CHAPTER

1

Introduction To Biology

Science is the study in which observations are made,experiments are done and logical conclusions are drawn in order to understand the principles of nature.

In ancient times, the scientific information was not classified into different branches, as it exists today. All the scientific information was included under one head i.e. 'science'. With the passage of time scientific information increased many folds and this enormous scientific knowledge was then classified into different branches like, biology, physics, chemistry, mathematics etc.

Scientific knowledge is the common heritage of mankind.
Dr. Abdus Salam

1.1 Introduction To Biology

Biology is the scientific study of life. The word "biology" has been derived from two Greek words; '**bios**' meaning 'life' and '**logos**' meaning 'thought or reasoning'. In the course of biology, we will study how man has thought about living things. To understand and appreciate nature, it is essential to study the structures, functions and related aspects of living organisms. The study of living organisms also provides information and remedies to human problems regarding health, food, environment etc.

Animation 1.1: Microscope
Source & Credit: savillbiology

1.1.1 Divisions and Branches of Biology

There are three major divisions of biology which study the different aspects of the lives of the major groups of organisms.

ZOOLOGY
This division of biology deals with the study of animals.

BOTANY
This division of biology deals with the study of plants.

MICROBIOLOGY
This division of biology deals with the study of microorganisms such as bacteria etc.
In order to study all the aspects of life, these divisions are further divided into different branches as defined below.

Morphology
This branch deals with the study of form and structures of living organisms.

Molecular biology (biochemistry) deals with the study of the molecules of life; e.g. water, proteins, carbohydrates, lipids, and nucleic acids.

Anatomy
The study of internal structures is called anatomy.

Histology
The microscopic study of tissues is called histology.

Cell biology
The study of the structures and functions of cells and cell organelles is called cell biology. This branch also deals with the study of cell division.

Physiology
This branch deals with the study of the functions of different parts of living organisms.

Genetics
The study of genes and their roles in inheritance is called genetics. Inheritance means the transmission of characters from one generation to the other.

Embryology
It is the study of the development of an embryo to new individual.

Taxonomy
It is the study of the naming and classification of organisms into groups and subgroups.

Palaeontology
It is the study of fossils, which are the remains of extinct organisms.

Environmental biology
It deals with the study of the interactions between the organisms and their environment.

Socio-biology
This branch deals with the study of social behaviour of the animals that make societies.

Parasites are the organisms that take food and shelter from living hosts and, in return, harm them.

Parasitology:
This branch deals with the study of parasites.

Biotechnology:
It deals with the practical application of living organisms to make substances for the welfare of mankind.

Immunology
It is the study of the immune system of animals, which defends the body against invading microbes.

Entomology
It is the study of insects.

Pharmacology

It is the study of drugs and their effects on the systems of human body.

Human population growth, infectious diseases, addictive drugs and pollution are the major biological issues today.

1.1.2 Relationship of biology to other sciences

The interrelationship among different branches of science cannot be denied. Biology includes information on various aspects of living things but these information relate to the other branches of science as well. Each branch of science has relationship with all other branches. For example, when studying the process of movement in animals, the biologists have to refer to the laws of motion in physics. This forms the basis of **interdisciplinary sciences** (Figure 1.1).

Biophysics:

It deals with the study of the principles of physics, which are applicable to biological phenomena. For example there is a similarity between the working principles of lever in physics and limbs of animals in biology.

Biochemistry:

It deals with the study of the chemistry of different compounds and processes occurring in living organisms. For example the study of basic metabolism of photosynthesis and respiration involves the knowledge of chemistry.

Discussion / Debate

Identify and evaluate the impact of scientific ideas and/or advancements in technology on society.

Biomathematics / Biometry:

It deals with the study of biological processes using mathematical techniques and tools. For example to analyze the data gathered after experimental work, biologists have to apply the rules of mathematics.

Biogeography:

It deals with study of the occurrence and distribution of different species of living organisms in different geographical regions of the world. It applies the knowledge of the characteristics of particular geographical regions to determine the characteristics of living organisms found there.

Bioeconomics:

It deals with the study of organisms from economical point of view. For example the cost value and profit value of the yield of wheat can be calculated through bioeconomics and benefits or losses can be determined.

