lignin which cements the cellulose fibres together. Cell wall bears tiny pores through which neighbouring cells form cytoplasmic connections called plasmodesmata.

Algae have cellulose in their cell wall. Fungal cell wall is made up of chitin. Prokaryotes also possess cell wall made up of peptidoglycan. Cell wall is absent in animals and animal like protists (protozoa).

Cell wall supports the structure of individual cells and the plant as a whole. It protects and gives shape to the cell. Plant cells can develop turgor pressure due to presence of cell wall.

Cell membrane

Cell membrane is a thin sheet like covering of the cell. Chemically it is composed of proteins 60-80 %, phospholipids 20-40 % and traces of carbohydrates. The structure of cell membrane is explained according to **fluid mosaic model**. It postulates that cell membrane consists of a double layer of phospholipids in which proteins are incorporated in a mosaic fashion. In fact, protein molecules float like icebergs in a sea like fluid of phospholipids. Cell membranes of eukaryotes also contain cholesterol. It prevents stiffening of cell membrane. Cholesterol is required for the fusion of secretory vesicles with membrane. Carbohydrates are either linked with proteins or lipids.

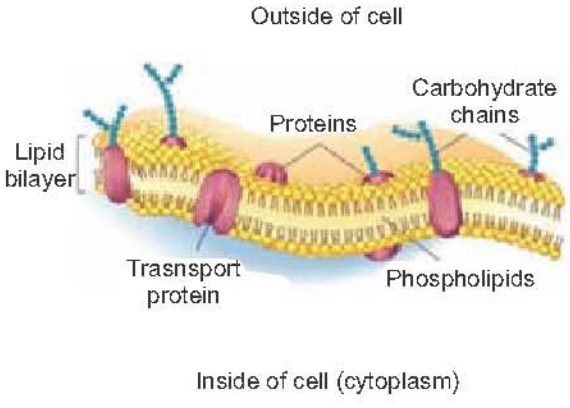


Fig 3.4. Fluid mosaic model of cell membrane

Cell membrane acts as barrier and gatekeeper for the cell. It is semipermeable so some molecules can move across the lipid bilayer but others are blocked. It maintains fixed environment inside the cell. Cell membrane acts as a barrier between the cell and its environment. It regulates the exchange of materials between cell and its environment.

Cytoplasm

Between the cell membrane and nucleus of the cell is an aqueous substance called cytoplasm. It is about 90% water having many dissolved and suspended materials. It is the site for many biochemical processes. It stores food granules and waste materials. It is home for a variety of cell organelles which are discussed below.

Endoplasmic reticulum

It is a system of membranes present throughout the cytoplasm of eukaryotic cells. Flattened sacs of the endoplasmic reticulum are called cisternae which form a network of interconnected channels. There are two forms of endoplasmic reticulum. **Rough Endoplasmic Reticulum (RER)** are covered with ribosomes. If ribosomes are absent it is **Smooth Endoplasmic Reticulum (SER).**

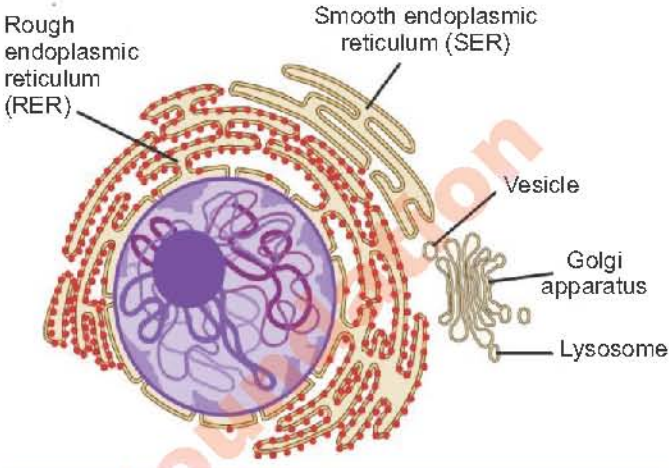


Fig 3.5: Structure of Rough and Smooth Endoplasmic Reticulum

A complex network of endoplasmic reticulum provides mechanical support to the cell. They are also involved in transport of substances within the cell. Due to attached ribosomes RER have role in the synthesis of some proteins. SER synthesize lipids including steroids. SER also detoxify harmful substances. In muscle cells SER have important role in contraction process.

Ribosomes

Proteins make up to about 55 % dry weight of a cell. A cell thus needs protein synthesis at high rate. This role is performed by the ribosomes. Ribosomes are tiny granular structures found both in prokaryotic and eukaryotic cells. They are not bound by any membrane. They are composed of roughly equal amount of proteins and ribosomal RNA (rRNA). The prokaryotic ribosomes, however, are smaller in size. A large number of ribosomes are scattered in the cytoplasm. In eukaryotes many ribosomes are also attached on the surface of RER.

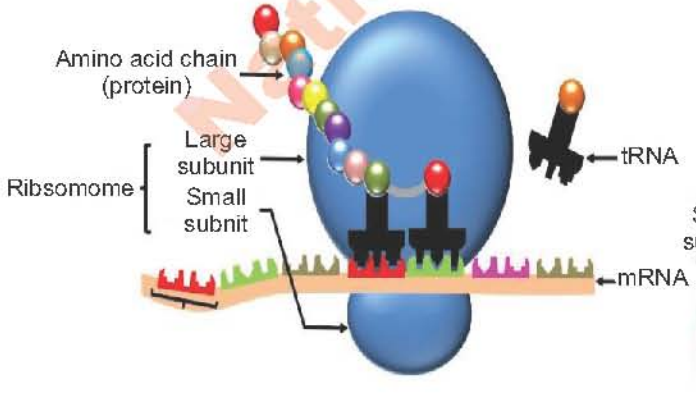


Fig 3.6: Function of ribosome

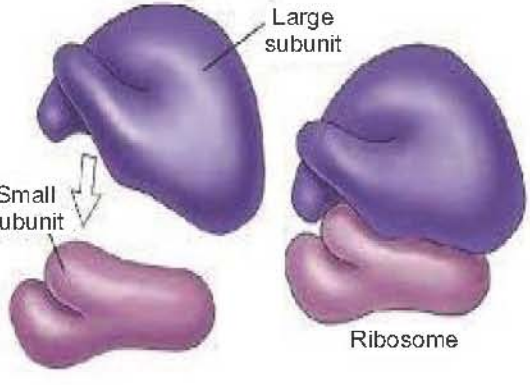


Fig 3.7: Subunits of ribosomes

Each ribosome consists of two subunits, one small and one large. These two subunits join when ribosome has to perform its function.

Golgi apparatus

Golgi apparatus was discovered by Camillo Golgi. It is present in all eukaryotic cells. Like endoplasmic reticulum, Golgi apparatus is also collection of flattened sacs called cisternae. However, in Golgi apparatus many cisternae are stacked over each other. They are constantly formed at one end and breakup into vesicles at the other end.

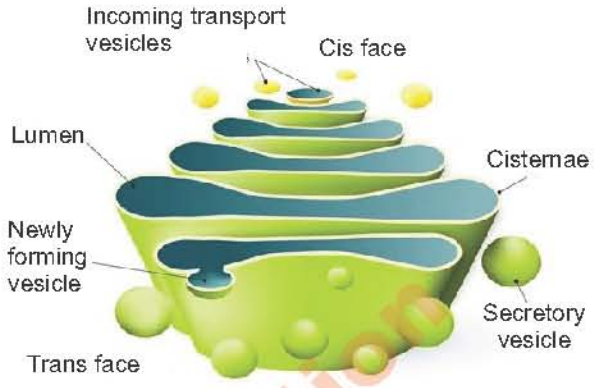


Fig 3.8: Structure of Golgi apparatus

Golgi apparatus store and modify materials into finished form before packing into vesicles. Some of these vesicles settle in cytoplasm as organelles like lysosomes. Others fuse with the cell membrane to release out packed material as cell secretion. Products of glands like enzymes, hormones, mucus etc. are secreted i

cellulose fibres which arrange themselves to form cell wall.

Lysosomes

They are single membrane bound small sac like structures. They contain a variety of digestive enzymes. The enzymes contained in lysosomes are synthesized on RER and then transported to Golgi apparatus. Lysosomes then bud off from Golgi apparatus with their processed enzymes.

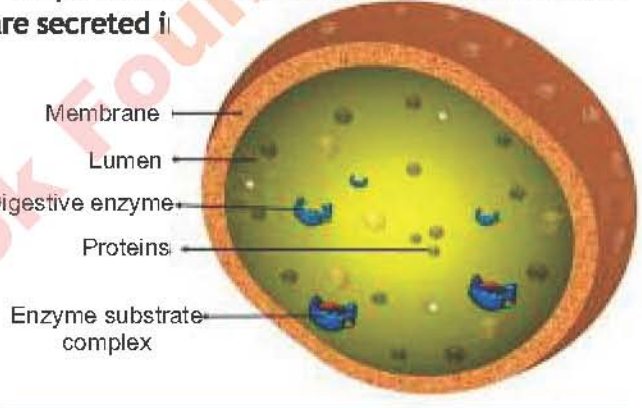


Fig 3.9: Structure of Lysosome

One important role of lysosome is **intracellular digestion.** In this process lysosomes digest materials taken up by the cell from outside as food vacuole. When lysosome fuses with the food vacuole, the lysosomal enzymes act on complex food substances and convert them into simple form. They also engulf and digest unwanted cell organelles. This process is termed as **autophagy.**

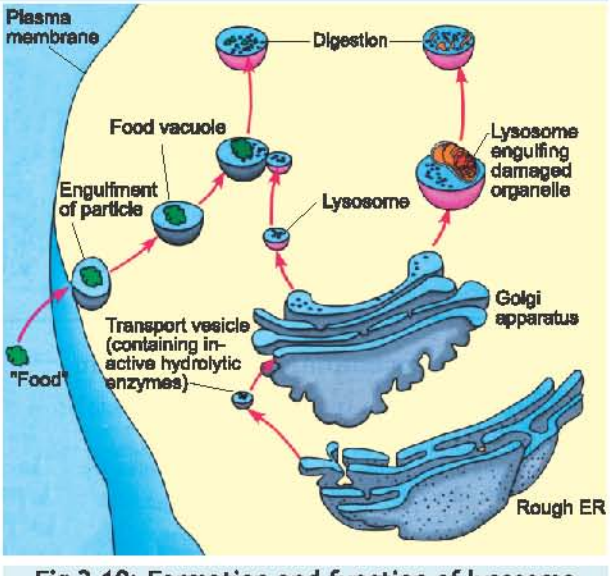


Fig 3.10: Formation and function of lysosome

Mitochondria

Energy is an important theme is biology. All systems, from cells to ecosystems require energy to work. Cells get energy by the breakdown of organic food in a process called respiration. If it requires oxygen, it is called

aerobic respiration. It takes place in mitochondria. Mitochondria are found in all aerobic eukaryotic cells. Mitochondria are double membrane bound structures. The outer membrane is smooth and inner membrane forms finger like projections called **cristae.** They increase the surface area for the respiration. The fluid inside the mitochondrion is called **matrix.** Mitochondria have their own DNA and ribosomes. They can multiply within the cell at their own. They produce energy in the form of ATP that is why they are called power house of cell.

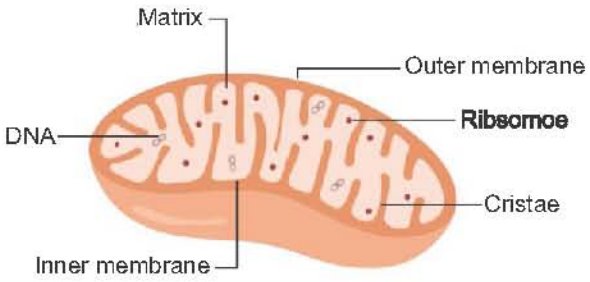


Fig 3.11: Structure of mitochondria

PLASTIDS

Plastids are double membrane bound organelles. They are found in plants and algae. There are three types of plastids i.e., chloroplast, chromoplast and leucoplast.

Chloroplast

Chloroplasts are usually oval in structure. Two membranes of the chloroplasts form chloroplast envelope. They have their own DNA and ribosomes. They can multiply within the cell at their own. They have a system of membranes containing chlorophylls and other photosynthetic pigments. This system consists of hollow coin like membranous structures called **thylakoids.** Many thylakoids stack to form **granum.** Some thylakoids of adjacent grana fuse to from intergrana. The fluid part of chloroplast is called **stroma.** Chloroplasts synthesize food by photosynthesis process. It takes place in two phases;

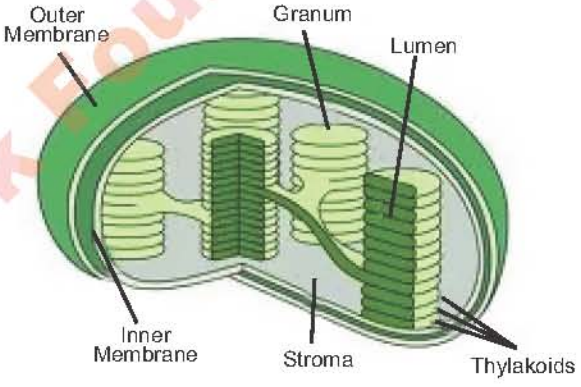


Fig 3.12: Structure of chloroplast

a. Light-dependent phase which takes place in thylakoid membranes.
b. Light-independent phase which takes place in stroma.

Chromoplast

Chromoplasts are coloured other than green. They may be red, pink, yellow, blue, purple etc. They are found in flower petals to attract insects. Insects help in pollination. They are also present in the wall of ripened fruits where they attract birds and other animals which help in seed dispersal.

Leucoplasts

Leucoplasts are non-pigmented plastids. They are food storing organelles usually found in roots, bulbs and stem tubers. They store carbohydrates, proteins or lipids.

Vacuole

A vacuole is a membrane bound fluid filled sac. Animal cell may have many small vacuoles which exist temporarily. They contain water and food substances. Some freshwater organisms like amoeba and sponges have **contractile vacuoles** which collect and pump out extra water and other wastes. Some cells ingest food by forming **food vacuoles** which is then digested into simple molecules. Food vacuoles also store food.

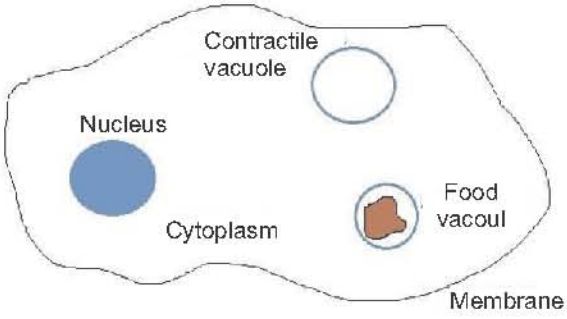


Fig 3.13: Structure and types of vacuole in animal cell

Plants cells have a large central vacuole as shown in figure 4.1. It is formed by joining small vacuoles. The membrane of plant vacuole is called **tonoplast**. It contains liquid called **cell sap**. Cell sap has dissolved materials like mineral salts, sugars, and amino acids. It also provides support and helps in growth. The primary role of the central vacuole in a plant cell is to maintain turgor pressure within the plant cell. **Turgor pressure** occurs when the fluid content of a cell pushes the cell membrane against the cell wall in order to provide shape to the plant cell.

