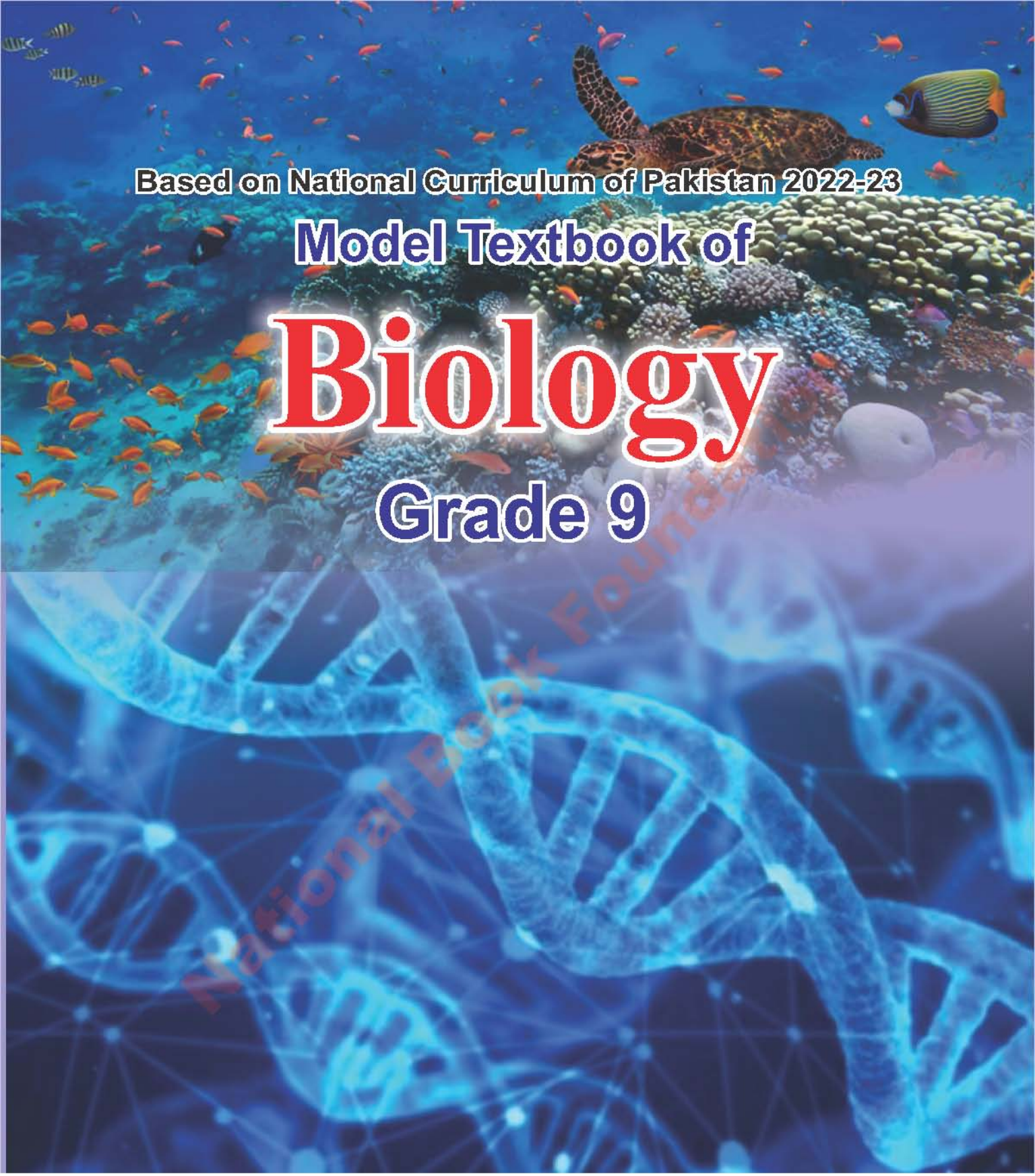

Based on National Curriculum of Pakistan 2022-23

Model Textbook of

Biology

Grade 9

National Book Foundation
as
Federal Textbook Board
Islamabad

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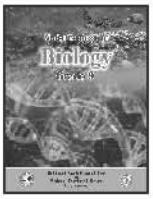

Authors
Jawaid Mohsin Malik, Ruquaya Shaikh, Dr. Kashif,
Abid Mughal, Sajid Ali Shah

Supervision
Dr. Mariam Chughtai
Director, National Curriculum Council
Ministry of Federal Education and Professional Training, Islamabad

IRC Members
Fiaz Nadeem, FDE, Dr Ijaz Ahmed, FGEIs, Ms. Shaista Nazeer, APSACS, Ms. Sana Saleem, Fazaia Teacher Training Institute Islamabad,Ms. Taseer Rehman, FDE, Zainab Wahab, Baharia, Abdul Rauf, FGEIs, Nida Liaqat, Fazaia Teacher Training Institute Islamabad, Fouzia Siddiqui, Baharia, Dr Javed Iqbal, FDE, Ms. Uzma Nasreen
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Zainab Wahab, ICT, Robeela Shabbir, Punjab, Abdul Ghani, GB, Abdul Rauf, ICT

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PREFACE

This Model Textbook 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 upon the foundation of learning from the previous grades. A key emphasis of the present textbook is on creating real life linkages of the concepts and methods introduced. This approach was devised with the intent of enabling students to solve daily life problems as they go up the learning curve and for them to fully grasp the conceptual basis that will be built upon 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 books. The present book 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 and the suggestions and feedback of students, teachers and the community are most welcome for further enriching the subsequent editions of this book.

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

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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 the leaves green but the flowers are 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 الْإِنْسَانَ مِنْ صَلْصَالٍ كَالْفَخَّارِ

"He made man from clay like the potter"

(Sura Rehman, Ayat 14)

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

3. Development

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

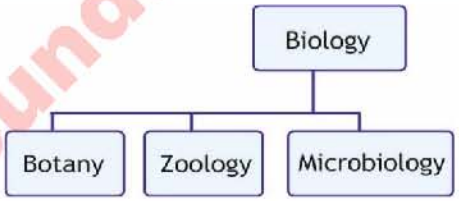
"Then fashioned we the drop a clot, then fashioned we the clot a little lump, then fashioned we the little lump bones, then clotted the bones with flesh,"

(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.

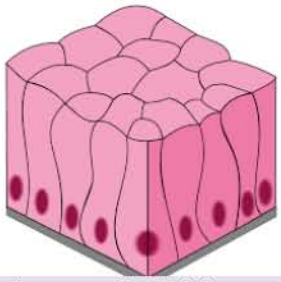


Fig 1.1. Epithelial tissue

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 *Home 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**: The study of laboratory examination of changes in tissues or organs due to diseases is called pathology. The examples of pathology are types of kidney disease, lung diseases and blood diseases etc.
14. **Immunology**: Pathology is the study and diagnosis of diseases.
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.

