

Based on National Curriculum of Pakistan 2022-23

Model Textbook of

Biology

Grade

9

National Curriculum Council

Ministry of Federal Education and Professional Training



National Book Foundation

as

Federal Textbook Board

Islamabad



© 2024 National Book Foundation as Federal Textbook Board, Islamabad
All rights reserved. This volume may not be reproduced in whole
or in part in any form (abridged, photo copy, electronic etc.)
without prior written permission from National Book Foundation

**Model Textbook of Biology
for Grade 9**



Authors

Jawaid Mohsin Malik, Ruquaya Shaikh, Dr. Kashif Ali,
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, Ms. Tayyaba, Ms. Nighat Shaeen, APSACS

IPCW-1 Members

Waqar Ahmad, KPK, Muhammad Sabir, AJK, Jahangir Khan, Balochistan, Muhammad Nawaz Shaikh, Sindh
Zainab Wahab, ICT, Robeela Shabbir, Punjab, Abdul Ghani, GB, Abdul Rauf, ICT

Desk Officer

Zehra Khushal

Management

National Book Foundation

**TEST
EDITION**

First Edition - First Impression: April 2024 | Pages: 168 | Quantity: 105000

Price: PKR 435/-

Code: STE-684, ISBN: 978-969-37-1590-3

Printer: University Press, Peshawar

Note: All the pictures, paintings and sketches used in this book are only
for educational and promotional purpose in public interest.

for information about other publications of National Book Foundation,
visit our Web Site: www.nbf.org.pk or Phone: 051-9261125
or E-mail: books@nbf.org.pk

to share feedback or correction, please send us an email to nbftextbooks@gmail.com

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

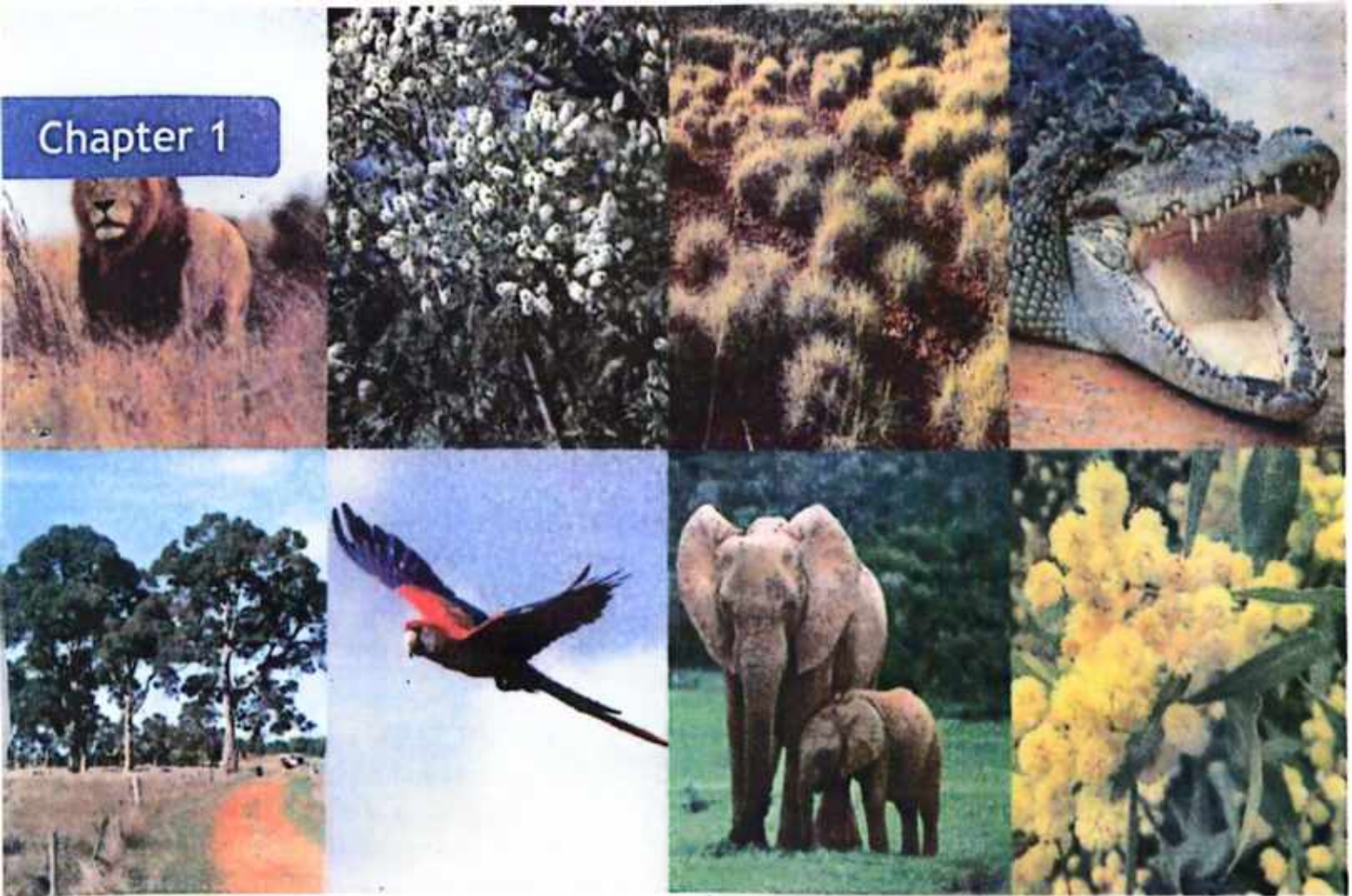
بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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