Centrioles

Centrioles are hollow open ended cylinder like structures. They are found in animal cell. They exist in pairs near the nuclear envelope. Each centriole consists of nine triplets of microtubules. At the start of cell division centrioles duplicate and two pairs move to the opposite poles, thus help in the formation of **spindle apparatus**. They are also involved in the formation of cilia and flagella.

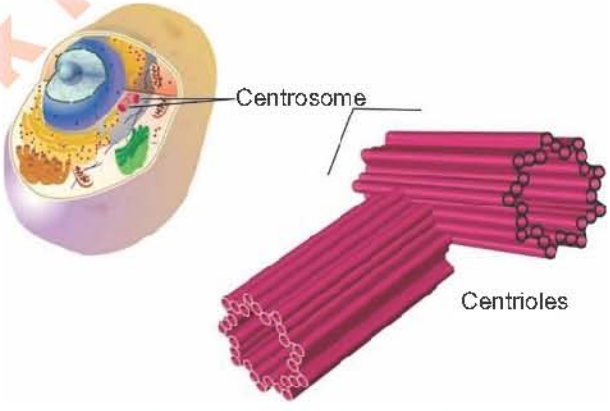


Fig 3.14: Pair of centrioles

Cytoskeleton

Cell has a system of a variety of fibrous proteins throughout the cytoplasm. These proteins collectively form cytoskeleton. Three types of cytoskeletal fibres are identified in the cell. These include; microtubules, microfilaments and intermediate filaments.

Microtubules are made up of **tubulin** protein. They are unbranched hollow tube like structures. Microtubules give rise to spindle fibres, cilia and flagella. **Microfilaments** are very thin protein fibres. They consist of contractile proteins mainly **actin**. They are responsible for the streaming movements of the cytoplasm. The overall cell movement is also regulated by the microfilaments. **Intermediate filaments** are composed of a variety of proteins including **keratin** and **vimentin**. They form a branching network in the cell. They maintain the cell structure. In tissues, they fix cells with each other.

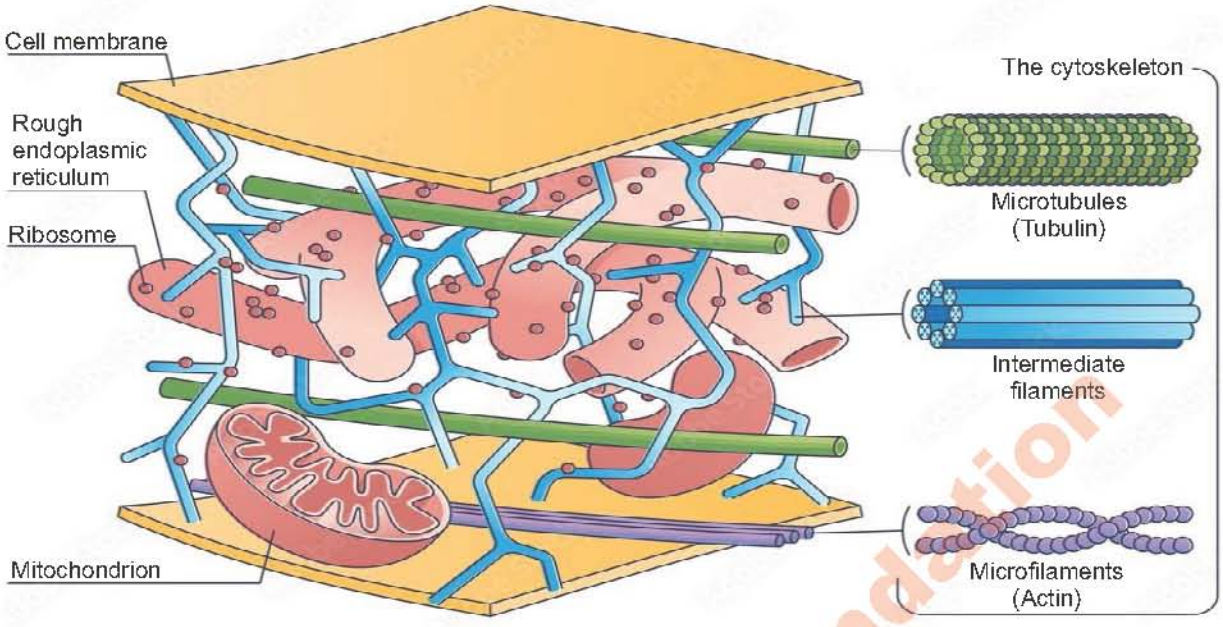


Fig 3.15: Structure and types of cytoskeleton

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 of microtubules. Cilia and flagella are connected to the **basal body**. The basal body serves to anchor a cilium or flagellum to the cell. The function of cilia and flagella is movement.

Fig. 3.15: Cilia and Flagella

Nucleus

Cell activities like metabolism, growth and reproduction need to be well regulated. In eukaryotic cell this role is served by the nucleus. Nucleus acts as control centre of the cell because it contains hereditary material DNA.

Nucleus is surrounded by two membranes which collectively form the **nuclear envelope**. Nuclear envelope bears **nuclear pores** at points where both membranes fuse with each other. Through nuclear pore nucleus communicates with the cytoplasm. Some nutrients and proteins enter the nucleus through these pores and ribosomes and mRNA leave the nucleus. Nucleus contains a fluid called **nucleoplasm**.

Nucleolus is a round darkly stained area in the nucleus. Ribosomes are assembled at this point. Here ribosomal RNA (rRNA) is formed which combines with proteins to form ribosomes. It disappears for some time during cell division.

Hereditary material in the nucleus is actually in the form of chromatin. Chromatin consists of **DNA** fibres coiled on **histone** proteins. During cell division chromatin fibres condense into more tightly coiled threads known as **chromosomes**. Each species has its own unique chromosomal set different from other species.

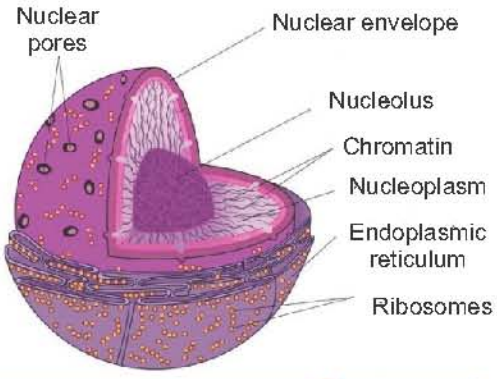


Fig 3.16: Structure of nucleus

3.1.2 Structural advantages of animal and plant cell

The cells of living organisms have basic similarities in structure due to common origin, however, they differ in many respects. Cell wall makes a major difference in plant and animal cell. The presence of cell wall in plant cell and absence in animal cell is reflected in their life styles.

Plant cell advantages/ disadvantages	Animal cell advantages/ disadvantages
Due to cell wall adjoining plant cells are cemented with each other. Supportive structure of plant as a whole is thus formed by cell wall.	The supportive structure of an animal as a whole is not dependent on a cell wall but rather on the collective arrangement and organization of tissues, organs, and skeletal systems present in the animal's body.
Transport channels in plants, xylem and phloem, are also formed because of presence of cell walls.	In animal cells, since they lack a cell wall, the transport of fluids, nutrients, and gases occurs through different structures and mechanisms.
The rigid wall helps plant cell to withstand high osmotic stress and store water.	Animal cells cannot withstand high osmotic pressure and cannot store larger volumes of water.
Plant cell can become turgid which allows plant parts to maintain structure and stay upright.	Animal cell cannot become turgid to provide support to the body
Plants cannot move from place to place because of rigidness provided by the cell wall.	Lack cell walls which makes then very flexible. Animal cells can move. Animal cells/ animals can move to suitable environmental conditions, find shelter and better feeding fields and opportunities for reproduction.
Due to rigid structure plant cell cannot reproduce at a faster rate.	It also helps animal cell to divide and reproduce at faster rate.

3.2 CELL SPECIALIZATION

In multicellular organisms, cells are specialized to perform their specific roles. Daughter cells formed by mitosis process undergo changes in a process called **differentiation**. They alter in size, stricture, metabolic activities and physiological responses. As a result, they become specialized in their role in the body. Some examples of the specialized cells are given below.

Epidermal cells of plants form protective covering of root, stem and leaves. They are flattened cells which pack tightly to form a continuous outer layer of plant body. Epidermal cells having some additional role are modified accordingly. For example, **root hair cells** which absorb water and minerals from the soil and **guard cells** of leaves which regulate the opening and closing of stomata.

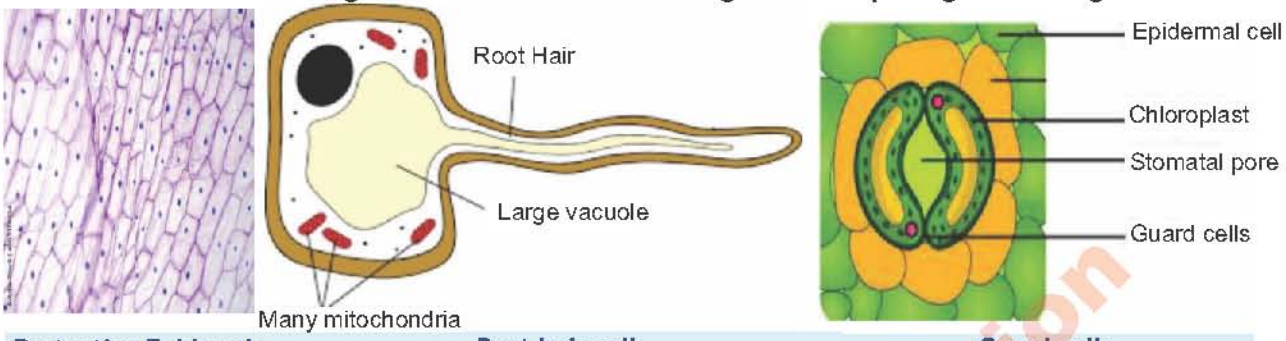


Fig 3.17: Epidermal cells

Mesophyll cells are photosynthetic cells of plants. They are present in plant leaves. They contain a large number of chloroplasts. Chlorophyll and other photosynthetic pigments are anchored in the thylakoid membranes of chloroplasts. These pigments absorb light energy and use it to produce food in photosynthesis process.

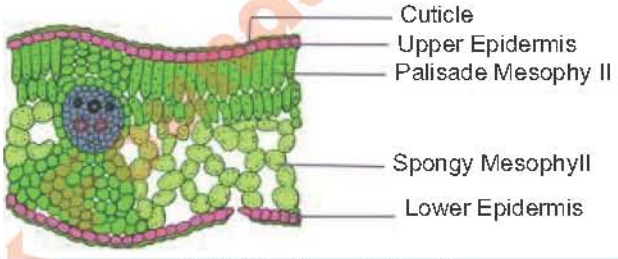


Fig 3.18: Mesophyll cells

Red blood cells (RBCs) are haemoglobin filled cells to transport oxygen in the body. They are biconcave disk shaped cells. This shape provides more surface area to absorb and release oxygen. Nucleus, mitochondria, endoplasmic reticulum etc. are absent. It helps to accommodate more haemoglobin. These cells are very flexible so they can easily pass through blood capillaries. The average age of RBCs is 120 days.

Fig 3.19: Red Blood cells

Neurons are the cells of nervous system. They are responsible for coordination in the animal bodies. To accomplish this job their structure is very unique. A neuron cell has a **cell body** and two types of cytoplasmic fibres. One of them are **dendrites** which conduct nerve impulses to the cell body. Others are **axons** which conduct messages away from the cell body. The dendrites and axons make it possible for neurons to communicate with far away cells of the body.

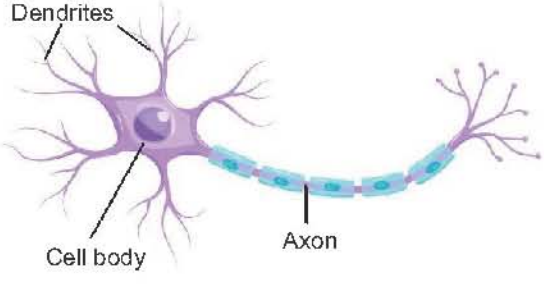


Fig 3.20: Neuron

Muscles cells have ability to contract and relax. Locomotion, breathing movements, blood pumping by the heart, change in size of eye pupil, peristaltic contraction of the gut, speech movements of tongue, lips etc. are result of the muscle contraction. To produce contractions muscle cells have elongated shape and are filled with **actin** and its associated contractile proteins.

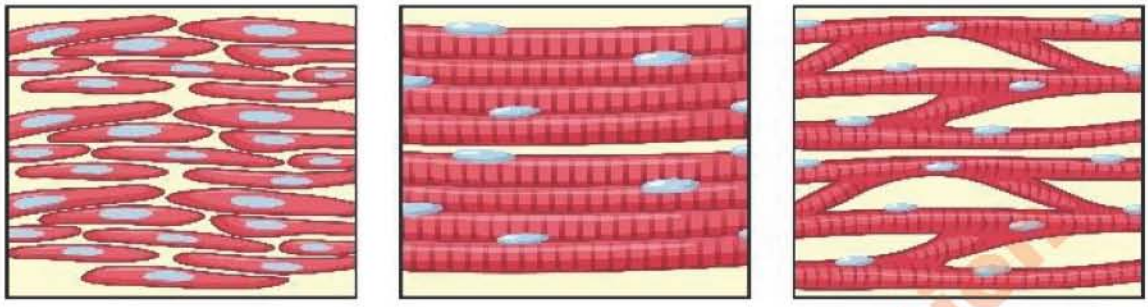


Fig 3.21: Types of muscles

Liver cells are almost round in shape and have prominent nucleus and abundance of cytoplasmic organelles. They are metabolically most active cells of the body. Their few important roles are;

a. Storage of glycogen, iron and some vitamins.
b. Detoxification of toxic substances.
c. Production of clotting proteins of blood.
d. Recycling of old red blood cells.

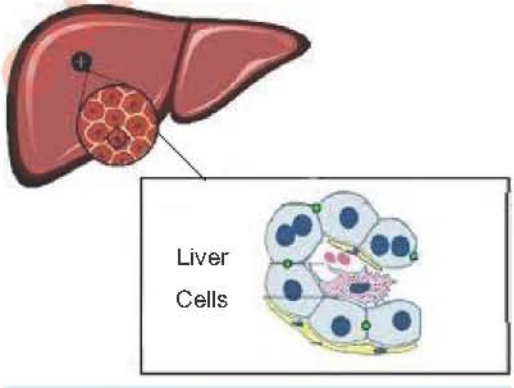


Fig 3.22: Liver and liver cells

3.3 DIVISION OF LABOUR

Within a cell different organelles perform their assigned roles. **Mitochondria** act as powerhouse of the cell as they produce energy for the cell. **Ribosomes** remain engaged in protein synthesis. **Chloroplasts** harvest light energy to manufacture organic food. For the normal survival and functioning of a cell its organelles must do their specified jobs. The performance of given function by different organelles is the division of labour.