Discussion / Debate
Identify and evaluate the impact of scientific ideas and/or advancements in technology on society

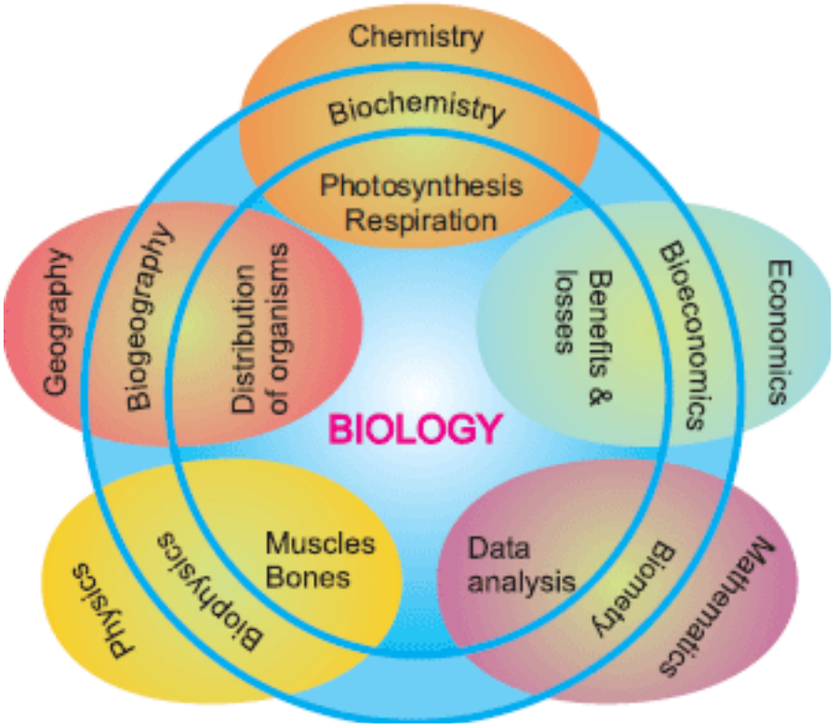


Figure 1.1: Relationship of biology with other sciences

1.1.3 Careers In Biology

It is essential that students of today, who will occupy positions of leadership tomorrow, have the background of the modern and forward-looking branches of science. An accurate and modern knowledge of biology, will promote a comprehension of both science and scientific research projects. It will benefit the learners in diverse list of careers. The following are the careers that a student of biology can plan to adopt.

Medicine / Surgery:

The profession of medicine deals with the diagnosis and treatment of diseases in human. In surgery the parts of the body may be repaired, replaced or removed, for example the removal of stones through renal surgery, transplantation of kidney, liver etc. Both these professions are studied in the same basic course (MBBS) and then students go for specializations.

Fisheries:

Fisheries is the professional study of fish production. There are departments in Pakistan where professionals of fisheries are employed. They serve for enhancing the quality and quantity of fish production. In Pakistan, this profession can be adopted after the bachelor or masters level study of zoology and fisheries.

Agriculture:

This profession deals with the food crops and animals which are the source of food. An agriculturist works for the betterment of crops like wheat, rice, corn etc and animals like buffalo cow etc from which we get food. In Pakistan there are many universities which offer professional courses on agriculture after the higher secondary education in biology.

Animal husbandry:

It is the branch of agriculture concerned with the care and breeding of domestic animals (livestock) e.g. cattle, sheep etc. Professional courses in animal husbandry can be adopted after the higher secondary education in biology.

Horticulture:

It deals with the art of gardening. A horticulturist works for the betterment of existing varieties and for the production of new varieties of ornamental plants and fruit plants. Biology students can adopt this profession after their higher secondary education.

Farming:

It deals with the development and maintenance of different types of farm. For example in some farms animal breeding technologies are used for the production of animals which are better protein and milk source. In poultry farms chicken and eggs are produced. Similarly in fruit farms, different fruit yielding plants are grown. A student who has gone through the professional course of agriculture, animal husbandry or fisheries etc. can adopt this profession.

Forestry:

In forestry, professionals look after natural forests and advises to the government for planting and growing artificial forests. Many universities offer professional courses in forestry after the higher secondary education in biology or after bachelor level study of zoology and botany.

Biotechnology:

It is the latest profession in the field of biology. Biotechnologists study and work for the production of useful products through microorganisms. Universities offer courses in biotechnology after the higher secondary education in biology and after the bachelor level studies of botany or zoology.