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.

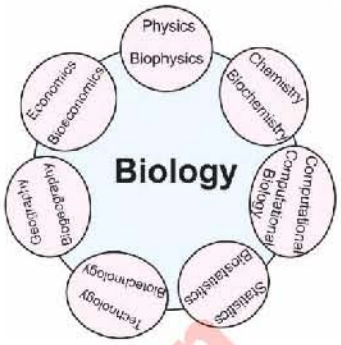


Fig. 1.3: Relationship of biology with other sciences

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.

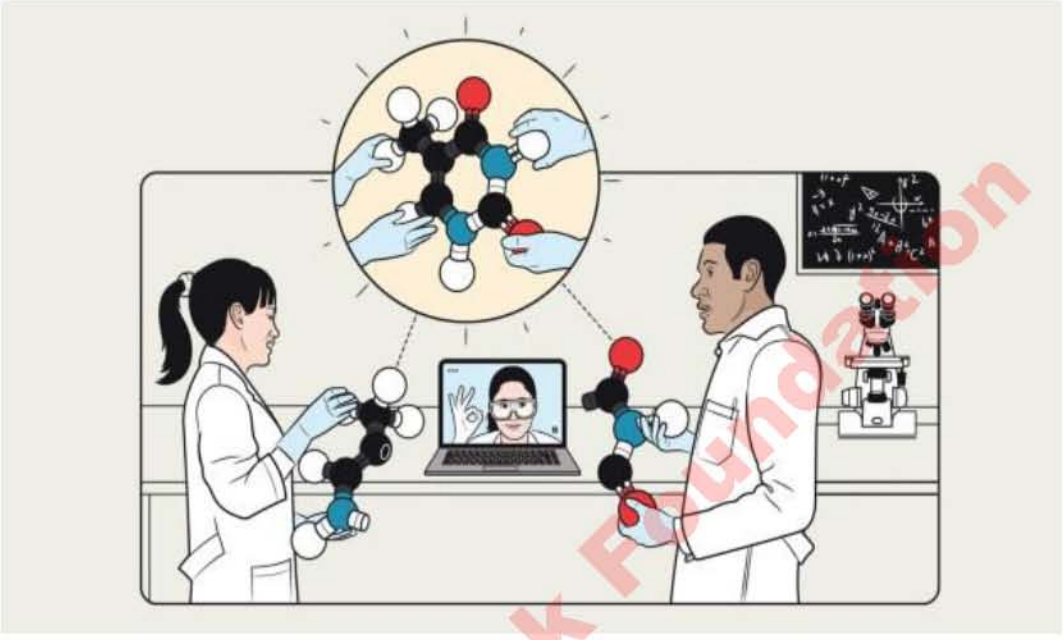


Fig.1.4. Collaboration in science

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 HYPOTHES, 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.

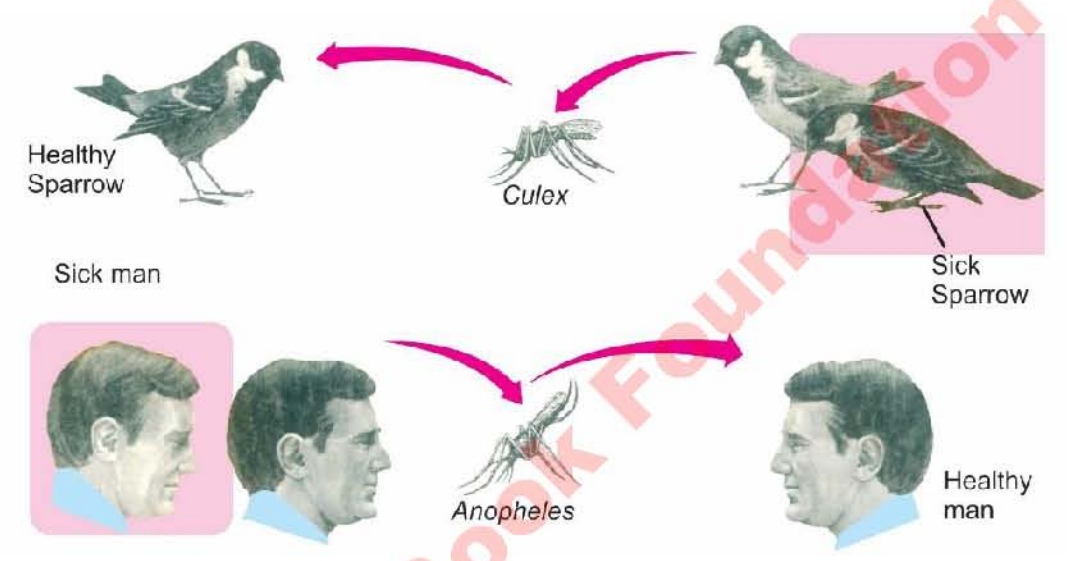


Fig. 1.5: Malaria in man is transmitted by *Anopheles* and in birds by *Culex*

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.