Cell is the unit of life, so a cell can perform all basic function of life. A cell can respire, take and utilize nutrients, grow in size, reproduce, show movements etc. In unicellular organisms, a single cell lives as an organism and performs all these life processes independently.

A huge number of cells assemble a body of multicellular organism. In multicellular organism it is not possible for billions or trillions cells to perform all life tasks independently. So cells arrange in groups to perform some given role. A group of cells performing same function is called **tissue**.

The cell originating from same zygote change their cell lines and differentiate into unique structures suitable for their roles. Muscles cells are elongated to make the body parts move by their contractions. Neurons form thin cytoplasmic fibres to conduct messages in the body. Muscles cells and neurons cannot exchange their function. Similarly, RBCs transport oxygen and

bone tissue provides mechanical support. In plants mesophyll cells prepare food by photosynthesis process and phloem cells transport this food to all parts of the plant body.

3.4 Stem cells

Around 220 types of cells are identified in human body. These cells vary in their size, shape and role. However, all these types of cells have a common origin. They all develop from a single cell the **zygote**. A cell which gives rise to cells of other types is called the **stem cell**. The zygote is very basic stem cell which has ability to produce all kinds of cell an organism.

In sexually reproducing organisms, life starts from zygote. As the development progresses, different cell lines are formed. Each cell line has its own stem cell. Brain, liver, and other body tissues are products of stem cells.

Stem cells by themselves are not differentiated and are un-specialized. Each daughter cell produced by division of a stem cell has capacity to remain un-specialized stem cell or differentiate into mature cell of some tissue. So stem cells divide, renew themselves and daughter cells differentiate into distinct cell type.

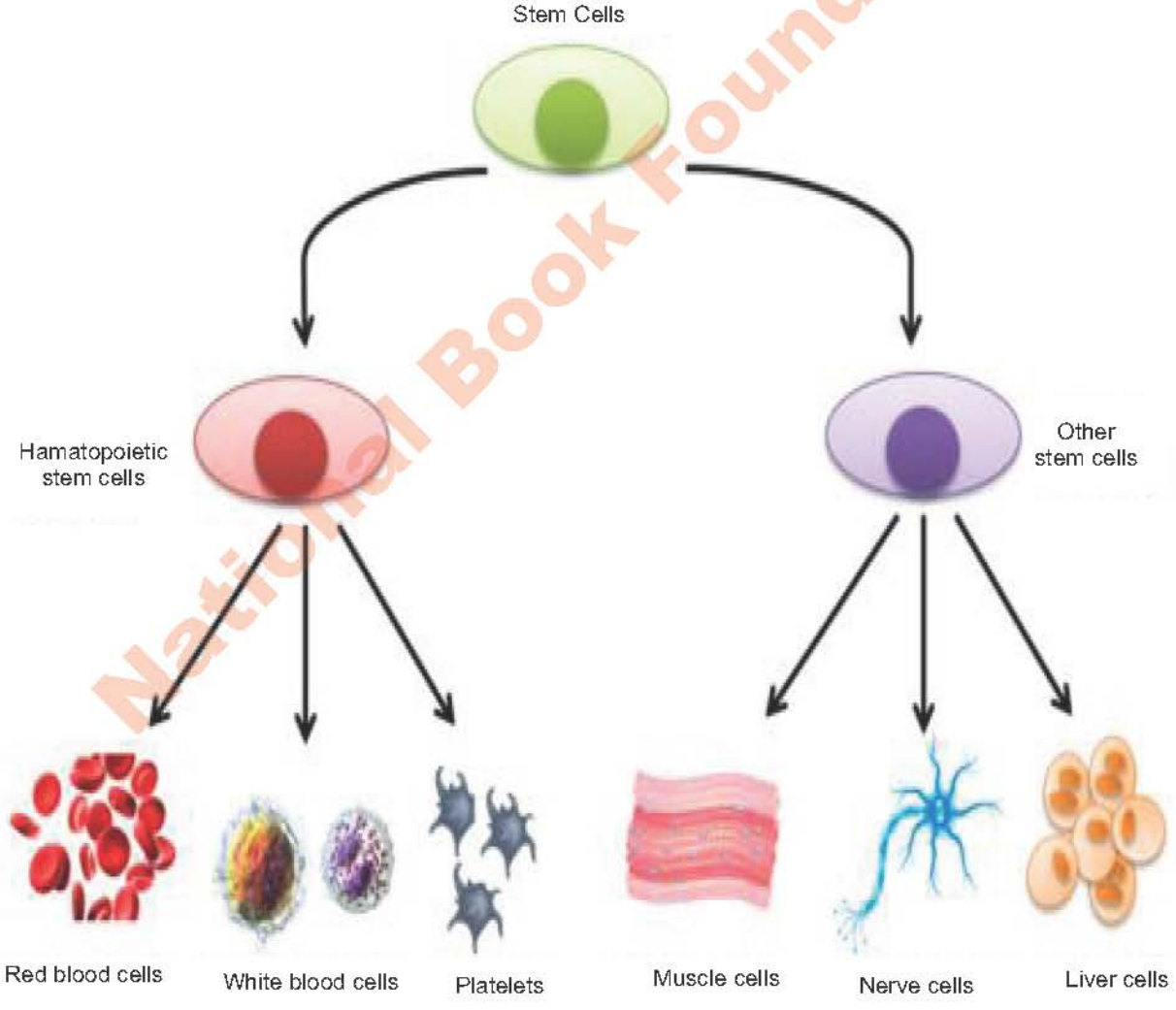


Fig 3.23: Stem cells and formation of specialized cells

STEAM ACTIVITY 3.1

Study of a plant cell

a. Place a small piece of onion skin in a drop of water on a slide and cover it with a cover slip.
b. Observe it under the microscope first under low power objective then under the high power objective.
c. Draw diagrams of onion skin cells in following table.

Diagram under low power objective lens	Diagram under high power objective lens

Steam Activity 3.2

Study of an animal cell

a. Gently pass the broad end of tooth pick on the inner side of your cheek.
b. Place the material o tooth pick in a drop of methylene blue solution on a slide and cover it with a cover slip.
c. Observe it under the microscope first under low power objective then under the high power objective.
d. Draw diagrams of human cheek cells in following table.

Diagram under low power objective lens	Diagram under high power objective lens

SUMMARY

1. The cell is considered as the basic unit of life because it is the smallest unit of living material.
2. Every cell is surrounded by cell membrane. The cell membrane is a highly fluid mixture of phospholipids and proteins.
3. 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.

4. Mitochondria are double membrane organelles in which the inner membrane is folded to form cristae. Mitochondrion is the site of aerobic respiration.
5. Golgi bodies are a series of flattened membrane sacs that process, sort, and modify proteins synthesized on the ER, and transport proteins to the plasma membrane, to the outside the cell and the lysosomes.
6. The endoplasmic reticulum is a series of internal membranes with many functions, i.e., protein synthesis lipid synthesis and transport.
7. Ribosomes are the site of protein synthesis.
8. Lysosomes breakdown organic molecules like proteins into simpler compounds that can be used by the cells.
9. Plant cell has cell wall, plastids and large vacuole.
10. Mesophyll cells, epidermal cells, neurons, muscles, red blood cells and liver cells are adapted to their particular functions.
11. Within a cell different organelles perform their assigned roles as there is division of labour.
12. A cell which gives rise to cells of other types is called the stem cell.

EXERCISE

Section I: Multiple Choice Questions

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. What are the functions of mitochondria?

   A) lipid synthesis B) protein synthesis

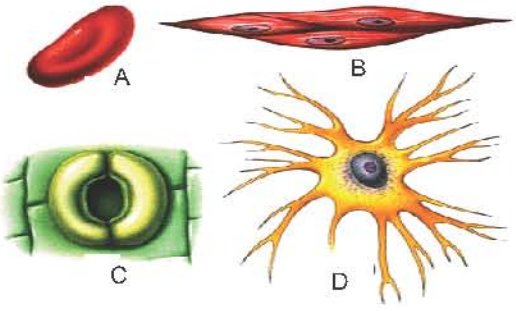
   C) photosynthesis D) cellular respiration

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

   A) Cellulose cell wall B) haemoglobin

   C) Large surface area D) nucleus

5. The diagrams show cells from different types of tissues (not drawn on scale). Which type of cell contracts when it is stimulated?



6. Which of the following cell organelles does not contain DNA?

A) Nucleus
B) Lysosomes
C) Chloroplast
D) Mitochondria

7. Phospholipids are required for cell membrane formation are synthesized in:

A) Mitochondria
D) Cytoplasm
C) Endoplasmic Reticulum
D) Smooth Endoplasmic Reticulum

8. Cytoskeleton is an important component of eukaryotic cells. Which of the following statement correctly describes cytoskeleton?

A) All the cytoskeletal structures are made up of same protein
B) There is no contractile protein in any cytoskeletal component.
C) Cytoskeleton provides mechanical support and has role in cell division.
D) The entire cytoskeleton is present around the cell membrane.

9. The shape of normal red blood cells is:

A) Oval
B) Crescent
C) Biconvex
D) Biconcave

10. Plastids of different types are correctly represented by:

	Photosynthetic	Pigmented	Food storage	Colour variety
A)	Chloroplasts	Leucoplasts	Chromoplasts	Chloroplasts
B)	Chromoplasts	Chloroplasts and chromoplasts	Chromoplasts and leucoplasts	Chromoplasts
C)	Leucoplasts and chloroplasts	Chromoplasts and leucoplasts	Leucoplasts	Chloroplasts
D)	Chloroplasts	Chloroplasts and chromoplasts	Leucoplasts	Chromoplasts

11. Which of the following statement correctly represents ribosomes?

A) They are present only in eukaryotic cell.

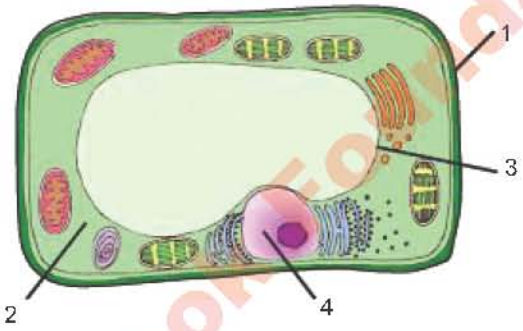
B) They are produced in the nucleus then migrate to the cytoplasm where they synthesize proteins.

C) They are covered by single membrane.

D) All ribosomes are attached to the inner surface of RER.

Section II: Short Answer Questions

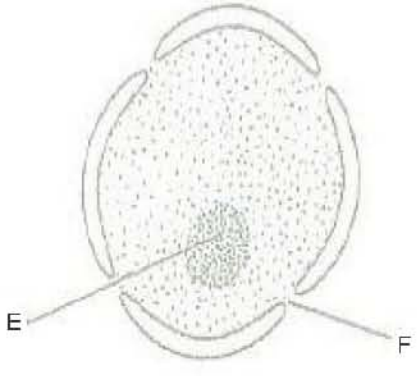
1. Why mitochondria are known as powerhouse of the cell?
2. What makes red blood cells more suitable for the transport of oxygen?
3. Give the modifications of epidermal cells for;
   a. Exchange of gases
   b. Absorption of water and minerals.
4. Following diagram shows a plant cell;



Keeping in view the parts labeled 1 to 4, answer the following questions:

   a. Give the number indicating the structure which controls the cell activities?
   b. Name a biochemical process taking place in part 2.
   c. What will happen to cell if part 1 is removed and part 3 is overfilled with water?

5. The diagram below represents a nucleus.



   a. Name the structure labeled E and F.
   b. Give the function of F.
   c. Which cytoplasmic organelles are formed by E?
   d. What happens to E during cell division?

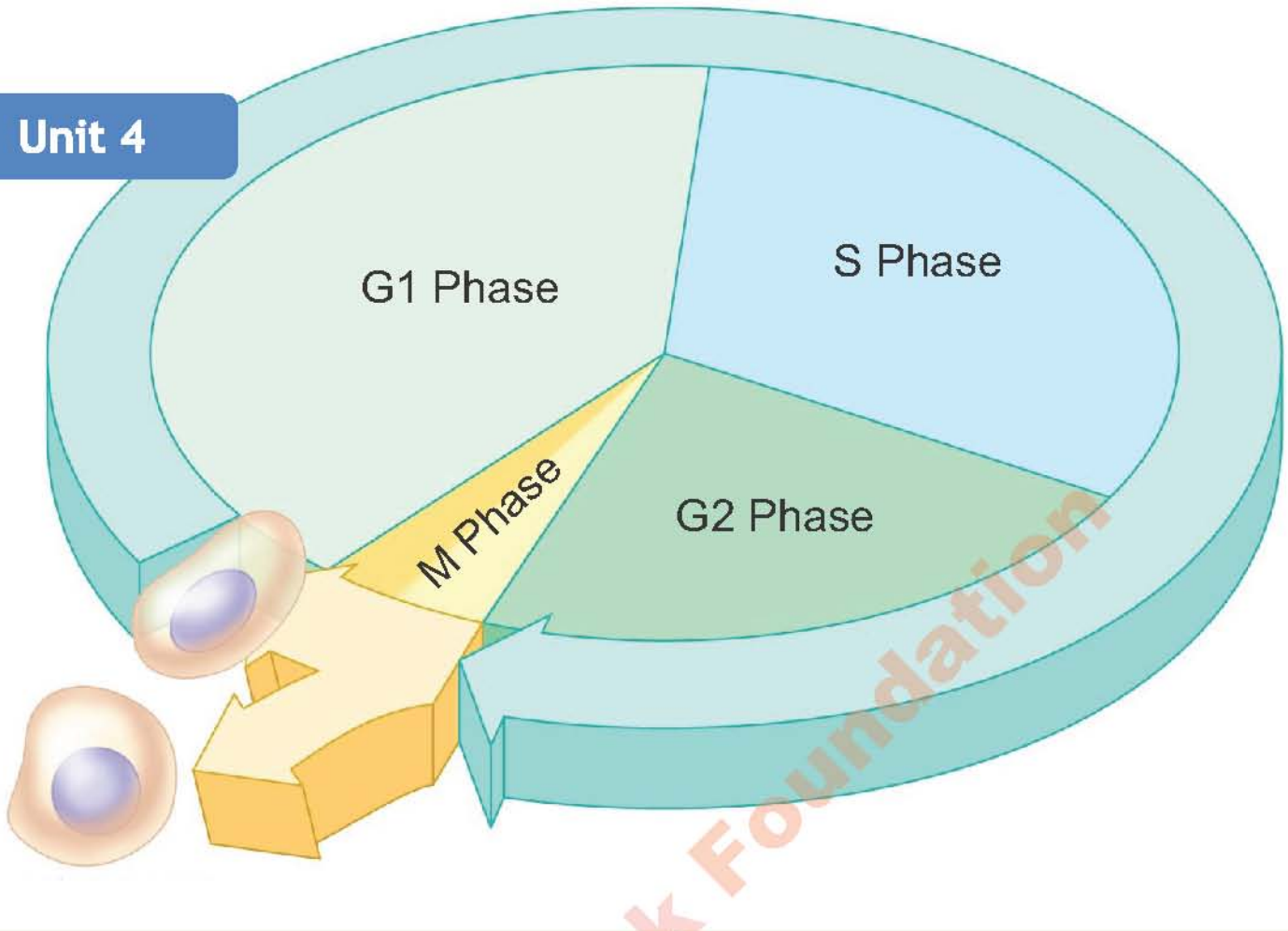
6. Cell shape is related to cell function. Give three examples to support your answer.
7. Plasma membrane has two main components according to fluid mosaic model. Which component represents fluid and which component represents mosaic?
8. Select the structures which are present in all cells of all kingdoms. Write one function of each selected structure.