1.1.4 Quran and biology

At many places in Holy Quran, Allah hints about the origin and characteristics of living organisms. In the same verses human beings have been instructed to expose the unknown aspects of life, after getting the hints. Here are few examples of such guidelines.

وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ ۖ

"We made every living thing from water."
(Sura: Ambia, Verse: 30)

We know that water makes the 60-70% of the composition of protoplasm of all living things. The above Verse hints at the common origin of all living things in water. As Allah has ordered human beings to think at the hints given by Him, we should study living things so that the mysteries of their origin can be revealed.

خَلَقَ الْإِنسَانَ مِن صَلْصَالٍ كَالْفَخَّارِ ۝

"He made man from clay like the potter."
(Sura: Rehman, Verse: 14)

In another verse, God says:

ثُمَّ خَلَقْنَا النُّطْفَةَ عَلَقَةً فَخَلَقْنَا الْعَلَقَةَ مُضْغَةً
فَخَلَقْنَا الْمُضْغَةَ عِظَامًا فَكَسَوْنَا الْعِظَامَ 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, Verse: 14)

When we think at the hints given in both these Verses, we find the events that occurred in the creation of human beings. Allah also hints at the method of the development of animals including human beings.

وَاللّٰهُ خَلَقَ كُلَّ دَآبَّةٍ مِّنْ مَّآءٍ ۚ فَمِنْهُمْ مَّنْ يَّمْشِيْ عَلٰى بَطْنِهٖ ۚ وَمِنْهُمْ مَّنْ يَّمْشِيْ عَلٰى رِجْلَيْنِ ۚ
وَمِنْهُمْ مَّنْ يَّمْشِيْ عَلٰٓى اَرْبَعٍ ۚ يَخْلُقُ اللّٰهُ مَا يَشَآءُ ۚ اِنَّ اللّٰهَ عَلٰى كُلِّ شَيْءٍ قَدِيْرٌ ۝

"Allah hath created every animal from water. Then some of them creep up over their bellies, others walk on two legs, and others on four. Allah creates what He pleases."
(Sura: Al-Nur, Verse: 45)

This Verse describes the common origin and modification of organisms and also supports the modern concepts of classification.
Thus, Quran hints not only at the origin and development of life but also at many characteristics of living organisms.

1.2 Muslim Scientists

Muslim scientists have made great contributions to the study of science and we are aware of their success in different fields of science. Here we would summarize the work of Jabir Bin Hayan, Abdul Malik Asmai and Bu Ali Sina in the development of the present day knowledge of plants and animals.

Jabir Bin Hayan (721 - 815 AD):

He was born in Iran and practised medicine in Iraq. He introduced experimental investigation in chemistry and also wrote a number of books on plants and animals. His famous books are "Al-Nabatat" and "Al-Haywan".

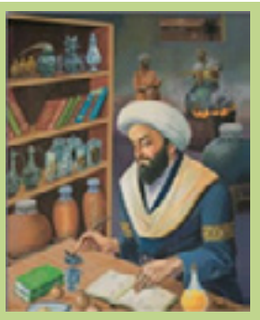
Abdul Malik Asmai (740 - 828 AD):

He is considered the first Muslim scientist who studied animals in detail. His famous writings include "Al-Abil (camel)", "Al-Khail (horse)", "Al-Wahoosh (animal)", and "Kalq al-Ansan".

Bu Ali Sina (980 - 1037 AD):

He is honoured as the founder of medicine and called as Avicenna in the West. He was a physician, philosopher, astronomer and poet. One of his books “Al-Qanun-fi al-Tib” is known as the canon of medicine in West.

Bu Ali Sina



Jabir Bin Hyan

1.3 The Levels Of Organization

In order to understand the various phenomena of life, biologists study biological organization at different levels, which are as follows.

1. Subatomic and Atomic level

All types of matter are made up of elements and each element contains a single kind of atoms (‘a’: not, ‘tom’: cut). The atoms are actually made up of many subatomic particles.

The most stable subatomic particles are electrons, protons and neutrons. Out of the 92 kinds of elements that occur in nature, 16 are called bioelements. These take part in making the body mass of a living organism (Figure 1.2). Out of these bioelements; Only six (O, C, H, N, Ca, & P) make 99% of the total mass. Other ten (K, S, Cl, Na, Mg, Fe, Cu, Mn, Zn, & I) collectively make 01% of the total mass.