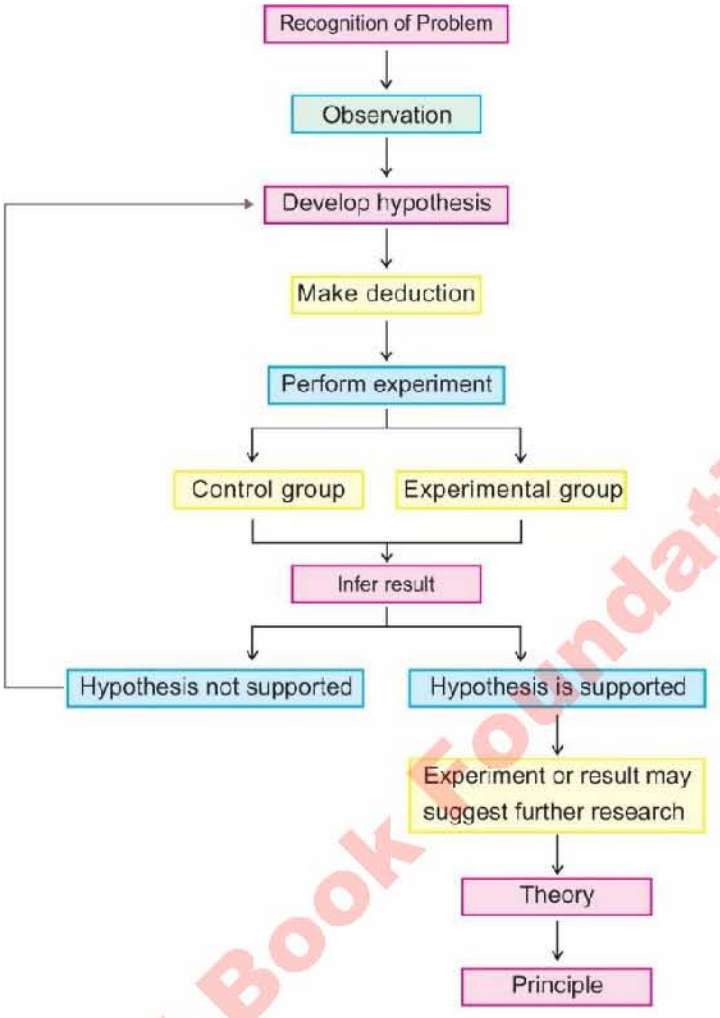


Fig 1.6: Scientific method of study

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 worked Classification method.

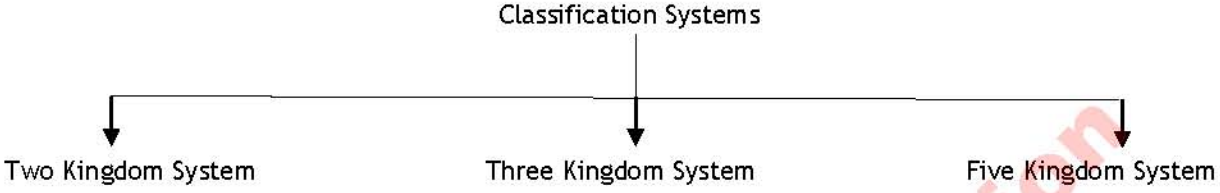
Andrea Caesalpino (1519-1603): He divided plants into fifteen groups and called them genera.

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.

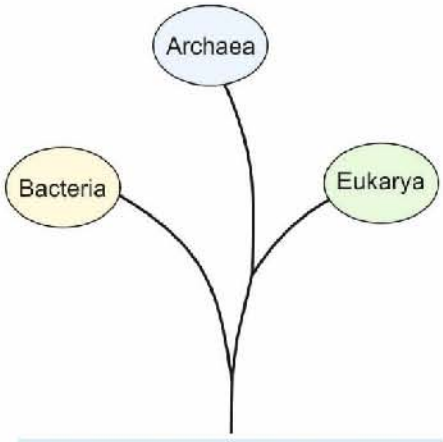


Fig. 2.2 The three domains of life

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 rigid cell wall.

2. The Domain Bacteria

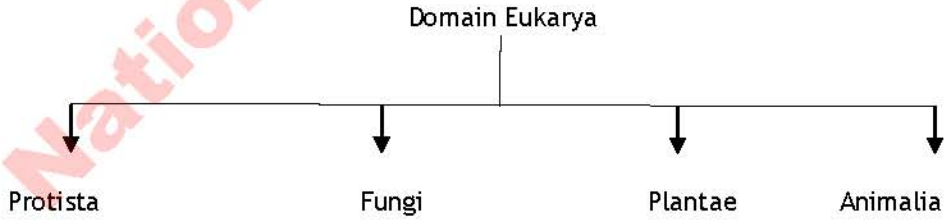
The domain bacteria have the following characteristics:

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.

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, star fish 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.

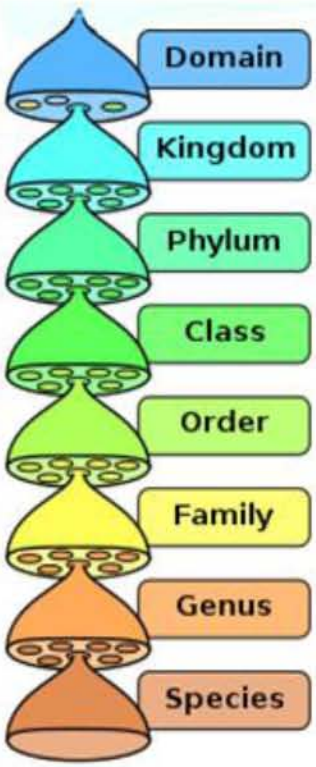


Fig2.3: Taxonomic ranks of classification

Table 2.1: Simple classification of human and pea			
Taxa	**Human**	**Taxa**	**Pea**
Kingdom	Animalia	Kingdom	Plantae
Phylum	Chordata	Phylum	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 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.

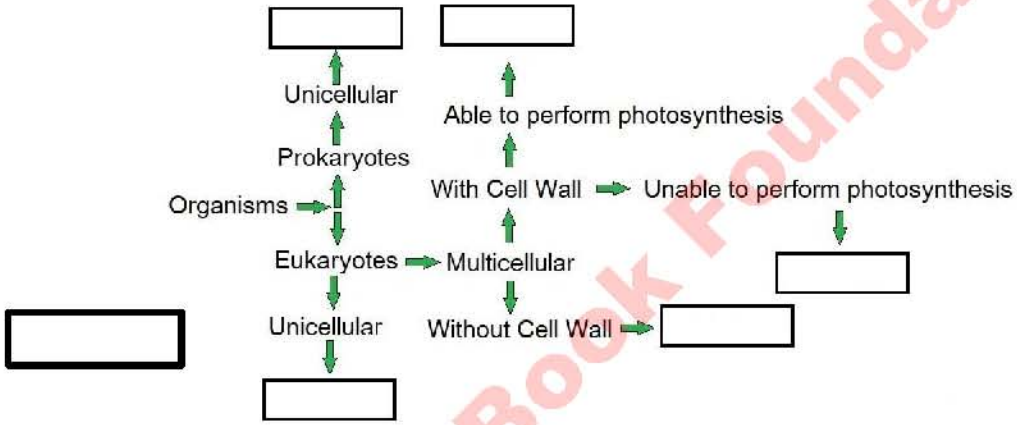
3. What is domain? Name the three domains of life.