   Cell membrane; Nucleus; Chromosomes; Cytoplasm; Ribosome; RER; SER; Golgi apparatus; Lysosome; Mitochondria; Centriole; Cilia; Flagella; Cell wall; Cytoskeleton; Vacuole; Plastids
9. Which cells in animals and plants do not have a nucleus? How do these cells perform their functions without nucleus?
10. Unripe oranges are green in colour. After ripening their colour changes. Suggest which organelles' number changed in them during ripening.
11. Which organelles are abundant in the salivary gland cell? Explain.

Section III: Extensive Answer Questions

1. Explain the structural model of cell membrane and give the roles of cell membrane.
2. How cell wall is important in the lifestyle of plants?
3. If a cell is rich in SER, list the roles in which this cell will be more efficient.
4. Give the significance of muscles in the life of animals.
5. Give the types of plastids and enlist the roles of each type.
6. Describe the structure and functions of animal cell. How it is different from plant cell?
7. Justify how the cells of leaf have a variety of specialized structure and function.
8. State the relationship between structure and function of mesophyll cells, epidermal cells, neurons, muscles, red blood cells and liver cells
9. Describe the role of the cell membrane in maintaining equilibrium while exchanging matter?

Unit 4



Cell Cycle

SLOs: After completing this lesson, the student will be able to:

1. Describe cell cycle
2. Explain mitosis meiosis and stages of mitosis and meiosis, by use of sketch and diagrams
3. Compare the process of mitosis and meiosis.
4. Outline the significance of mitosis and meiosis.

According to the cell theory, new cells originate by division in the pre-existing cell. The cell which divides is called parent cell and the new cell formed as a result of division are called daughter cell. The process of cell division is needed of development, growth, healing and for sexual and asexual reproduction. Cell not only increase in number but also manage to transfer genetic characteristics to the next generations. During cell cycle, cells grow in size, form new molecules and organelles, replicate their chromosomes and divide by equally distributing genetic material in the daughter cell.

4.1 CELL CYCLE

The cell cycle is the sequence of events which involves growth of newly formed cell, replicates its genome and divides into two daughter cell ultimately. It consists of two main phases; interphase and mitotic phase.

Interphase is the period in cell cycle between two consecutive divisions. It is divided into G_1 (Gap 1), S (Synthesis), and G_2 (Gap 2).

G_1 phase: It starts with the production of new cell. Cell grows in size, increases the number of its organelles, forms needed proteins and other substances. During this phase cell prepares itself for the next phase of cell cycle (S phase). It forms enzymes and nucleotides of DNA required for replication process.

S phase: It is the synthesis phase of DNA. The cell replicates its entire genetic material to form its two copies. That is why each chromosome has two chromatids during cell division, one for each of the daughter cell. These chromatids are attached with one centromere and are called sister chromatids.

G_2 phase: During this phase cell prepares for mitotic phase. Cell forms proteins especially those required for the formation of spindle fibres. Also cell accumulates energy to complete the division process. More mitochondria are formed.

G_o phase: During G_1, cell may exit the cell cycle and enter in G_o phase. In G_o cell stops to divide. Some cells e.g., neurons, once mature never divide again. They remain in G_o forever. Cell of liver, kidneys etc. enter G_o temporarily. When needed they re-enter the cell cycle and start to divide again. Many epithelial cells divide continuously. They never enter in G_o phase.

Mitotic phase (M phase): During this phase cell divides into daughter cell.

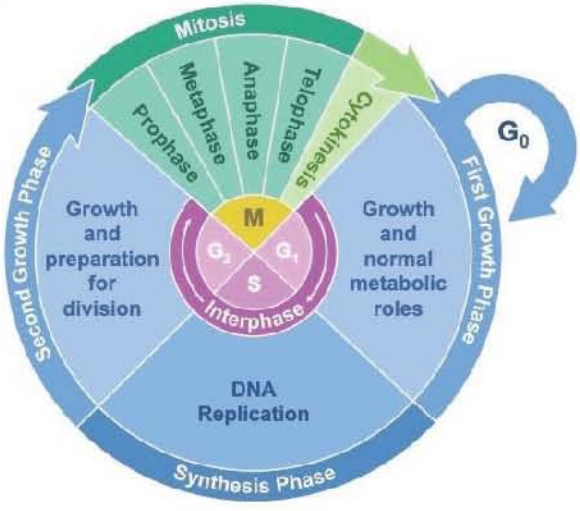


Fig 4.1: Cell cycle

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 distant parts of the body. The spread of cancer cells beyond their original site is called metastasis.

4.2 SPINDLE APPARATUS

Cytoskeleton of the eukaryotic cell forms spindle apparatus during the cell division. Major component of the cytoskeleton are microtubules. The spindle apparatus separates chromatid or chromosomes during cell division and move them to opposite poles. In this way hereditary material of the parent cell is equally distributed into daughter cell.

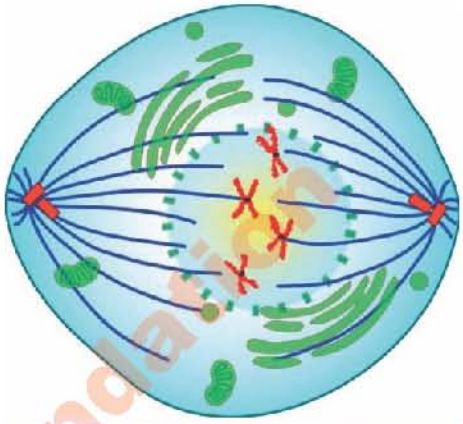


Fig 4.2: Spindle apparatus

A pair of centrioles is situated near the nucleus of animal cell. They duplicate and another pair is formed. Both pairs migrate to opposite poles. They also give rise to spindle fibres. Spindle apparatus is formed around the nucleus, but as soon as nuclear envelop disintegrates, spindle fibres penetrate in to the region of nucleus. They later on attach to the centromere of chromosome and pull them to their poles.

There are no centrioles in plant cell, the spindle apparatus of plant cell is formed without centrioles.

4.3 MITOSIS

The cell division in which parent cell produces two daughter cell with the same number of chromosomes as in the parent cell. Mitosis is a continuous and very fast process which takes less than an hour, but to study easily it is divided into **karyokinesis** and **cytokinesis.**

Karyokinesis

It is division of the nucleus, which form two nuclei in a dividing cell. It is further divided into; **prophase, metaphase, anaphase** and **telophase.**

Prophase

During interphase hereditary material is found in the form of very thin threads called chromatin. If a cell is going to divide, all of its chromatin fibres duplicate during S phase of interphase.

Prophase is the longest phase of cell division. At the start of prophase chromatin fibres coil up and condense into chromosomes. Due to duplication all chromosome consists of two chromatids. The chromatids of each chromosome are attached to each other at centromere.

Nucleolus disappears as its DNA is packed into chromosomes. At the end of prophase nuclear membrane splits into vesicles which disperse in the cytoplasm.

Spindle apparatus is formed.

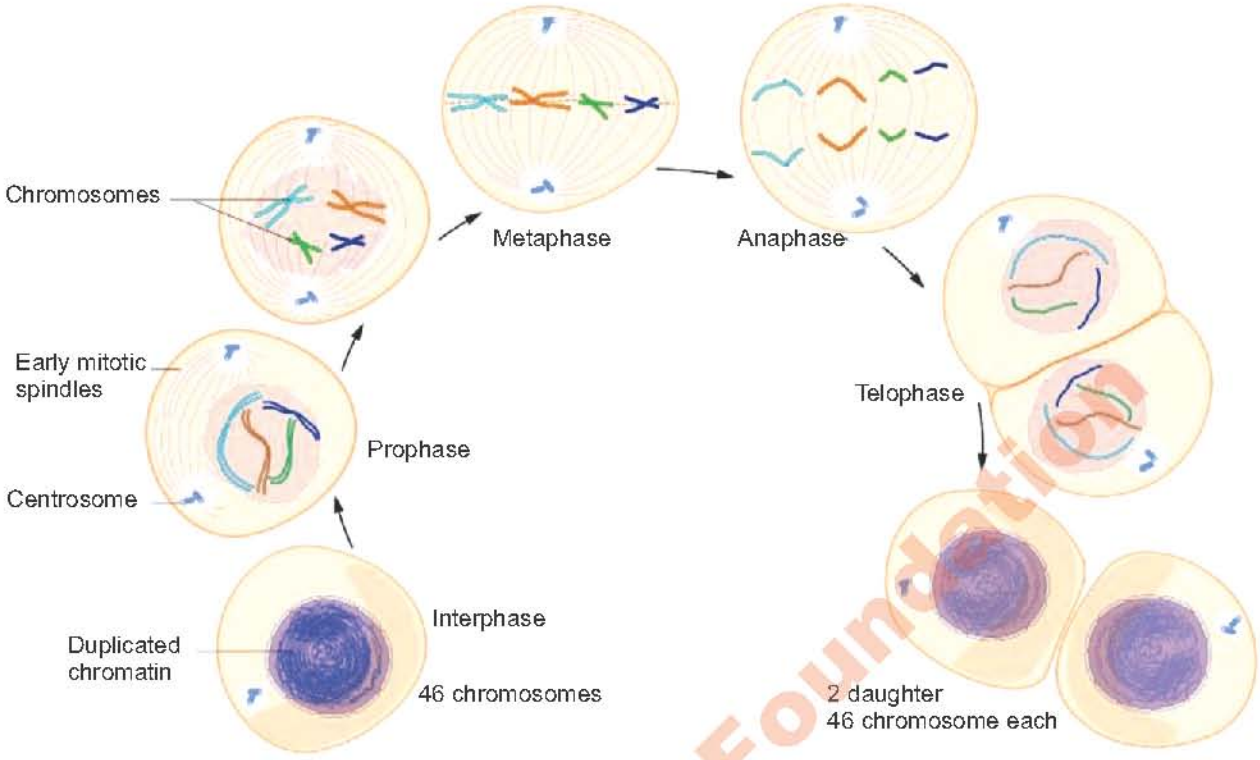


Fig 4.3: Mitosis

Metaphase

Chromosomes are aligned at the equator of spindles. Two spindle fibres, one from each pole, are attached at the centromere of chromosomes.

Anaphase

Spindle fibres pull the centromeres which split and chromatids are separated from each other. Individual chromatids are pulled until they reach their respective poles.

Telophase

Chromatids reach at their poles. They uncoil and lengthen to form chromatin fibres again. The spindle apparatus disintegrates. Nuclear membrane is formed around chromatin at each pole. Nucleoli reappear in both nuclei.

Cytokinesis

It is division of the cytoplasm which results in the formation of two daughter cells. It starts while telophase is in progress. The pattern of cytokinesis is different in animal and plant cell.

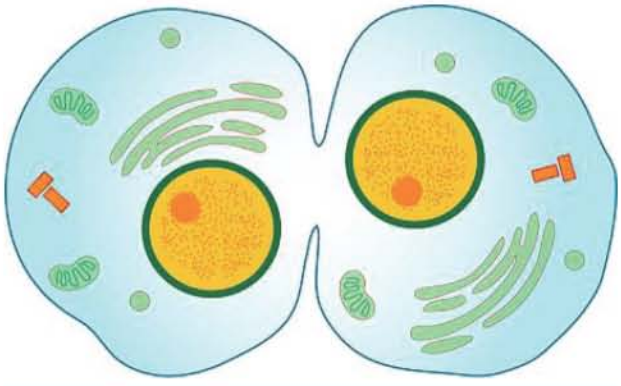


Fig 4.4: Cytokinesis in animal cell

Cell membrane in animal cell begins to invaginate in the equator region. As a result, a cleavage furrow is formed which continues to grow inward. Cell membranes in the furrow finally join up and separate the two daughter cells.

In plant cell spindle fibres in the equator region form a structure called **phragmoplast**. Golgi apparatus forms vesicles which appear in the centre of phragmoplast initially and then grow at equatorial plane. The content in these vesicles form middle lamella and primary walls of daughter cells. Later on some cells form secondary walls.

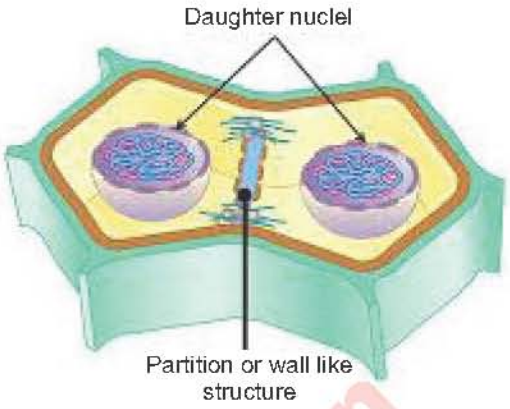


Fig 4.5: Cytokinesis in plant cell

4.3.1 Significance of Mitosis

The main function of mitosis is to maintain the number of chromosomes and genetic material in all cells of an organism. Following is the significance of the mitosis.

Genetic stability: Mitosis produces two daughter cells with the same number of chromosomes as in parent cell. Before the start of cell division, DNA of the parental chromosomes replicates to form two exact copies. Daughter cells thus will have same genetic information.

Development and growth: Life of sexually reproducing multicellular organisms start from a single cell, the zygote. The continuous cell division process leads to the development of adult form. The organisms also grow in size by increasing cell number. Thus the development and growth of multicellular organisms depends on mitosis.

Cell replacement and wound healing: The replacement of worn out cells involves mitosis. The epithelial cells of skin, digestive tract and respiratory tract die off regularly. They are replaced by identical cells produced by mitosis. Damage repair and wound healing depends on the process of mitosis.

Regeneration: Some animals have ability to form whole part of the body if it is removed accidentally. This is called regeneration. For example; sea star can regenerate arm, earthworms can regenerate head, and salamander can regenerate its limb. The production of new cells to form missing parts involves mitosis.

Fig 4.6: Regeneration of arm in Sea star

Asexual reproduction: Mitosis is the basis of asexual reproduction. This reproduction involves only one parent. All asexually produced offspring are genetically identical to their parent organism. The vegetative propagation is very common in plants. It involves new generations from root, stem or leaf of parent plant. Potato, onion, garlic, ginger, grasses etc. reproduce asexually. Many animal species like sponges, planaria and hydra undergo asexual reproduction.