Contents

Chapter	Description	P. No.
1	The Science of Biology	5
2	Biodiversity	20
3	Cell	31
4	Cell Cycle	48
5	Tissues, Organ and Organ Systems	64
6	Molecular Biology	77
7	Metabolism	93
8	Plant Physiology	112
9	Plant Reproduction	129
10	Evolution	146
	Glossary	157

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 الْمَاءِ 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 عِظًا
فَكَسَوْنَا الْعِظَ 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,"

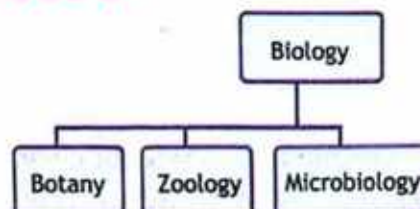
(Sura Al-mominoon, Ayat 14)

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.

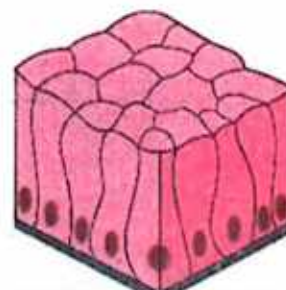


Fig 1.1. Epithelial tissue

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 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.

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.

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.

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.

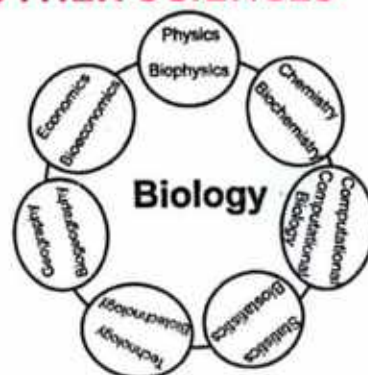


Fig. 1.3: Relationship of biology with other sciences

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 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.

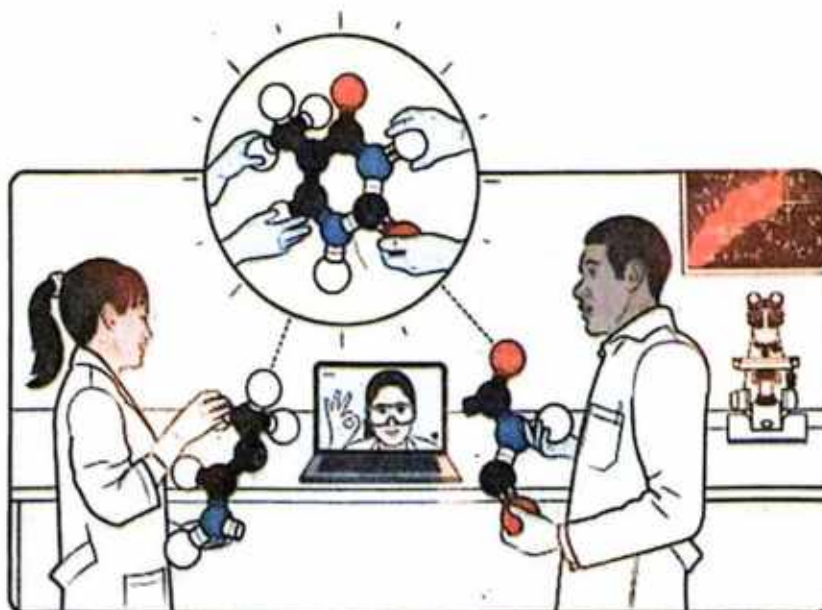


Fig.1.4. Collaboration in science

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.