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

5. Can you differentiate between? :

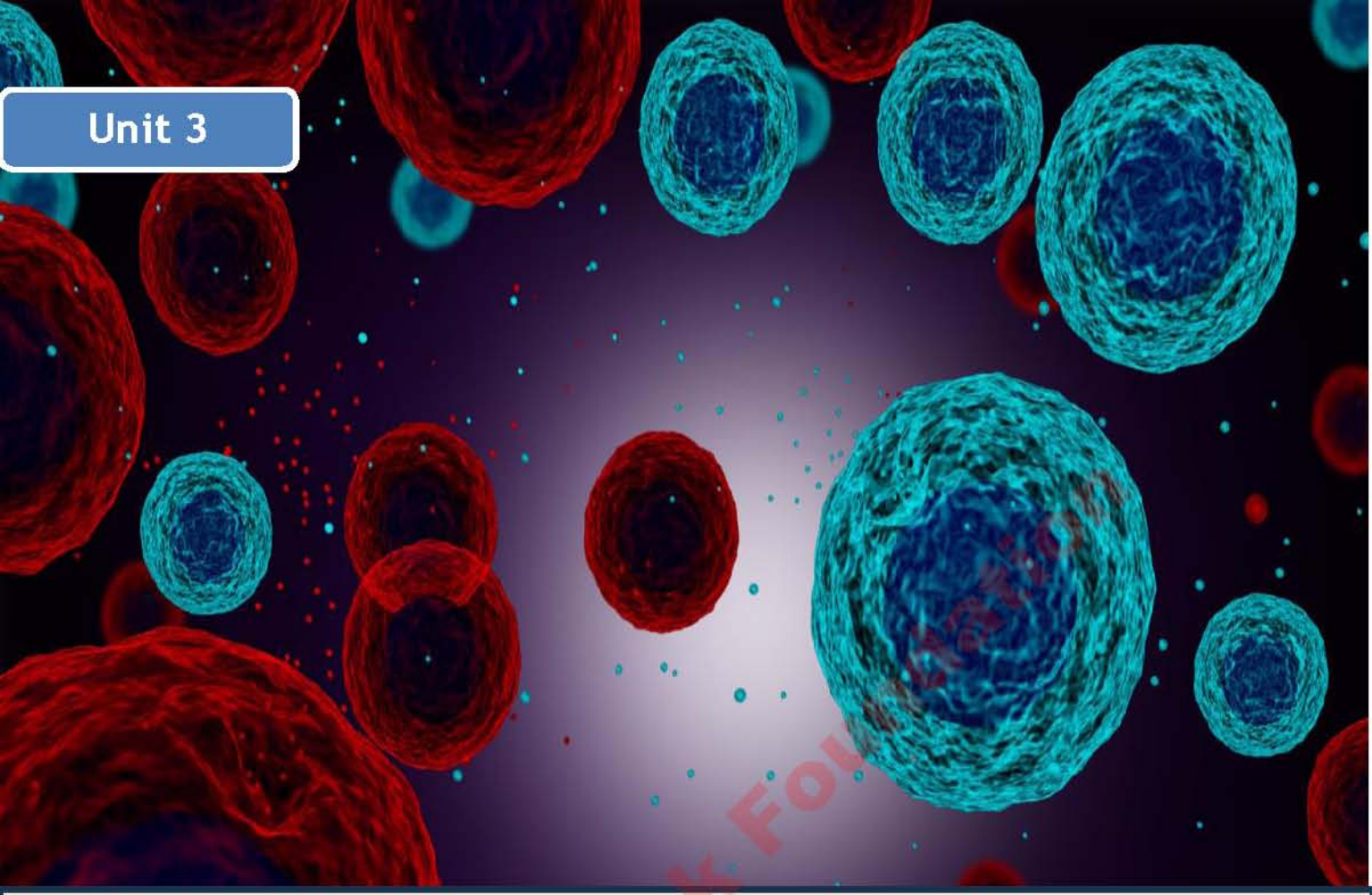
(a) Bacteria and Protists (b) Fungi and Plants (c) Plants and animals.

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.