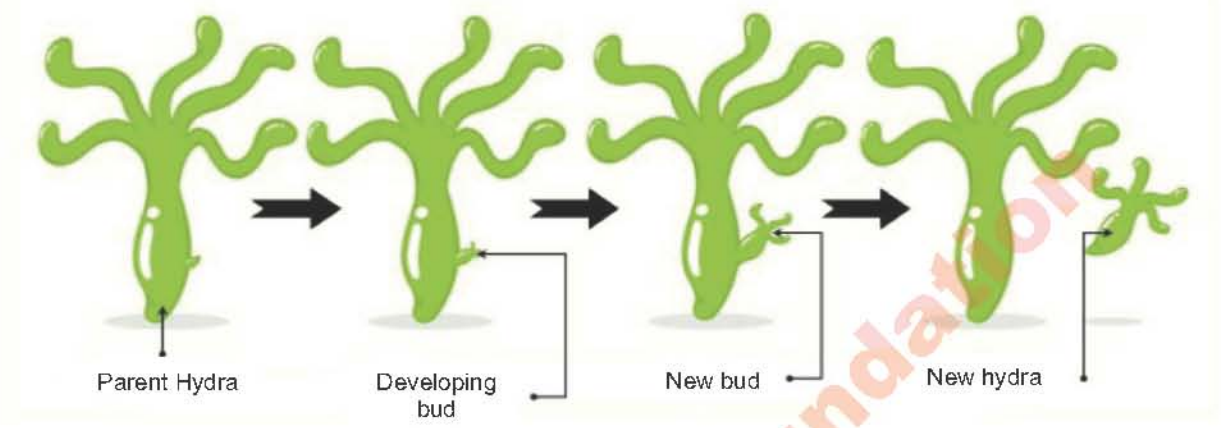


Fig 4.7: Budding in Hydra

Cloning and tissue culture: Mitosis has made it possible for scientists to produce a very large number of identical copies of the living organisms in artificial environment. This process is called cloning or tissue culture if small mass of tissue cells is used.

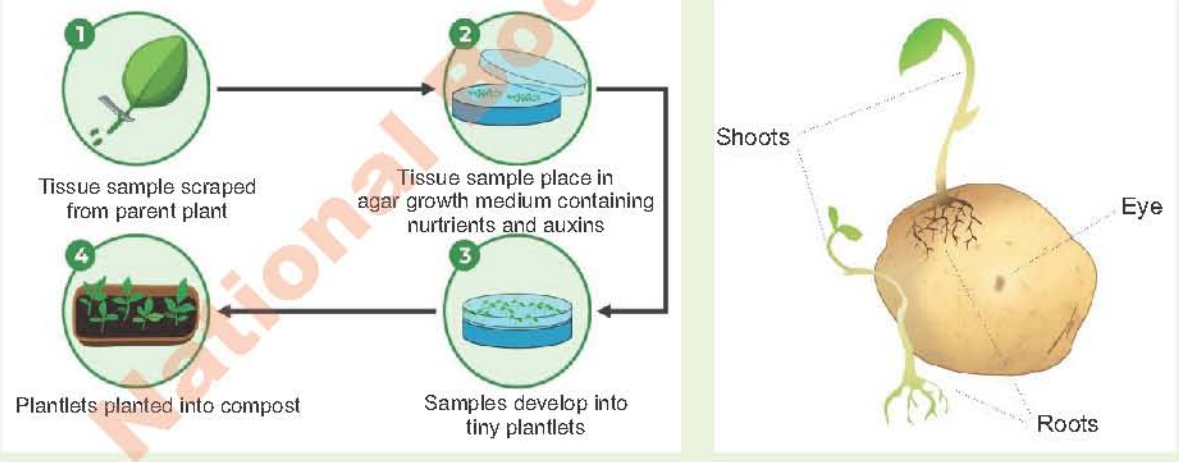


Fig 4.8: Cloning by (a) Tissue culture (b) Vegetative propagation in potato

4.5 MEIOSIS

It is a type of cell division which give rise to four daughter cells each having half the number of chromosome of the parent cell. It takes place only in cells involved in sexual reproduction. Such parent cells are usually **diploid** which by this reduction division produce **haploid** daughter cells. Cells which have two sets of chromosomes are called diploid (2n) and cells with half the number of chromosomes are called haploid (n). Chromosomes in a diploid cell are in homologous pairs. Haploid cells carry one member of each homologous pair.

Meiosis is a continuous process but for convenience is divided into **interphase I, meiosis I, interphase II** and **meiosis II.**

Interphase I

Before the onset of division process, cell forms a copy of its genome by replication process. That is why chromosomes appear with two chromatids during division process.

Meiosis I

It is the reduction division which for daughter cells reduces the number of chromosomes to half. Firstly, karyokinesis forms two haploid nuclei which is followed by cytokinesis.

Karyokinesis in meiosis I

It is further divided into **prophase I, metaphase I, anaphase I** and **telophase I.**

Prophase I

It is the longest phase of meiosis. Chromosomes begin to appear as thicker fibres due to coiling of chromatin. Homologous chromosomes line up point to point against each other and form pairs. Their centromeres are in the same position. This pairing process of homologous chromosomes is called **synapsis**. Each pair is called bivalent.

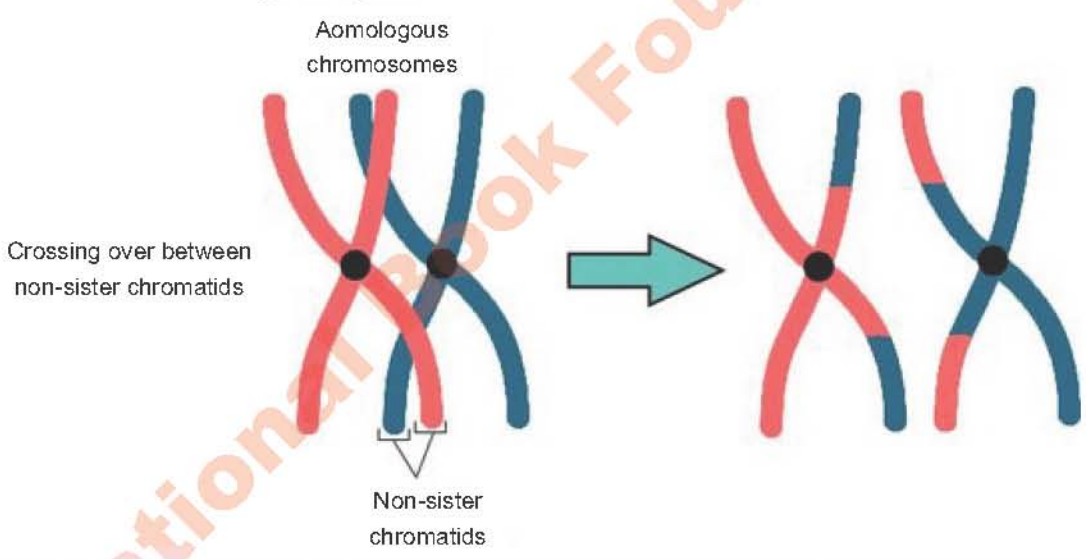


Fig 4.9: Crossing over in non-sister chromatids

The non-sister chromatids of homologous chromosomes join each other at some points along their length. Such points are called **chiasmata**. Each chiasma is a site for the exchange some genetic material between chromatids. The exchange of segments of non-sister chromatids during prophase I is called **crossing over**.

Sister chromatids are two exactly similar copies attached by a centromere while The chromatids of two homologous chromosomes are non-sister chromatids.

To the end of prophase I, chromosomes are fully condensed and paired chromosomes repel each other. However, they are still attached at chiasmata.

Nucleoli and nuclear envelop disappear. Spindle apparatus is formed.

Metaphase I

Bivalents are arranged at the equatorial plate. Spindle fibres are attached to the centromere of chromosome. One member of a homologous pair receives a spindle fibre from one pole and other member from the opposite pole.

Anaphase I

Spindle fibres pull on the homologous chromosomes. Separated chromosomes of each pair move to the opposite poles. Each pole receives haploid set of chromosomes.

Telophase I

Once at their pole, chromosomes uncoil into chromatin. A nuclear envelop is formed at each pole around the haploid set.

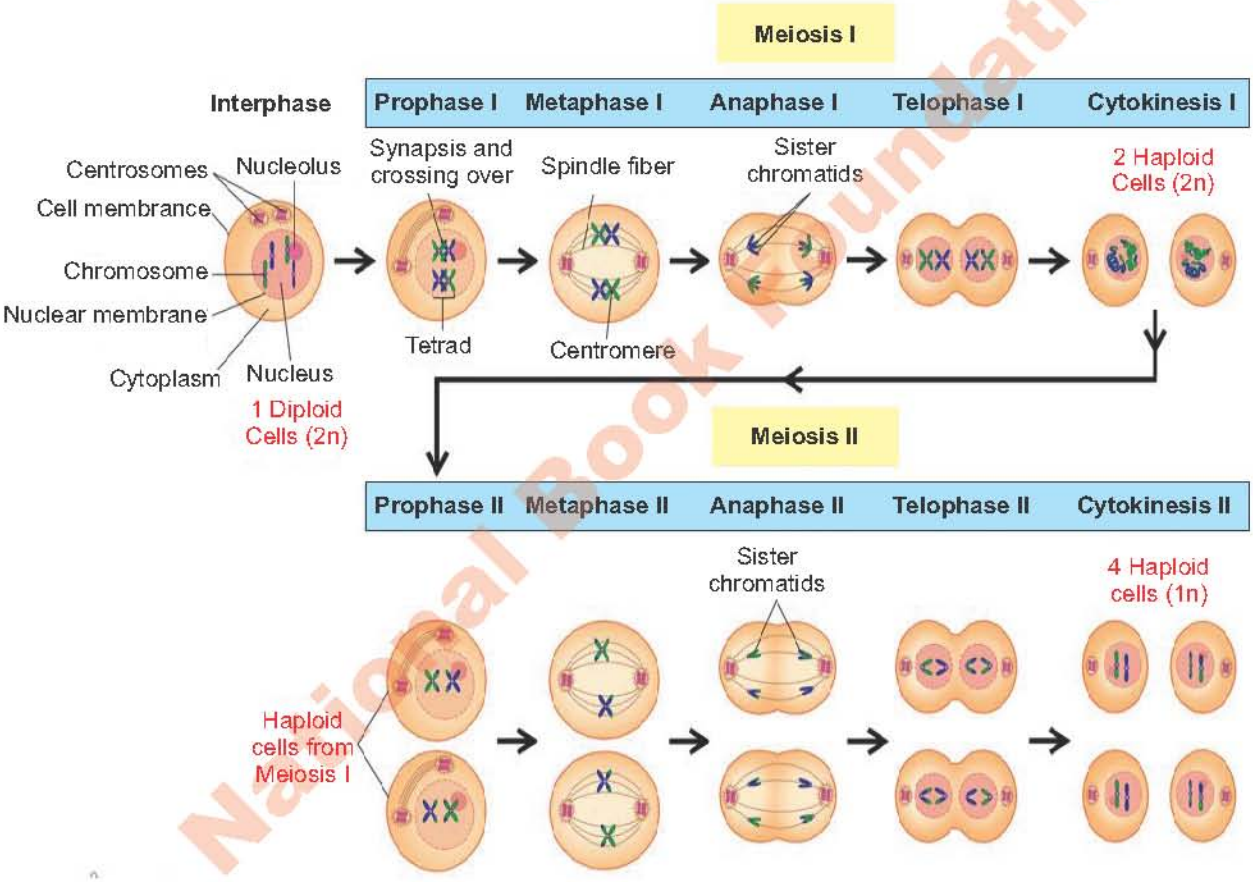


Fig 4.10: Meiosis

Cytokinesis

Cytokinesis occurs by cleavage in animal cell of by forming cell wall in plant cell. Although each daughter cell is haploid with half the number of chromosomes, their chromosomes are composed of two chromatids. Due to crossing over, these chromatids are not genetically identical. They must be separated in second meiosis.

Two haploid daughter cells thus formed enter in interphase II.

Interphase II

This phase varies in length but there is no further DNA replication during this phase.

Meiosis II

It is similar to mitosis and is divided into **prophase II, metaphase II, anaphase II** and **telophase II.**

Prophase II

Chromatin coils again so chromosomes appear as thick fibres. Spindle apparatus is organized. Nucleoli disappear and nuclear envelop disintegrates.

Metaphase II

Chromosomes line up separately around the equator of the spindles. Spindle fibres are attached to the centromere of chromosome. Like mitosis here each chromosome is attached by a fibre from both poles.

Anaphase II

Centromeres divide and spindle fibres pull the chromatids to the opposite poles.

Telophase II

Chromatids reach at their poles and uncoil. The spindle apparatus disappears. Nuclear envelops are formed around chromatin at each pole.

Germ cell are diploid which undergo meiosis to from haploid gametes. All other diploid cells of body undergo mitosis and are called somatic cells.

Cytokinesis

Cleavage furrow is animal cells and cell wall formation in plant cells gives four daughter cell at the end of meiosis process. All cells formed by meiosis process are haploid as they have half the number of parental chromosomes. Also they have changed genetic makeup because of crossing over between homologous chromosomes during meiosis I.

4.4.1 Significance of meiosis

Maintenance of chromosomes in sexual reproduction

Maintenance of chromosomes: During the life cycle of sexually reproducing organisms, diploid germ cells undergo meiosis to produce haploid daughter cell which act as gametes. Fusion of such haploid gametes thus maintains chromosome number specific for each species.

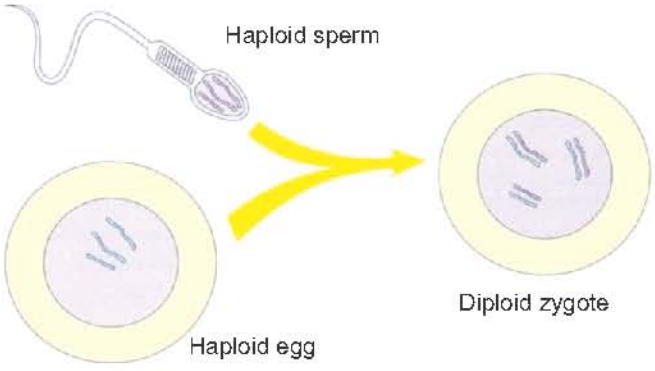


Fig 4.11: Fertilization of sperm and egg cell to form zygote

Human have 46 chromosomes in their somatic cells. The haploid gametes (eggs and sperms) formed by meiosis have 23 chromosomes. In fertilization process a 23 chromosome sperm fuses with an egg also having 23 chromosomes. The original chromosome number of 46 is restored in the zygote.

In plants meiosis takes place during spore formation.

Genetic variations

Variations are the differences among the members of same species. They are necessary for the survival of species in always changing environment. It is because of meiosis that new combinations of genes appear in gametes and then in zygote. Crossing over and independently formed combinations of chromosomes in gametes are two important events of meiosis. Both crossing over and chromosomal combination provide basis of variations.