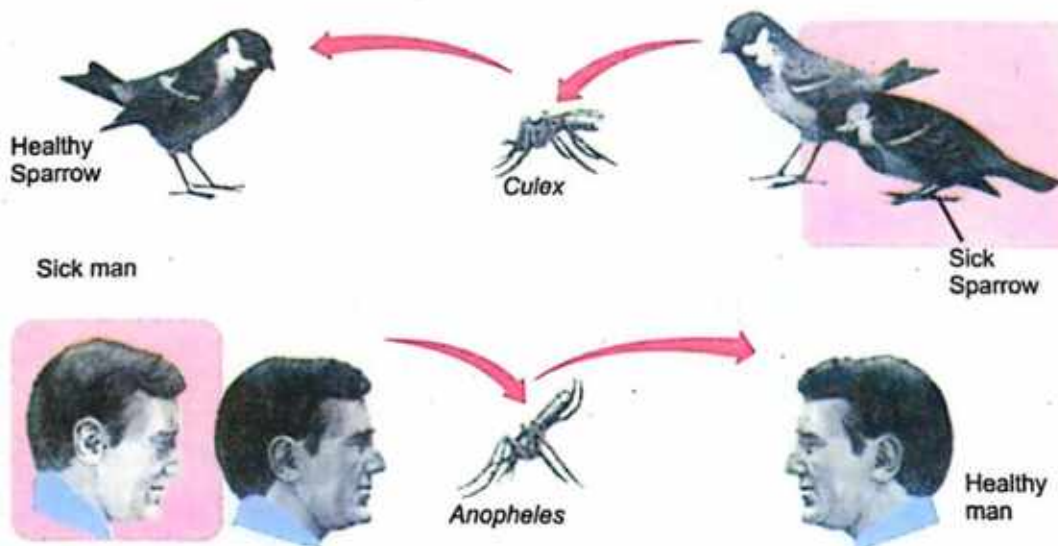


Fig. 1.5: Malaria in man is transmitted by *Anopheles* and in birds by *Culex*

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.



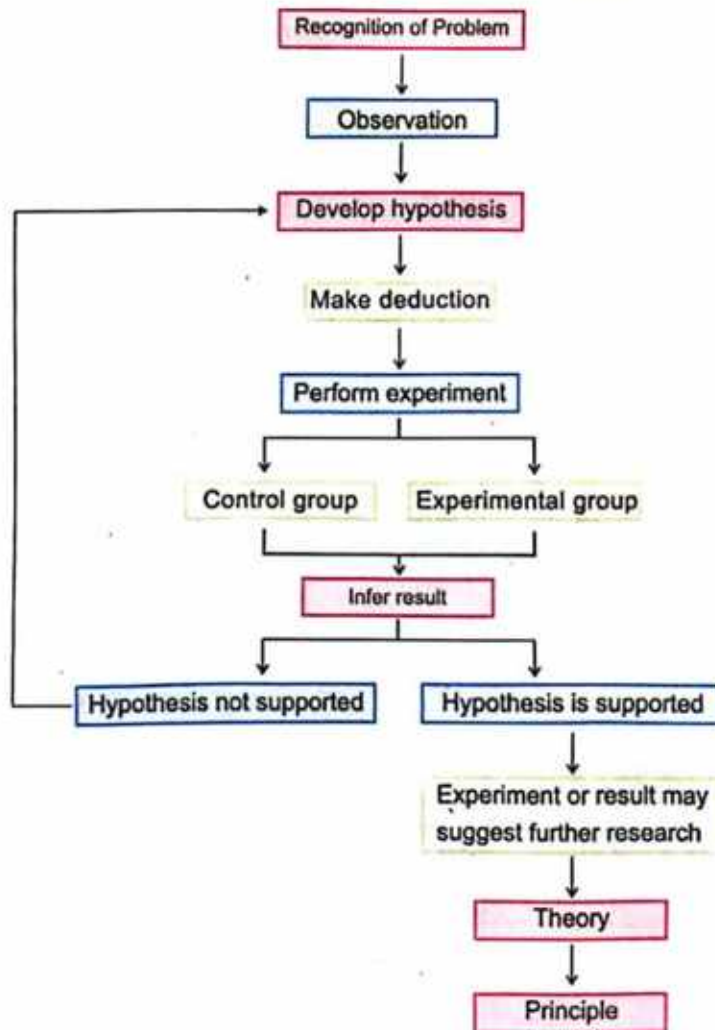


Fig 1.6: Scientific method of study

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?
- theories are hypothesis that have been proven true
 - theories are based on limited data while hypothesis are based on wide range of data
 - theories are uncertain while hypothesis are certain
 - theories are educated guess while hypothesis are widely accepted explanation of natural phenomenon
11. Malaria is caused by:
- mosquito
 - stagnant water
 - swamp
 - 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?
- Plasmodium* are dead
 - Plasmodium* are in incubation period
 - Plasmodium* are not mature
 - Plasmodium* are inactive
13. You are doing a control experiment which
- proceeds slowly enough that a scientist can record the results
 - may include experimental groups and control groups tested in parallel
 - is repeated many times to make sure the results are accurate
 - 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	<i>Anopheles</i>	<i>Aedes</i>	<i>Culex</i>
B	<i>Aedes</i>	<i>Culex</i>	<i>Anopheles</i>
C	<i>Anopheles</i>	<i>Culex</i>	<i>Aedes</i>
D	<i>Culex</i>	<i>Anopheles</i>	<i>Aedes</i>

Section II: Short Answer Questions

1. Define the following branches of biology and give at least one significance of studying these branches
- Molecular biology
 - Physiology
 - Palaeontology
 - Pharmacology
2. Can you distinguish between?
- Anatomy and Morphology
 - Cytology and Genetics
 - Biotechnology and Immunology
 - 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.F.A King
 - Ronald Ross
 - 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.