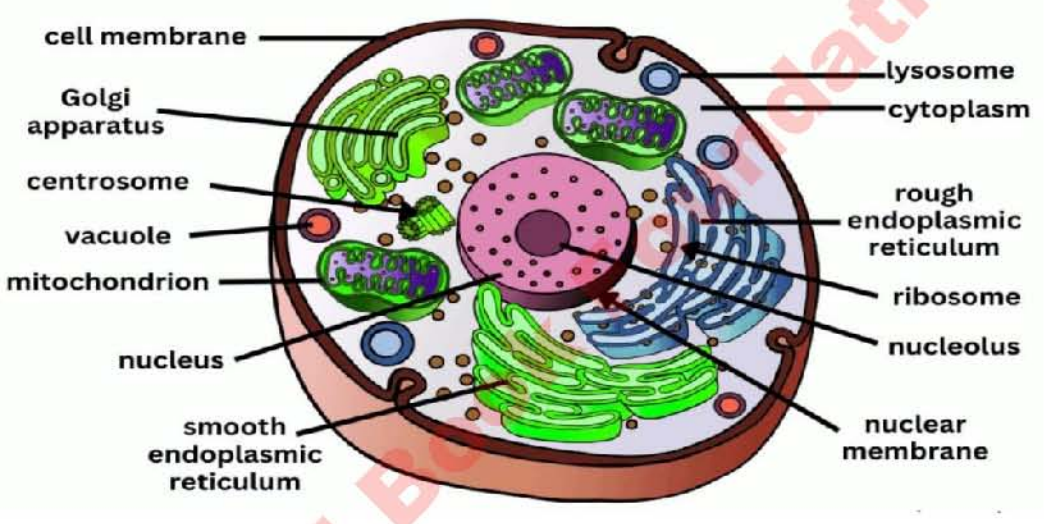


Fig 3.1: Animal cell

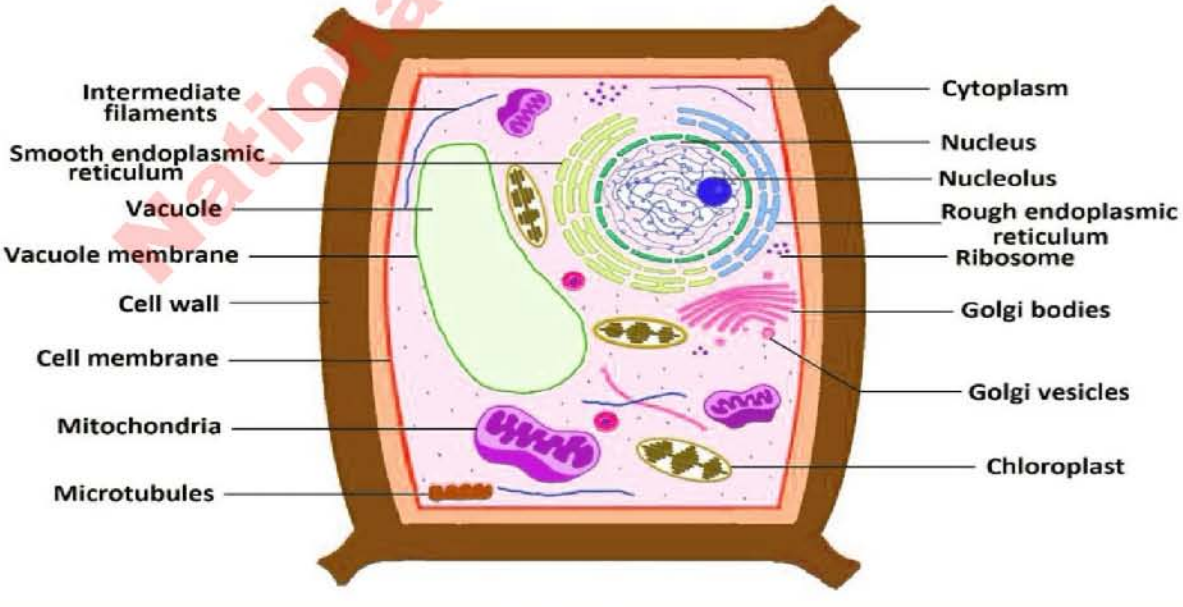


Fig 3.2: Plant cell

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.

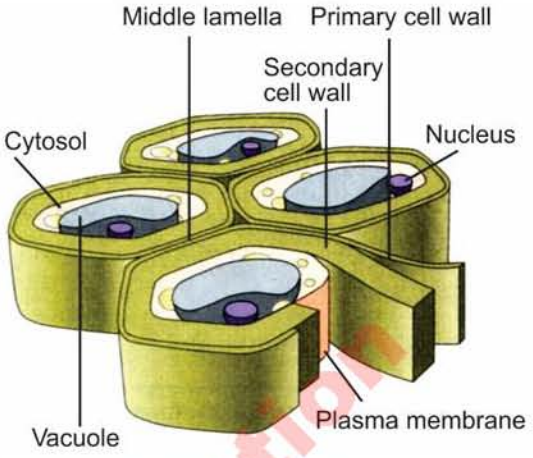


Fig 3.3: Plant Cell wall

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.

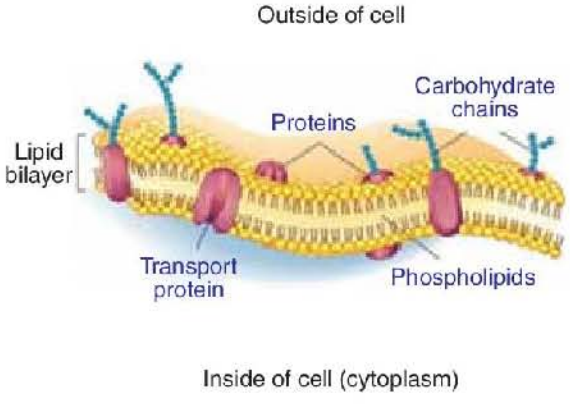


Fig 3.4. Fluid mosaic model of cell membrane

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)**.

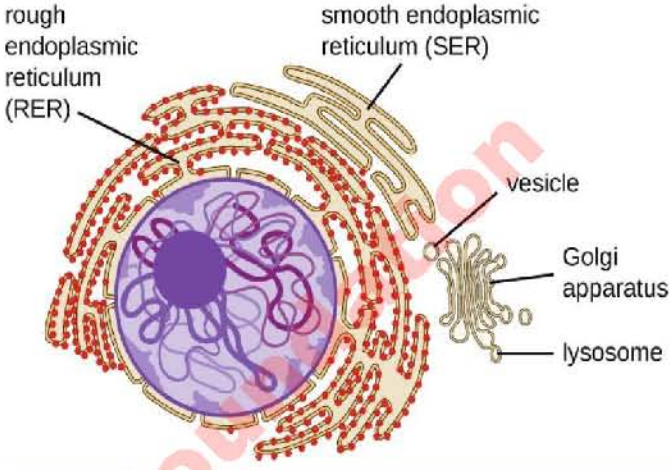


Fig 3.5: Structure of Rough and Smooth Endoplasmic Reticulum

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.

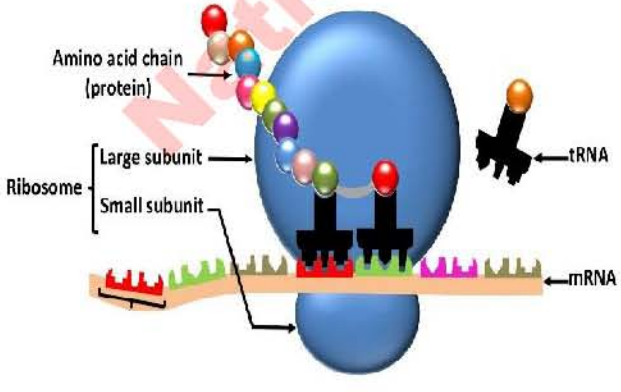


Fig 3.6: Function of ribosome

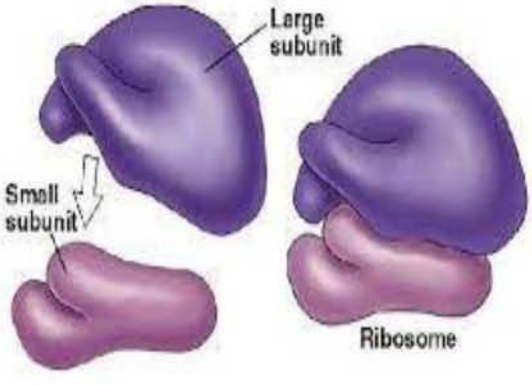


Fig 3.7: Subunits of ribosomes

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.

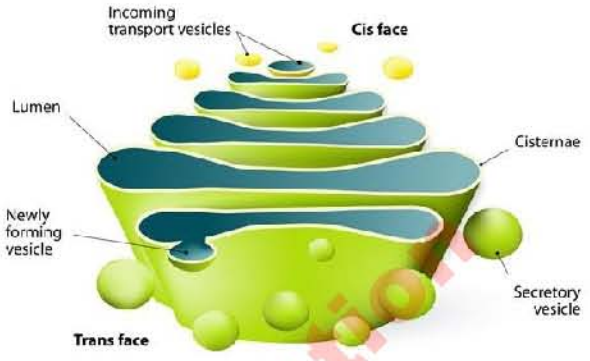


Fig 3.8: Structure of Golgi apparatus

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 in this way. In plant cell, it secretes 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.