Fig 4.12: Variation in Butterfly patterns

Table 5.7 Comparison of mitosis and meiosis

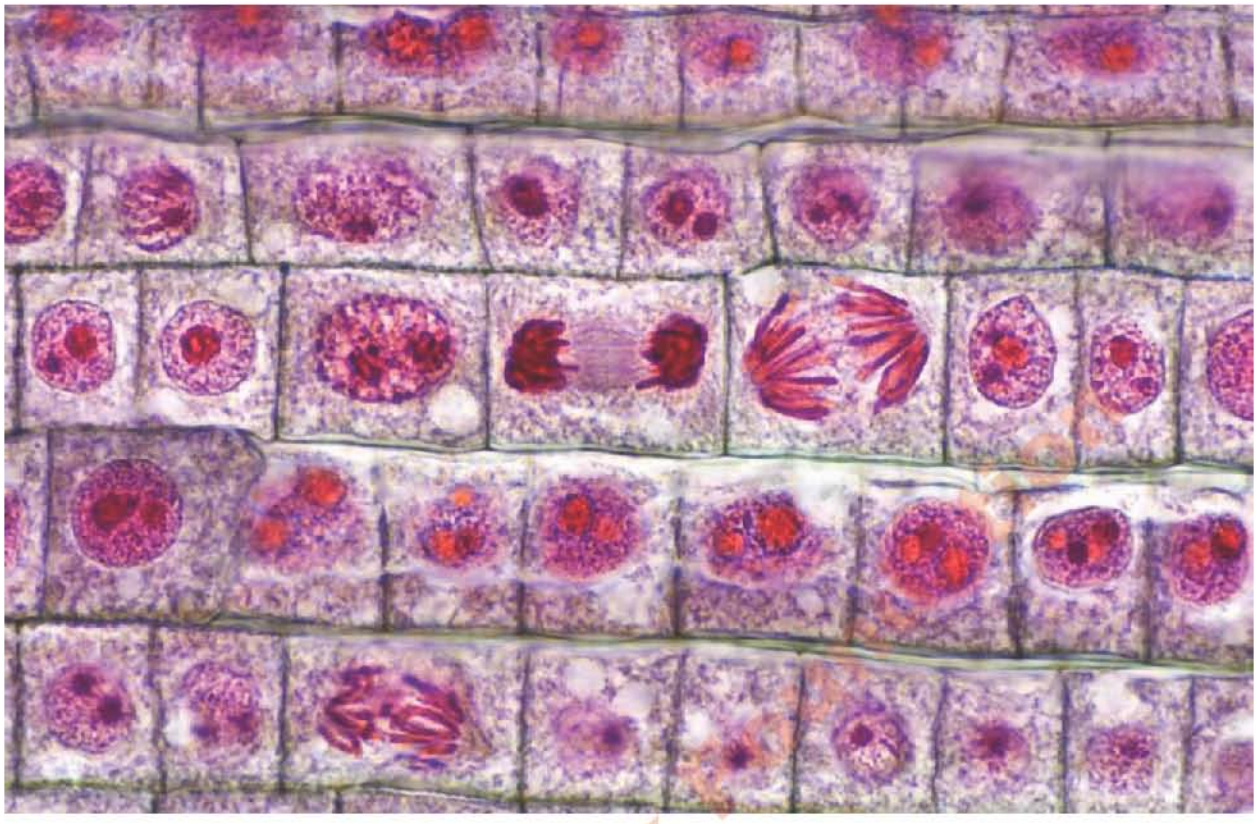
Mitosis	Meiosis
It occurs in somatic cells	It occurs in germ line cells
Cell divides only once	Cell divides twice
It produces two daughter cells	Four daughter cells are produced
Daughter cells produced are diploid	All daughter cells are haploid
Daughter cells become part of somatic body	Daughter cells form gametes
All chromosomes remain independent of each other	Homologous chromosomes pair with each other
No chiasmata formation	Chiasmata are formed
There is no crossing over during mitosis process	Crossing over takes place during meiosis I
Daughter cells are genetically alike.	Daughter cells are genetically different from each other and parent cell
In most cases daughter cells can divide again.	Gametes produced by meiosis cannot divide any more.

STEAM ACTIVITY 4.1

Study of Mitosis in onion root tip

Materials Required

Compound microscope, Acetocarmine stain, Water, Burner, N/10 Hydrochloric acid, Filter paper, Coverslip, Aceto alcohol (Glacial acetic acid and Ethanol in the ratio 1:3), Glass Slide, Onion root peel, Forceps, Blade, Watch glass, Dropper, Needle, Vial.



Procedure

1. Place an onion on a tile
2. With the help of a sharp blade, carefully snip the dry roots of the onion
3. Place the bulbs in a beaker containing water to grow the root tips
4. It may take around 4 to 6 days for the new roots to grow and appear
5. Trim around 3 cm of the newly grown roots and place them in a watch glass
6. With the help of forceps, shift it to a vial holding freshly prepared aceto-alcohol i.e., a mixture of glacial acetic acid and ethanol in the ratio 1:3
7. Allow the root tips to remain in the vial for one complete day
8. With the help of forceps, pick one root and set in on a new glass slide
9. With the help of a dropper, allow one drop of N/10 HCl to come in contact with the tip of the root. Additionally, add around 2 to 3 drops of the acetocarmine stain
10. Heat it lightly on the burner in such a way that the stain does not dry up
11. Excessive stain can be carefully treated using filter paper
12. The more stained part of the root tip can be trimmed with the help of a blade.
13. Discard the lesser stained part while retaining the more stained section
14. Add a droplet of water to it
15. With the help of a needle, a coverslip can be mounted on it

16. Gently tap the coverslip with an unsharpened end of a needle in order for the meristematic tissue of the root tip present under the coverslip to be squashed properly and to be straightened out as a fine cell layer
17. The onion root tip cells' slide is now prepared and ready to be examined for different stages of mitosis
18. Observe and study mitosis by placing the slide under the compound microscope. Focus as desired to obtain a distinct and clear image

Observations and Conclusion

1. The slide containing the stained root tip cells is placed on the stage of the compound microscope, changes taking place are noted and sketched.
2. The different phases of mitosis, such as prophase, metaphase, anaphase and telophase can be observed.

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 itself for the S phase. DNA and the chromosomes are replicated during the S phase. During G2 phase, protein synthesis increases for cell division.
4. Spindle apparatus separates chromatid or chromosomes during cell division.
5. During mitosis, identical chromosomes are distributed to each daughter cell. Chormosomal number remains after mitosis.
6. Mitosis is divided into two ph
7. Karyokinesis divides nucleus in four phases i.e., Prophase, Metaphase, Anaphase and Telophase.
8. Cytokinesis divides cytoplasm to form two individual cells.
9. Mitosis is important for genetic stability, development, growth, cell replacement, wound healing, regenration, asexual reproduction, tissue culture and cloning.
10. A diploid cell undergoing meiosis completes two successive cell divisions (Meiosis I and Meiosis II) to give rise to four haploid cells which later form gametes.
11. 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.
12. 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.
13. In sexual reproduction, two haploid gametes fuse to form a single diploid zygote.
14. Meiosis is important for mainrenance of chromosomal number in sexual reproduction and genetic variations.

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

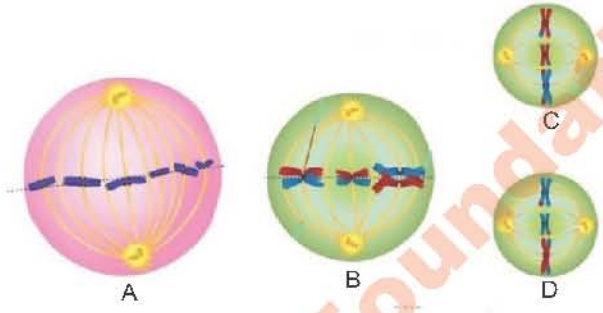
1. A bivalent consists of:
   A) Two chromatids and one centromere
   B) Four chromatids and two centromeres
   C) Four chromatids and four centromeres
   D) Two chromatids and two centromeres
2. During cell division spindle fibres attach a chromosome at:
   A) Centromere B) Telomere
   C) upper arm of chromosome D) lower arm of chromosome
3. Some student of SSC observed a thin cross section from root tip of onion plant under the microscope. They found dividing cells at different stages of their life cycle. One of the students found a cell at late prophase and counted 28 chromosomes in it. The number of chromosomes in daughter cells should be:
   A) 14 B) 28 C) 56 D) 07
4. Crossing over results in genetic recombination. It occurs between:
   A) Two chromatids of the same chromosome.
   B) Two chromatids of any two non-homologous chromosomes
   C) Two chromatids of opposite gametes
   D) Two chromatids of homologous chromosomes
5. The spindle apparatus of plants differs from that of animals in not having:
   A) microtubules B) equator of spindle
   C) centrioles D) centromere
6. Substance and energy required for the replication of DNA is accumulated in the cell during:
   A) G_1 B) G_2 C) S phase D) M phase
7. All of the following events takes place both in mitosis and meiosis except:
   A) Condensation of chromatin to form chromosomes
   B) Formation of spindle apparatus
   C) Nuclear envelop and nucleolus disappear
   D) Chromosomes pair for crossing over
8. The cell shown in this diagram is passing through:

   A) Prophase I of meiosis B) prophase of mitosis
   C) telophase of meiosis I D) anaphase of meiosis II

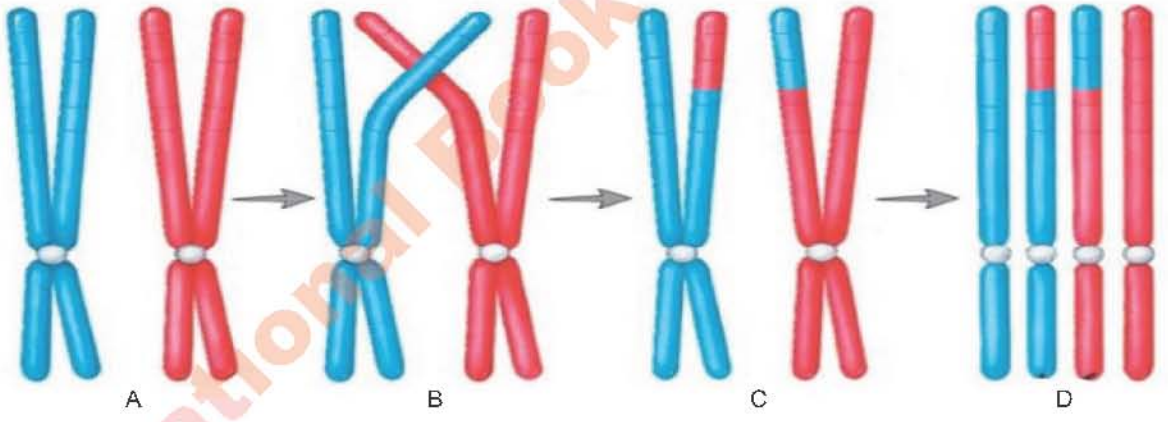
9. The longest phase of meiosis is:
   A) Interphase I
   B) Prophase I
   C) interphase II
   D) prophase II

10. What causes the number of chromosomes to reduce to half when a cell divides by meiosis?
   A) replication of DNA during interphase I
   B) separation of homologous chromosomes during meiosis I
   C) separation of sister chromatids of all the chromosomes during meiosis I.
   D) crossing over during meiosis I

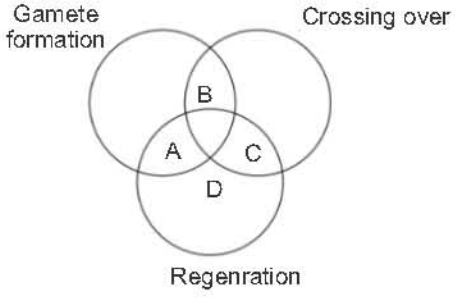
11. Which of the following cell is at Metaphase I stage?



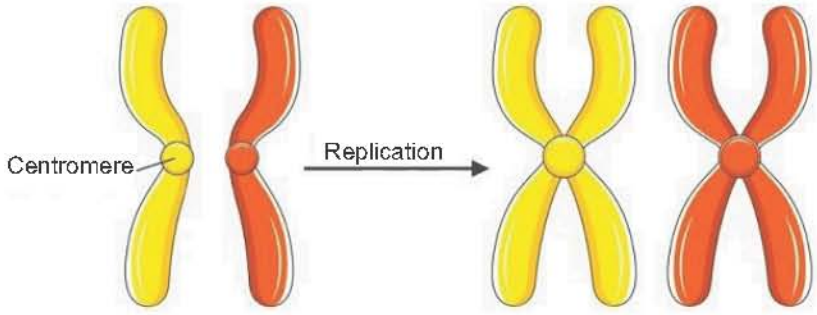
12. This diagram is showing different stages of crossing over. Which stage contains chiasma?



13. Which processes involve meiosis?



14. diagram shows replication of chromosomes.



What is the total number of chromosomes in this diagram?

A. 2 B. 3 C. 4 D. 6

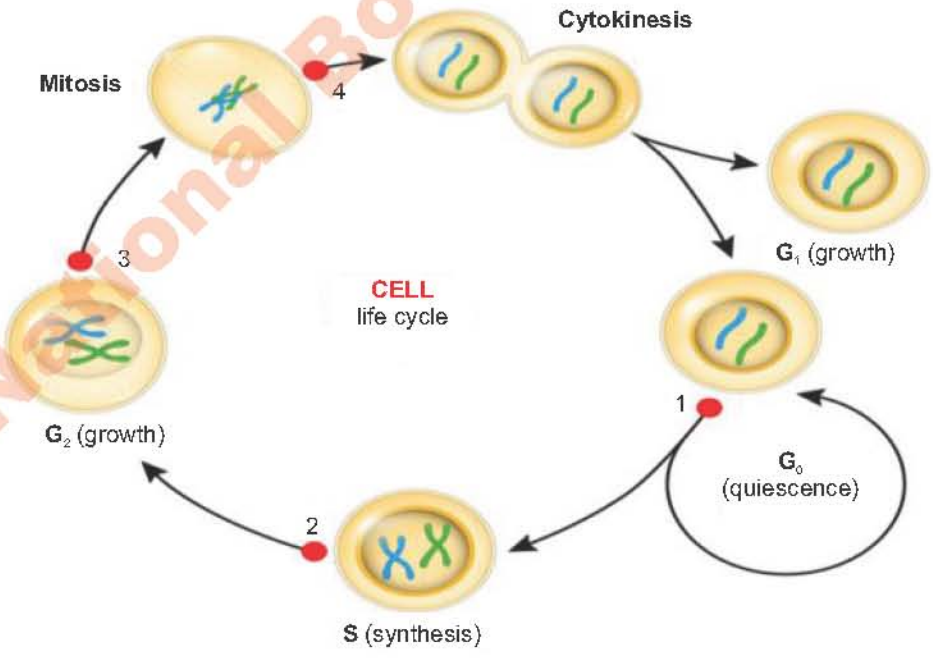
15. Chromosomal number of Fruit fly is 8. The gametes of fruit fly contain:

A. 2 chromosomes B. 4 chromosomes

C. 8 chromosomes D. 16 chromosomes

Section II: Short Answer Questions

1. Explain spindle apparatus in detail
2. What is the significance of crossing over?
3. Enlist the events taking place during G_1 phase.
4. Cell cycle below shows the formation of two daughter cells, cell A and cell B. Cell A continues in the cell cycle while cell B exits in G_o.

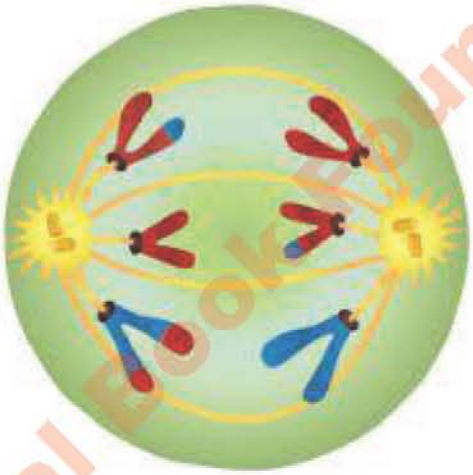


What will be the difference in materials they synthesize after the production of cell A and cell B?