Recalling

Protons and neutrons are located inside nucleus of atom while electrons orbit in energy levels (electrons shells) around the nucleus. The number of electrons in the outermost shell determines the manner in which atoms react with each other.

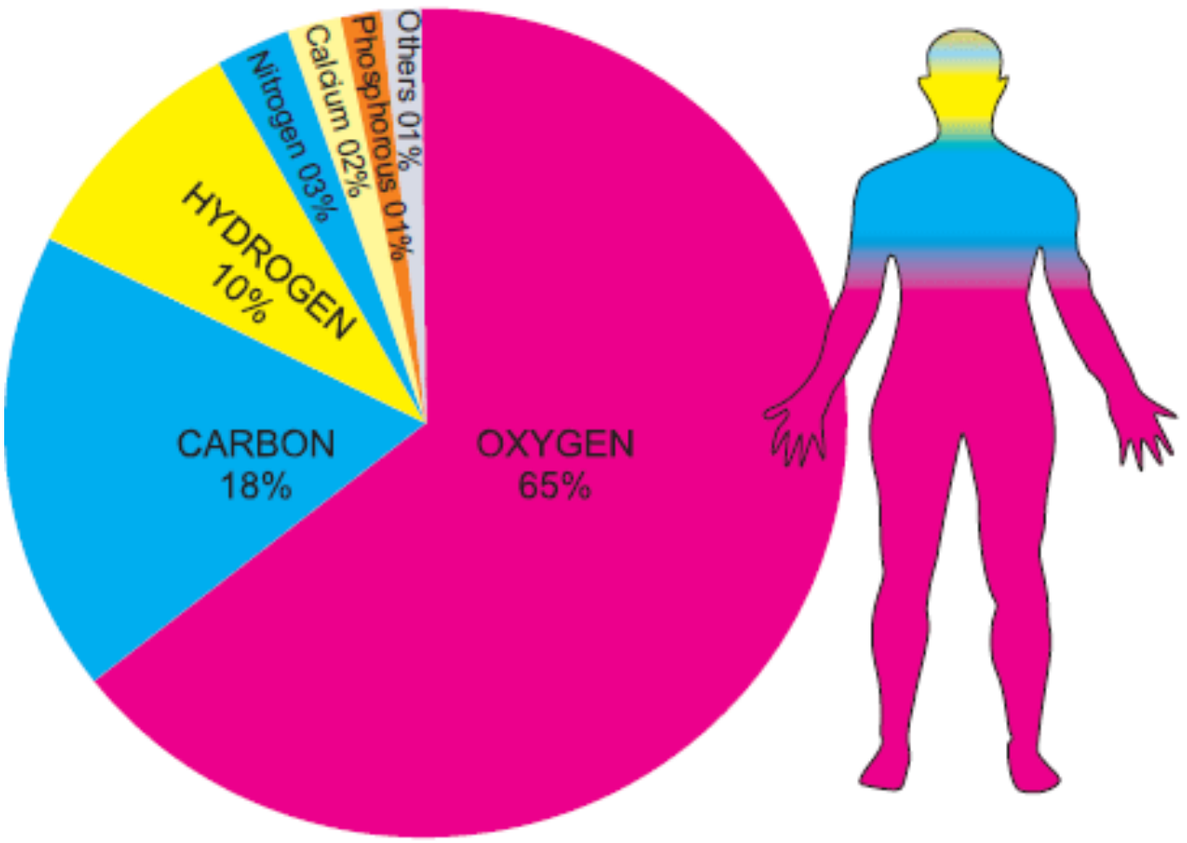


Figure 1.2: Percentage composition (by mass) of bioelements in the protoplasm of living organisms

Recalling

A molecule is the smallest part of a compound that retains the properties of that compound.

2. Molecular level

In organisms, bioelements usually do not occur in isolated forms rather they combine through ionic or covalent bonding. The stable particle formed by such bonding is called as molecule or biomolecule.

An organism is formed by enormous number of biomolecules of hundreds of different types. These molecules are the building material and are themselves constructed in great variety and complexity due to specific bonding arrangements. Biomolecules are classified as micromolecules and macromolecules. **Micromolecules** are with low molecular weight e.g. glucose, water etc. and **macromolecules** are with high molecular weights e.g. starch, proteins, lipids etc.