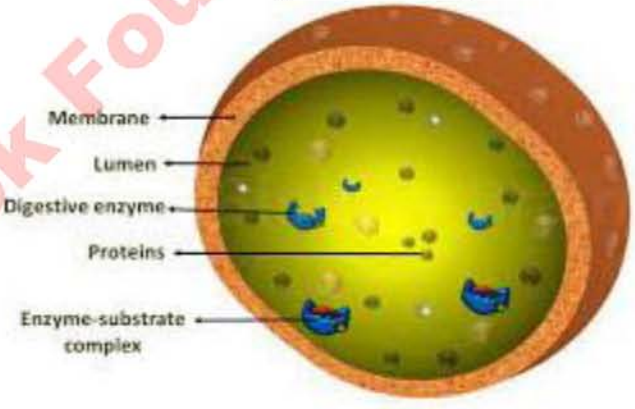


Fig 3.9: Structure of Lysosome

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**.

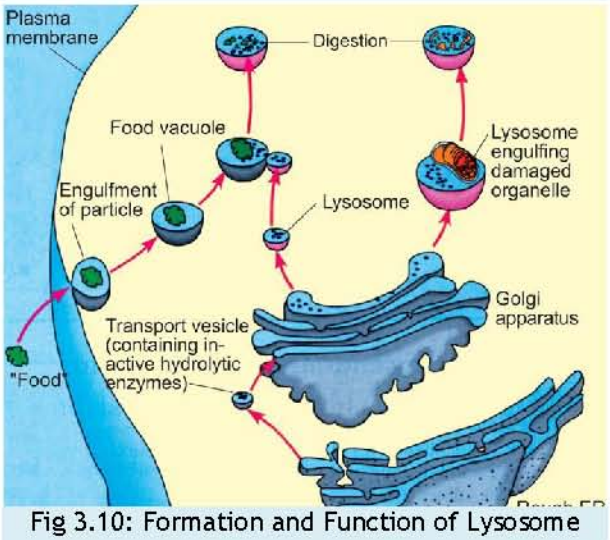


Fig 3.10: Formation and Function of Lysosome

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.

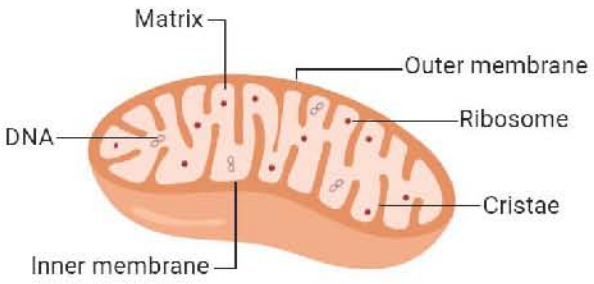


Fig 3.11: Structure of Mitochondria

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;

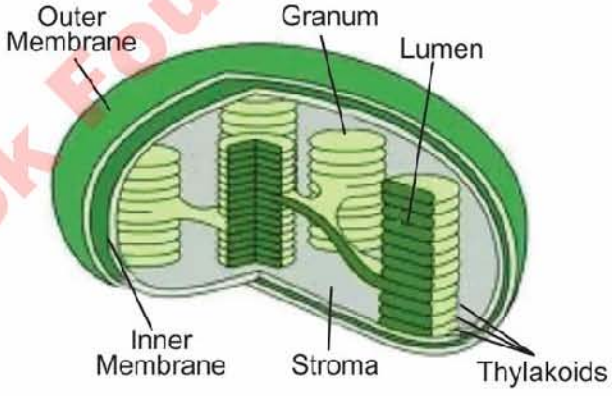


Fig 3.12: Structure of Chloroplast

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.

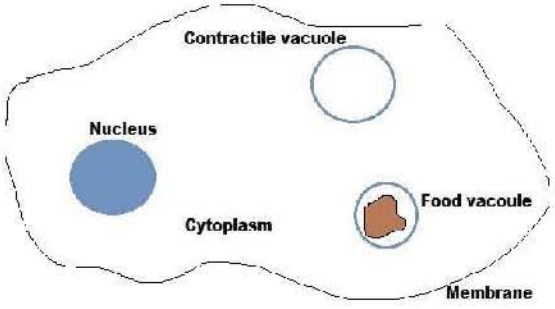


Fig 3.13: Structure and types of vacuole in animal cell

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.

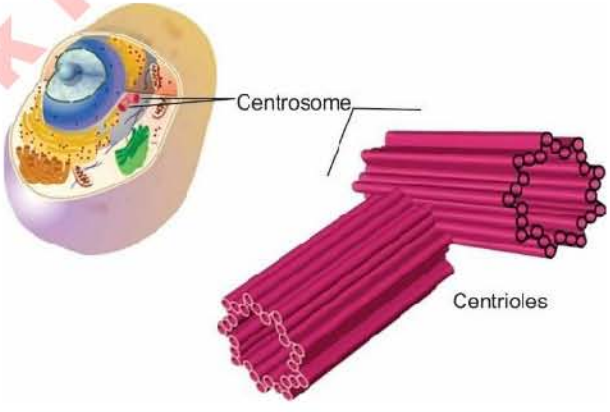


Fig 3.14: Pair of Centrioles

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.

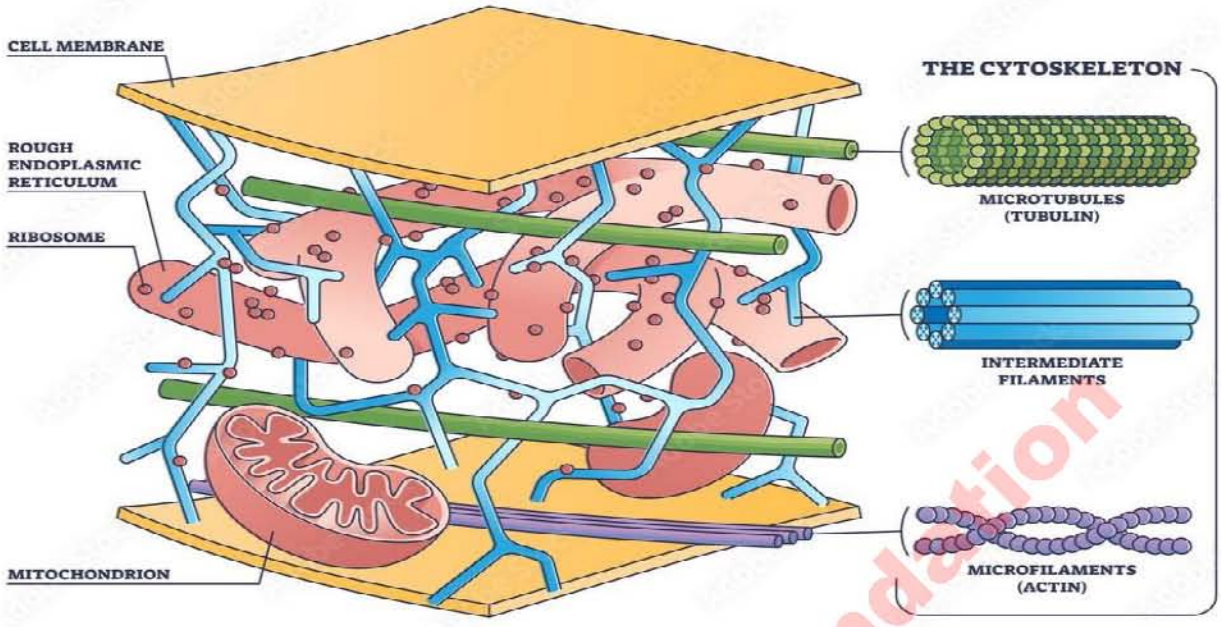


Fig 3.15: Structure and types of Cytoskeleton

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.