5. Why do epithelial cells of skin divide continuously?
6. Give differences between meiosis I and meiosis II.
7. In rapidly dividing cells which phase of cell cycle is reduced? Explain.
8. What is the difference between cytokinesis of a plant cell and an animal cell?
9. Both skin cells and cancerous cells divide rapidly. Why cancerous cells are harmful but skin cells are not?
10. How haploid organisms produce gametes?
11. Downs syndrome is due to extra copy of chromosome number 21. That is why Down syndrome people have 47 chromosomes. Why their chromosome number is high?

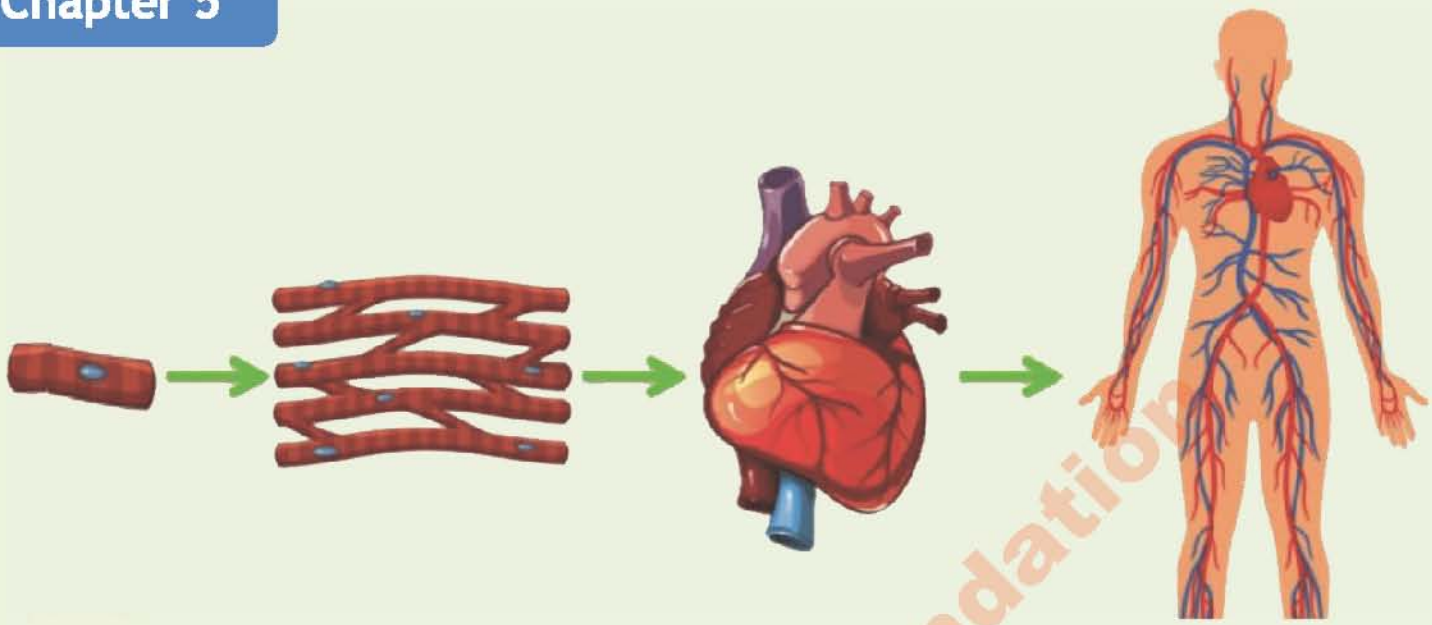
Section III: Extensive Answer Questions

1. If a cell completes meiosis I but meiosis II fails to occur, what type of anomalies will appear in the two daughter cell thus formed?
2. A cell is shown in this diagram. Answer following questions after observing it.



   a. Give at least one finding on the basis of which you can identify it animal or plant cell.
   b. Identify the stage of cell division the given cell is passing through?
   c. Enlist the reasons of your identification.
3. Meiosis II is identical to mitosis, explain.

Chapter 5



TISSUES, ORGANS AND ORGAN SYSTEMS

SLOs: After completing this lesson, the student will be able to:

1. Describe the concept of emergent properties as gain in functionalities and how it applies to the following:
   a. going from sub cellular organelles to cells
   b. going from cells to tissues
   c. going from tissues to organs
   d. going from organ to systems
   e. going from organ systems to living organisms
2. Distinguish between tissues, organs and systems, with examples from animals and plants.
3. Enlist the different types of tissues come together to form the stomach organ in the human body.
4. Discuss the organ systems come together to form the human body.
5. Describe the advantages of homeostasis.
6. Discuss the various organs and systems of the human body work to maintain homeostasis.
7. Discuss the different types of tissues come together to form the leaf.
8. Explain plant physiology in terms of structure and roles of various plant organs.

5.1 THE LEVELS OF ORGANIZATION

Whether we study an individual organism or the world as whole, we can identify a pattern of increasing complexity. Cell organelles are the parts that make up a cell, like the nucleus, ribosomes and the mitochondria. Each individual organelle has a specific role to play, and when combined, multiple organelles will form a single cell.

The cells in complex multicellular organisms like human beings are organized into **tissues** i.e., groups of similar cells that work together on a specific task. **Organs** are structures made up of two or more tissues organized to carry out a particular function, and groups of organs with related functions make up different **organ systems.**

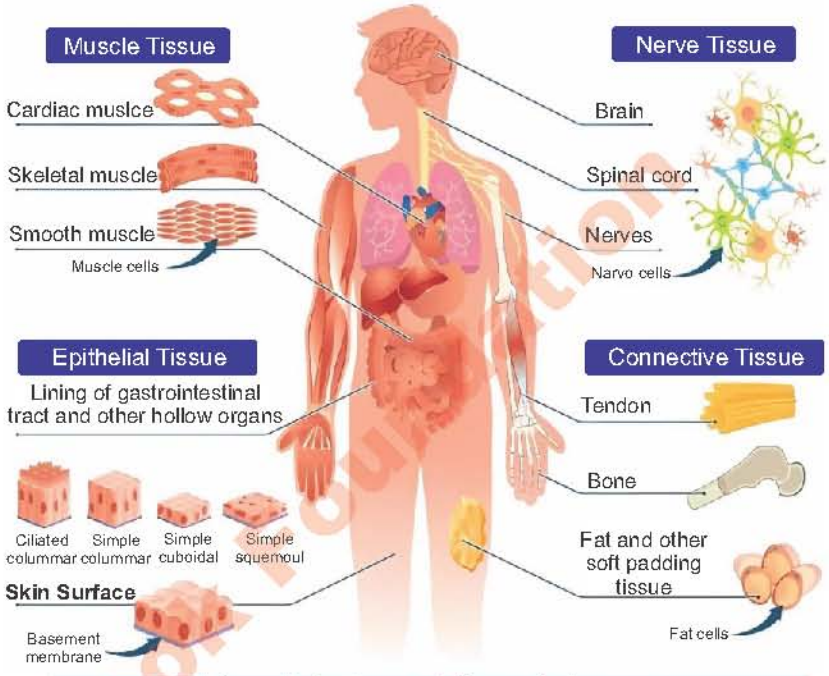


Figure 5.1: Types of tissues in humans

At each level of organization—cells, tissues, organs, and organ systems—structure is closely related to function. For instance, the cells in the small intestine that absorb nutrients look very different from the muscle cells needed for body movement. The structure of the heart reflects its job of pumping blood throughout the body, while the structure of the lungs maximizes the efficiency with which they can exchange gases.

Table 5.1: The Levels of Organization and their 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

5.1.1. Organs

Organs, such as the heart, the lungs, the stomach, the kidneys, the skin, and the liver, are made up of two or more types of tissues organized to serve a particular function. For example, the heart pumps blood, the lungs bring in oxygen and eliminate carbon dioxide, and the skin provides a barrier to protect internal structures from the external environment.

Most organs contain all four tissue types. The layered walls of the

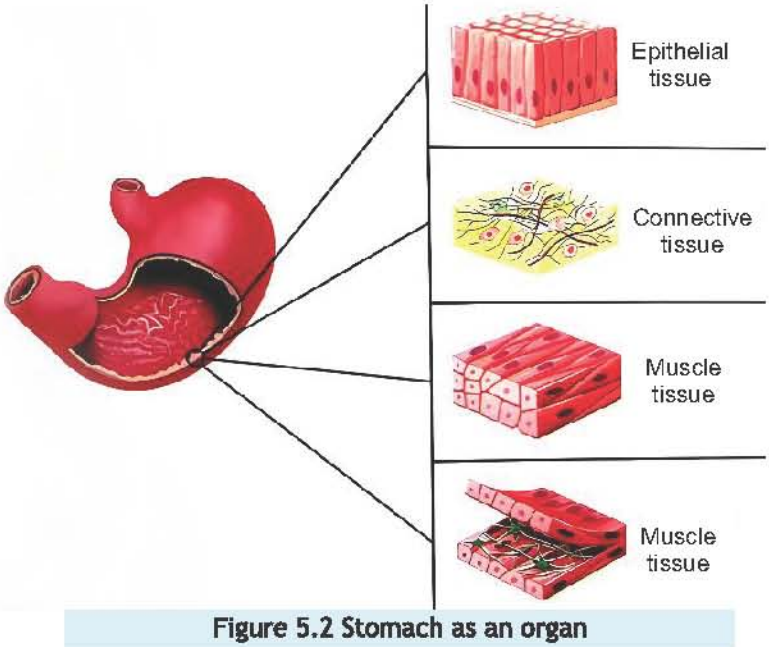


Figure 5.2 Stomach as an organ

stomach provide a good example of how tissues form an organ. The inside of the stomach is lined by epithelial cells which secretes mucus, hydrochloric acid and pepsin enzyme. Around the epithelial layer are layers of connective tissue and smooth muscle, along with glands, blood vessels, and neurons. The smooth muscle contracts to move food through the gut. Connective tissues support the tissues of the mucosa and connect it to the muscular layer. The blood supply of the submucosa provides nutrients to the wall of the stomach. Nervous tissue in the submucosa controls smooth muscle contraction and secretion of digestive substances.

5.1.2. Organ systems

Organs are grouped into **organ systems**; in which they work together to carry out a particular function for the organism.

For example, the heart and the blood vessels make up the cardiovascular system. They work together to circulate the blood, bringing oxygen and nutrients to cells throughout the body and carrying away carbon dioxide and metabolic wastes. Another example is the respiratory system, which brings oxygen into the body and gets rid of carbon dioxide. It includes the nose, mouth, pharynx, larynx, trachea, and lungs.

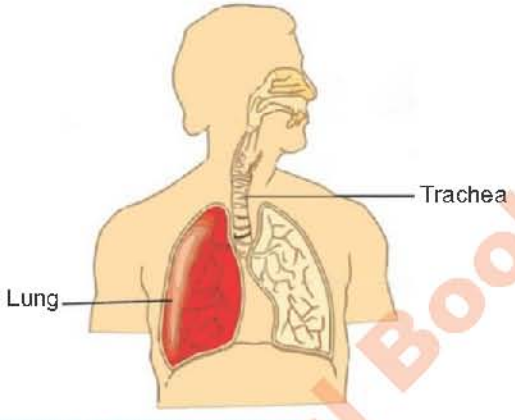


Figure 5.3 Respiratory system

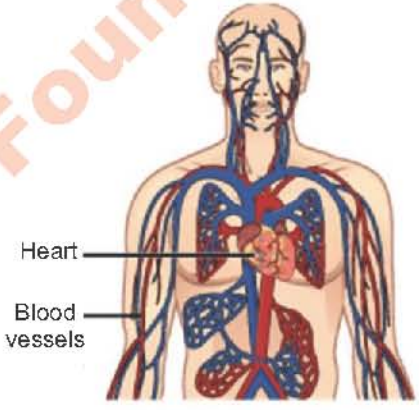


Figure 5.4 Circularity system

5.1.3. Organ systems work together

Just as the organs in an organ system work together to accomplish their task, the different organ systems also cooperate to keep the body running.

For example, the respiratory system and the circulatory system work closely together to deliver oxygen to cells and get rid of the carbon dioxide that these cells produce. The circulatory system picks up oxygen in the lungs and drops it off in the tissues, then performs the reverse function for carbon dioxide. The lungs expel the carbon dioxide and bring in new oxygen-containing air. Only when both systems are working together can oxygen and carbon dioxide be successfully exchanged between cells and environment.

5.2 HOMEOSTASIS

The tendency to maintain a stable, relatively constant internal environment is called **homeostasis**. The body maintains homeostasis for many factors for example, temperature, the concentration of various ions, pH and the concentration of glucose. If these values get too high or low, you can end up getting very sick.

Homeostasis is maintained at many levels, not just the level of the whole body as it is for temperature. For instance, the stomach maintains a pH that's different from that of surrounding organs, and each individual cell maintains ion concentrations different from those of the surrounding tissue fluid. Maintaining homeostasis at each level is key to maintaining the body's overall function. So, how is homeostasis maintained?

5.2.1. Maintaining homeostasis

Biological systems like those of your body are constantly being pushed away from their balance points. For instance, when you exercise, your muscles increase heat production, pushing your body temperature upward. Similarly, when you drink a glass of fruit juice, your blood glucose goes up. Homeostasis is the ability of your body to detect and oppose these changes and work to maintain balance points.

5.2.2. Homeostatic responses in temperature regulation

If you get either too hot or too cold, sensors in the periphery and the brain tell the temperature regulation centre of your brain—in a region called the hypothalamus—that your temperature has strayed from its set point.

For instance, if you've been exercising hard, your body temperature can rise *above* its set point, and you'll need to activate mechanisms that cool you down. Blood flow to your skin increases to speed up heat loss into your surroundings, and you might also start sweating so the evaporation of sweat from your skin can help you cool off. Heavy breathing can also increase heat loss.

How does this work? First, high temperature will be detected by **sensors**—primarily nerve cells with endings in your skin and brain—and relayed to a temperature-regulatory **control centre** in your brain. The control centre will process the information and activate **effectors**—such as the sweat glands—whose job is to oppose the stimulus by bringing body temperature down.