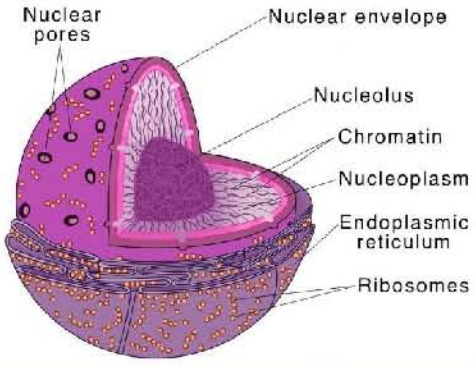


Fig 3.16: Structure of Nucleus

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.

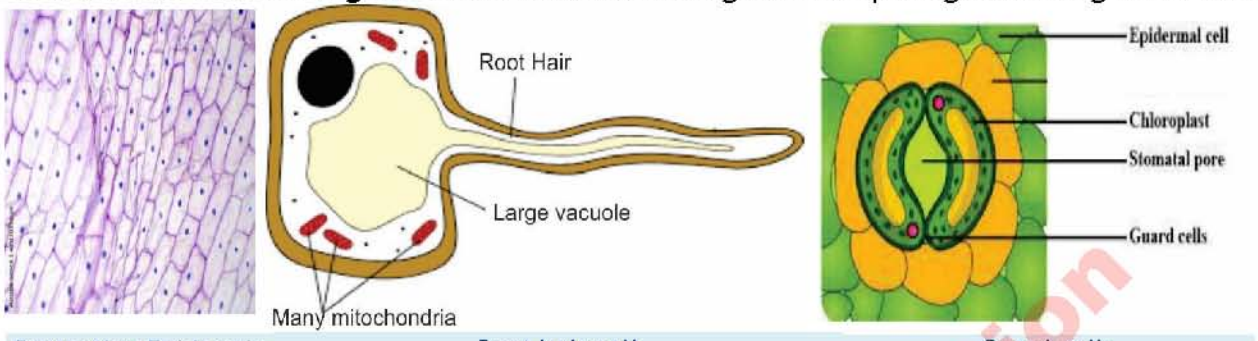


Fig 3.17: Epidermal cells

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.

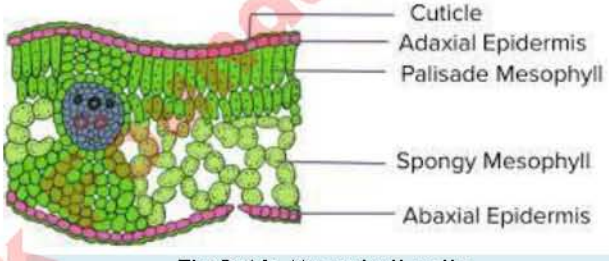


Fig 3.18: Mesophyll cells

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.

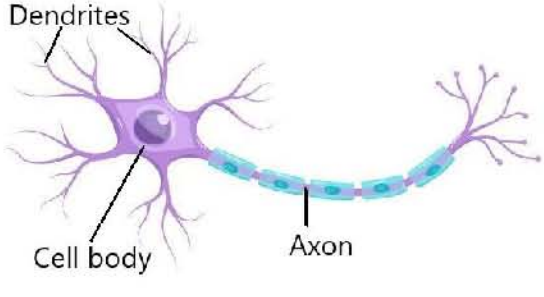


Fig 3.20: Neuron

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.

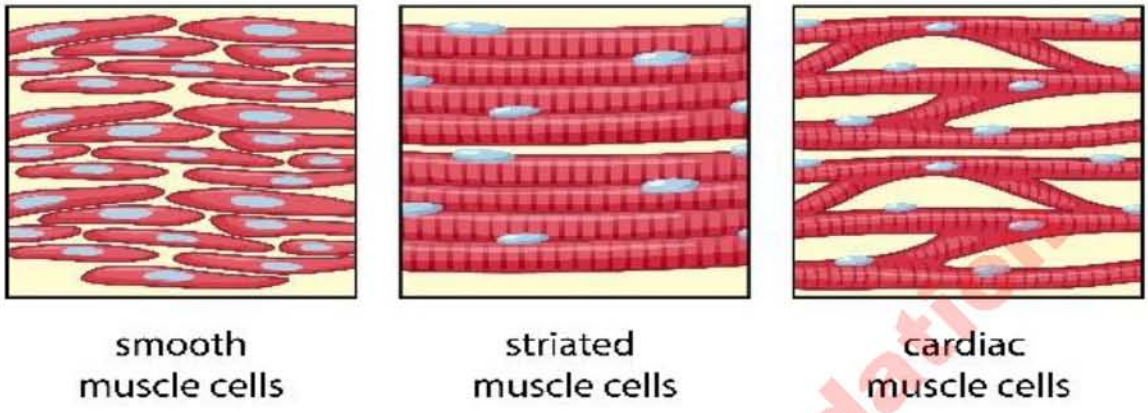


Fig 3.21: Types of muscles

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.

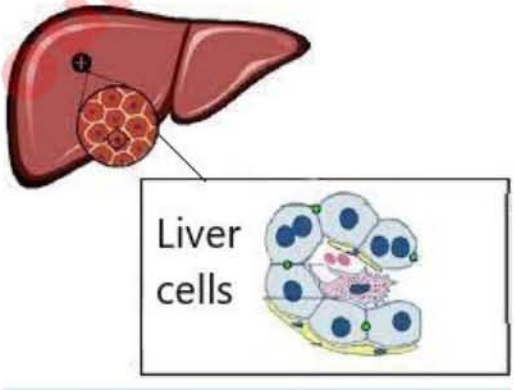


Fig 3.22: Liver and liver cells

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.