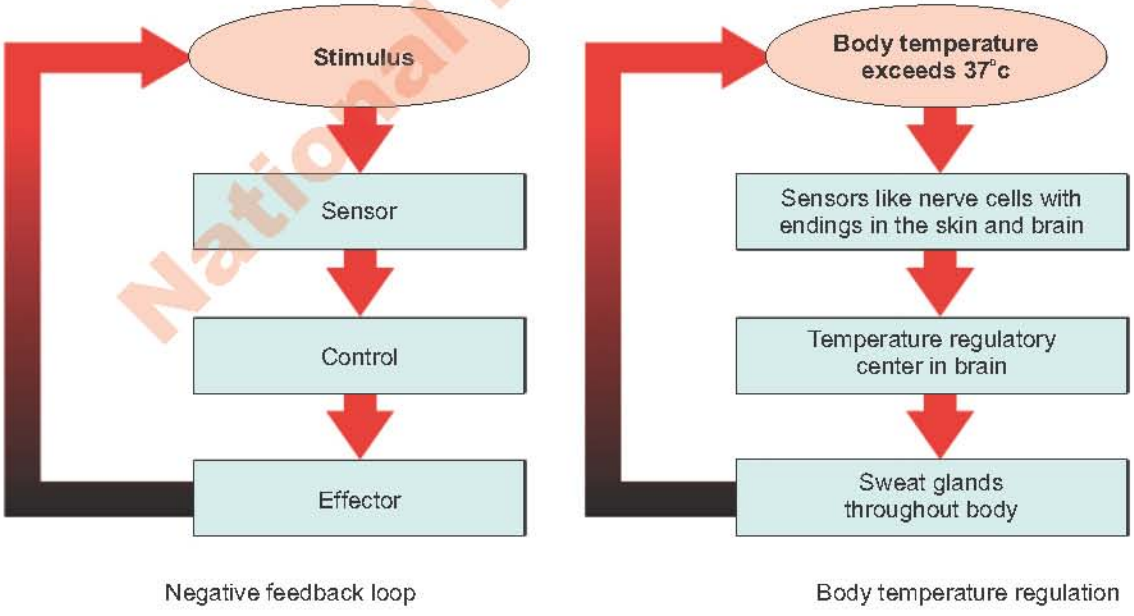


Figure 5.5: Homeostatic response in temperature regulation

Table 5.2: Major organ systems of the human body and homeostasis			
Organ system	**Function**	**Organs, tissues, and structures involved**	**Role in Homeostasis**
Cardiovascular	Transports oxygen, nutrients, and other substances to the cells and transports wastes, carbon dioxide, and other substances away from the cells	Heart, blood, and blood vessels	help stabilize levels of gases and wastes, body temperature and pH
Lymphatic	Defends against infection and disease and transfers lymph between tissues and the blood stream	Lymph, lymph nodes, and lymph vessels	Maintain tissue fluid homeostasis
Digestive	Processes foods and absorbs nutrients, minerals, vitamins, and water	Mouth, salivary glands, oesophagus, stomach, liver, gallbladder, exocrine pancreas, small intestine, and large intestine	Maintains levels of nutrients in blood
Endocrine	Provides communication within the body via hormones and directs long-term change in other organ systems to maintain homeostasis	Pituitary, pineal, thyroid, parathyroid, endocrine pancreas, adrenals, testes, and ovaries.	Maintains balance of many blood components like glucose, water, calcium etc.
Integumentary	Provides protection from injury and fluid loss and provides physical defence against infection by microorganisms;	Skin, hair, and nails	Involved in temperature regulation
Muscular	Provides movement and support	Skeletal, cardiac, and smooth muscles	Helps in temperature regulation by heat production

Table 5.2: Major organ systems of the human body and homeostasis

Organ system	Function	Organs, tissues, and structures involved	Role in Homeostasis
Nervous	Collects, transfers, and processes information and directs short-term change in other organ systems	Brain, spinal cord, nerves, and sensory organs—eyes, ears, tongue, skin, and nose	Maintains homeostasis by rapidly controlling body functions
Respiratory	Delivers air to sites where gas exchange can occur	Mouth, nose, pharynx, larynx, trachea, bronchi, lungs, and diaphragm	Controlling the balance of oxygen and carbon dioxide in the body
Skeletal	Supports and protects soft tissues of the body; provides movement at joints; produces blood cells; and stores minerals	Bones, cartilage, joints, tendons, and ligaments	By regulating the level of calcium and other minerals in the blood (storing or releasing them from bones)
Urinary	Removes excess water, salts, and waste products from the blood and body and controls pH	Kidneys, ureters, urinary bladder, and urethra	By regulating levels of water, salts, H+ and wastes in blood
Immune	Defends against microbial pathogens—disease-causing agents—and other diseases	Leukocytes, tonsils, adenoids, thymus, and spleen	By removing pathogens, fighting infections and helping in healing

5.3 PLANT TISSUES

Plants are multicellular eukaryotes with tissue systems. Plant tissues are composed of cells that are similar and perform a specific function. Different tissues combine to form organs. Each organ itself is also specific for a particular function together making up the tissue systems.

Plant tissues differentiate into three main types: dermal, ground, and vascular tissue. **Dermal tissue** covers and protects the plant. The **ground tissue** serves as a site for photosynthesis,

provide support, and helps to store water and sugars. The **vascular tissue** transports water, minerals, and sugars to different parts of the plant.

5.3.1. Plant organs and organ systems relation with plant physiology

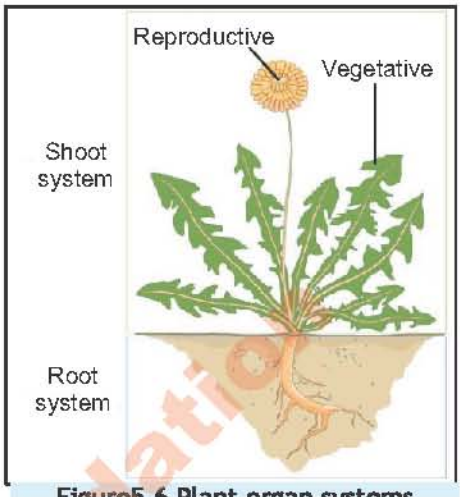


Figure5.6 Plant organ systems

Plant tissues form **organs** (such as leaves, stems, or roots), each of which perform a specific set of functions. Leaves perform photosynthesis. Stems support the plant and transport substances.

Together, organs often work to form **organ systems.** Vascular plants have two distinct organ systems: a shoot system, and a root system. The **shoot system** consists of two portions: the vegetative (non-reproductive) parts of the plant, such as the leaves and the stems, and the reproductive parts of the plant, which include flowers and fruits. The shoot system generally grows above ground, where it absorbs the light needed for photosynthesis. The **root system**, which is usually underground anchors the plant into the ground, absorbs water and minerals, and serves as a storage site for food.

5.3.2. Structure and Functions of Cells of a Leaf

Leaves are thin, flat organs responsible for photosynthesis in the plants. It develops laterally at the node. It is an important part of the shoot system as it performs photosynthesis and transpiration. Leaf cells need water, carbon dioxide and light for photosynthesis and oxygen for respiration. Leaves transfer the synthesized food to other parts of the plant. So, there are varieties of functions and accordingly there are varieties of cells, in the leaf. Each type of cell performs a special function.

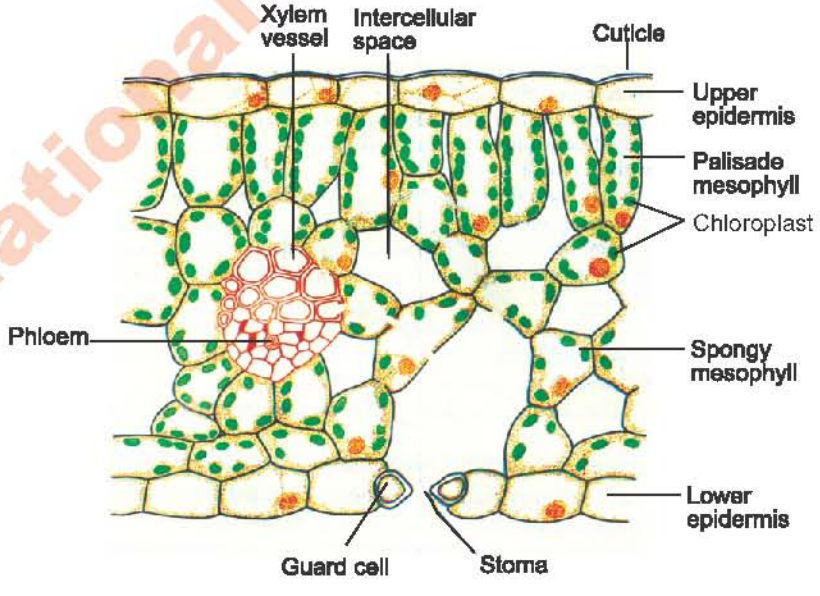


Fig 5.7 : Transverse section of a leaf

Epidermis is the outermost layer. It is a 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 with the environment 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 i.e., **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 shaped 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.

Activity 4: Study of animal tissues	
Materials required	**Main skills practised**
Compound microscope Prepared slides of sections of animal's epithelial, connective, muscle and nervous tissue Charts of animal's epithelial, connective, muscle and nervous tissue	Following instructions Using microscope Observing slides Making drawings Interpreting results Making conclusions

Introduction

In this activity you will have an opportunity to observe animal tissues. You will identify shape of cells and relate it with function of tissue.

Points for pre-lab discussion
Q.1. What is a tissue?
Q.2. How do animals support their body parts, absorb materials or move?
Q.3. Do you except any "photosynthetic tissue" in animals?
Q.4. What is the location of different tissues in animals?

Procedure

a. You are provided with charts and slides of four types of tissues.
b. Study the features of these tissues from charts.
c. Examine each tissue type one by one under the microscope using the low power lens first and then the high power lens to see greater details.
d. Fill in the following table using the results of your observations.

TISSUE	DIAGRAM: LABEL MAJOR PARTS
Epithelial tissue	
Connective tissue	
Muscle tissue	
Nervous tissue	

SUMMARY

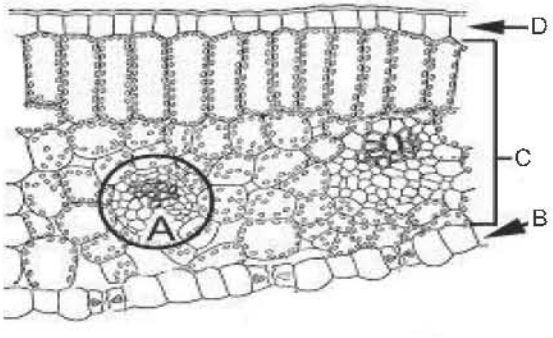
1. Cell organelles are sub cellular structures which work together to form cells.
2. Group of cells with similar functions make tissues.
3. Organs are structures made up of two or more tissues organized to carry out a particular function.
4. Groups of organs with related functions make up different organ systems.
5. All organ system work in a coordinated way to keep the organism living and working.
6. The tendency to maintain a stable, relatively constant internal environment is called homeostasis.
7. Different organ systems of an organism work together to maintain homeostasis.
8. Plant tissues differentiate into three main types: dermal, ground, and vascular tissue.
9. Animal tissues differentiate into four main types: epithelial, connective, muscular and nervous tissue.

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

1. The diagram shows cells in part of the leaf of a green plant. Which region contains cells which are responsible for the process of transport?



2. 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

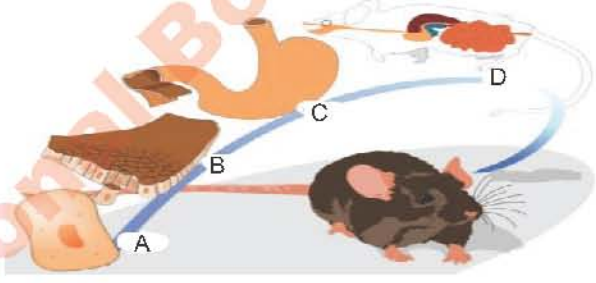
3. What are the functions of xylem and phloem in green plants?

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

4. If tissue level is not developed in the level of organization, which next level will not form?

A) Molecular level B) atomic level C) organ level D) organelle level

5. Following diagram shows level of organization in a rat. Which one is the organ level?



6. Which of the following lists the levels of body organization from smallest to largest?

A) organism, organ system, organ, tissue, cell

B) tissue, cell, organ, organ system, organism

C) organ, organ system, organism, tissue, cell

D) cell, tissue, organ, organ system, organism

7. This statement about Homeostasis is incorrect:

A) because of this, the fluctuations of the internal environment are of extremely narrow range as compared to that of the external environment

B) there is one system regulating the homeostatic activities

C) homeostatic mechanisms keep the internal environment constant despite wide changes in the external environment

D) homeostasis is necessary for the survival of cells

8. Which of the following statements best describes homeostasis?

A) keeping the body in a fixed and unaltered state

B) dynamic equilibrium

C) maintaining a near-constant internal environment

D) altering the external environment to accommodate the body's needs

9. Organisms have the ability to change and modify their internal conditions according to the environment through:

A) osmoregulation B) excretion

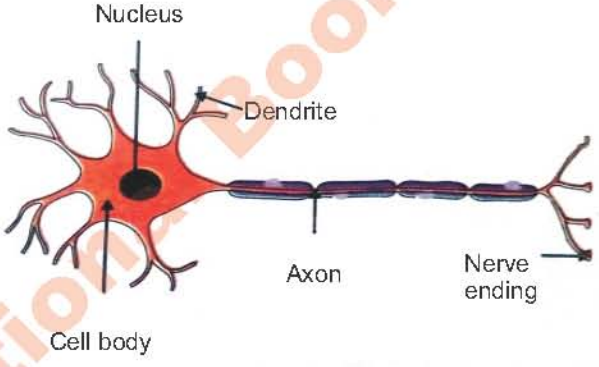
C) thermoregulation D) all of the above

10. You can observe spongy mesophyll and xylem in the section of leaf. These are part of the same:

A) cell and organism B) organ and organism

C) cell and tissue D) tissue and organ

11. The diagram shows a sample of material taken from an organism.



Which level o organization does the sample show?

A) cell B) organ

C) organ system D) tissue

12. Which structure is not an organ?

A) artery B) flower

C) spinal cord D) xylem

13. Which description of xylem is correct?

A) a cell used for absorption B) an organ system used for conduction

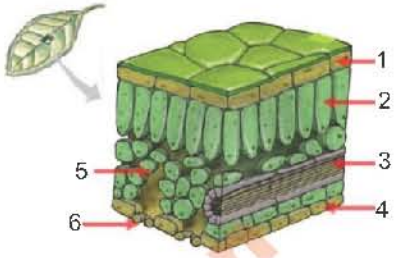
C) a tissue used for transport D) an organ used for transport

14. Which structure is at a different level of organization from the other three?

A) kidney B) liver

C) neuron D) lung

15. The diagram shows tissues from section of leaf. Which type of cells will perform photosynthesis?



A) 1 and 4 B) 2 and 5

C) 2 and 3 D) 3 and 6

Section II: Short Answer Questions

1. Can you differentiate between:

(a) Organ and organelle (b) Animal and plant tissues

(c) Xylem and phloem (d) Epithelial and muscular tissue

(e) Nervous and connective tissue (f) Epidermal and ground tissue

(g) Root and shoot system (h) Vegetative and reproductive part

2. How different tissues form stomach?
3. Why respiratory and cardiovascular systems work together?
4. How temperature is regulated in our body?

Section III: Extensive Answer Questions

1. Justify how the cells of leaf have a variety of specialized structure and function.
2. State the relationship between structure and function of root hairs, xylem vessels and red blood cell.
3. Write a detailed note on animal tissues.
4. Give an account of levels of biological organization.
5. Explain the functions of different organ system of humans.
6. How different organ systems o humans work together to maintain homeostasis?
7. Cells and tissues are adapted to perform their function in the best way. Explain this statement by using example of leaf.

Approved by National Curriculum Council, Secretariat
Ministry of Federal Education & Professional Training
vide letter No. F.1-1 (2024)-NCC/DEA/Dir/English, Dated: 04th March 2024

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