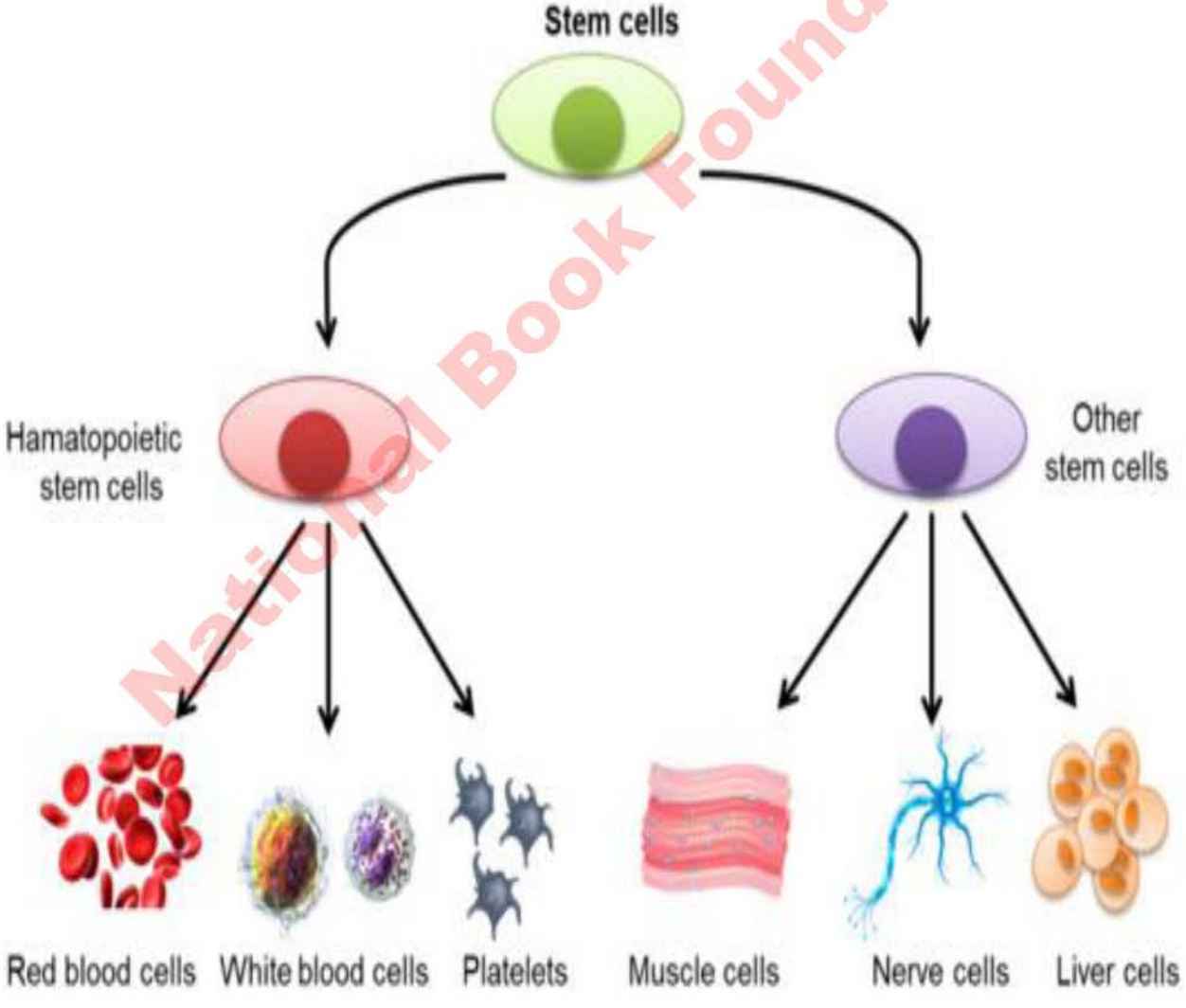


Fig 3.23: Stem cells and formation of specialized cells

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

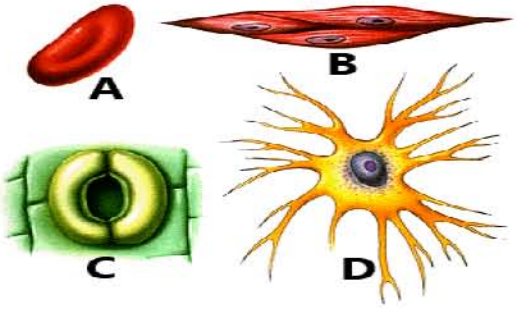
   C) photosynthesis D) cellular respiration

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.

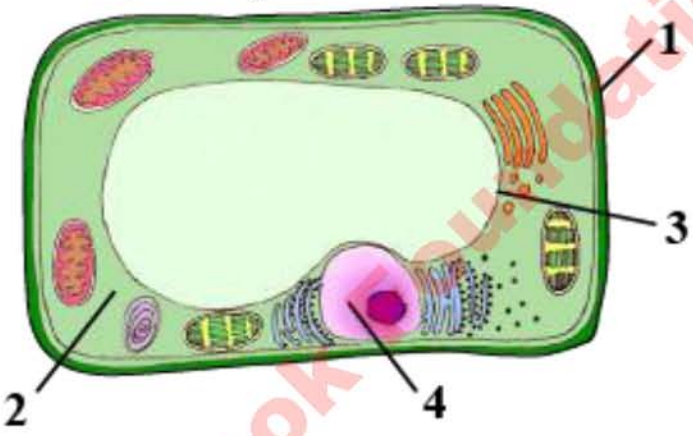
B) They are produced in the nucleus then migrate to the cytoplasm where they synthesize proteins.

C) They are covered by single membrane.

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

Section II: Short Answer Questions

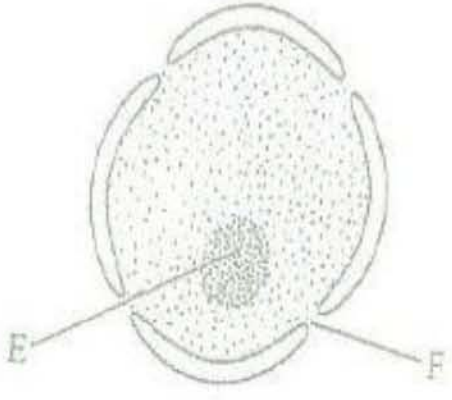
1. Why mitochondria are known as powerhouse of the cell?
2. What makes red blood cells more suitable for the transport of oxygen?
3. Give the modifications of epidermal cells for;
    a. Exchange of gases
    b. Absorption of water and minerals.
4. Following diagram shows a plant cell;



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?

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