3. Organelle and Cell level

Biomolecules assemble in a particular way and form organelles. The organelles are actually sub-cellular structures and when they assemble together, units of life i.e. cells are formed.

Each type of organelle is specialized to perform a specific function. For example; mitochondria are specialized for cellular respiration and ribosomes are specialized for protein synthesis. In this way, functions of the cell are accomplished by these specialized structures. It is an example of the division of labour within the cell.

In the case of prokaryotes and most protists, the entire organism consists of a single cell. In the case of most fungi, all animals and all plants, the organism consists of up to trillions of cells.

4. Tissue level

In multicellular organisms, similar cells (performing similar functions) are organized into groups, called tissues. We can define a tissue as a group of similar cells specialized for the performance of a common function. Each cell in a tissue carries on its own life processes (like cellular respiration, protein synthesis), but it also carries on some special processes related to the function of the tissue. There are different types of plant tissues e.g. epidermal tissue, ground tissue, etc. Animal tissues are also of different types e.g. nervous tissue, muscular tissues etc.

5. Organ and Organ system level

In higher multicellular organisms more than one type of tissue having related functions are organized together and make a unit, called organ. Different tissues of an organ perform their specific functions and these functions collectively become the function/s of that organ. For example stomach is an organ specialized for the digestion of proteins and for storing food. Two major types of tissue are present in its structure. Epithelial (glandular) tissue secretes gastric juice for the digestion of proteins.

Muscular tissue performs contractions of stomach walls for grinding of food and moving food to posterior end. So two tissues perform their specific functions, which collectively become the function of stomach.

The next level of organization in multicellular organisms is the organ system level. Different organs performing related functions are organized together in the form of an organ system. In an organ system, each organ carries out its specific function and the functions of all organs appear as the function of the organ system. For example, digestive system is an organ system that carries out the

process of digestion. Major organs in its framework are oral cavity, stomach, small intestine, large intestine, liver, and pancreas. All these organs help in the process of digestion.

The organ system level is less complex in plants (e.g. root system) as compared to animals. This is due to a greater range of functions and activities in animals than in plants.

6. Individual level

Different organs and organ systems are organized together to form an individual or organism. In organism, the functions, processes and activities of various organs and organ systems are coordinated. For example, when a man is engaged in continuous and hard exercise, not only his muscles are working but also there is an increase in the rate of respiration and heart beat. This accelerated rate of respiration and heart beat supplies more oxygen and food to the muscles which they need for continuous work.

7. Population level

Biologists extend their studies to the population level where they study interactions among member of the same species living in the same habitat. A population is defined as a group of organisms of the same species located at the same place, in the same time. For example, human population in Pakistan in 2010 comprises of 173.5 million individuals (according to the Ministry of Population Welfare, Government of Pakistan).

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

Habitat means the area of the environment in which organism lives.

8. Community Level

A community is an assemblage of different populations, interacting with one another within the same environment. A forest may be considered as a community. It includes different plant, microorganisms, fungi and animal species. Communities are collections of organisms, in which one population may increase and others may decrease. Some communities are complex e.g. a forest community, a pond community etc. Other communities may be simple e.g. a fallen log with various populations under it. In a simple community number and size of populations is limited. So any change in biotic or abiotic factors may have drastic and long lasting effects.

9. Biosphere level

The part of the Earth inhabited by organisms' communities is known as biosphere. It constitutes all ecosystems (areas where living organisms interact with the nonliving components of the environment) and is also called the zone of life on Earth.

1.3.1 Cellular organizations

All the organisms have been divided into five major groups i.e. prokaryotes, protists, fungi, plants and animals. All organisms are made of cells. There are two basic types of cells. The organisms in first group are made of prokaryotic cells while all other groups have eukaryotic cells.

Cells organize in three ways to make the bodies of organisms. Cells make unicellular, colonials and multicellular organizations and the organisms formed through these organizations are unicellular organisms, colonial organisms and multicellular organisms.

In **unicellular organisms**, only one cell makes the life of an organism. All the life activities are carried out by the only cell. Amoeba, Paramecium, and Euglena are common examples (Figure 1.4).

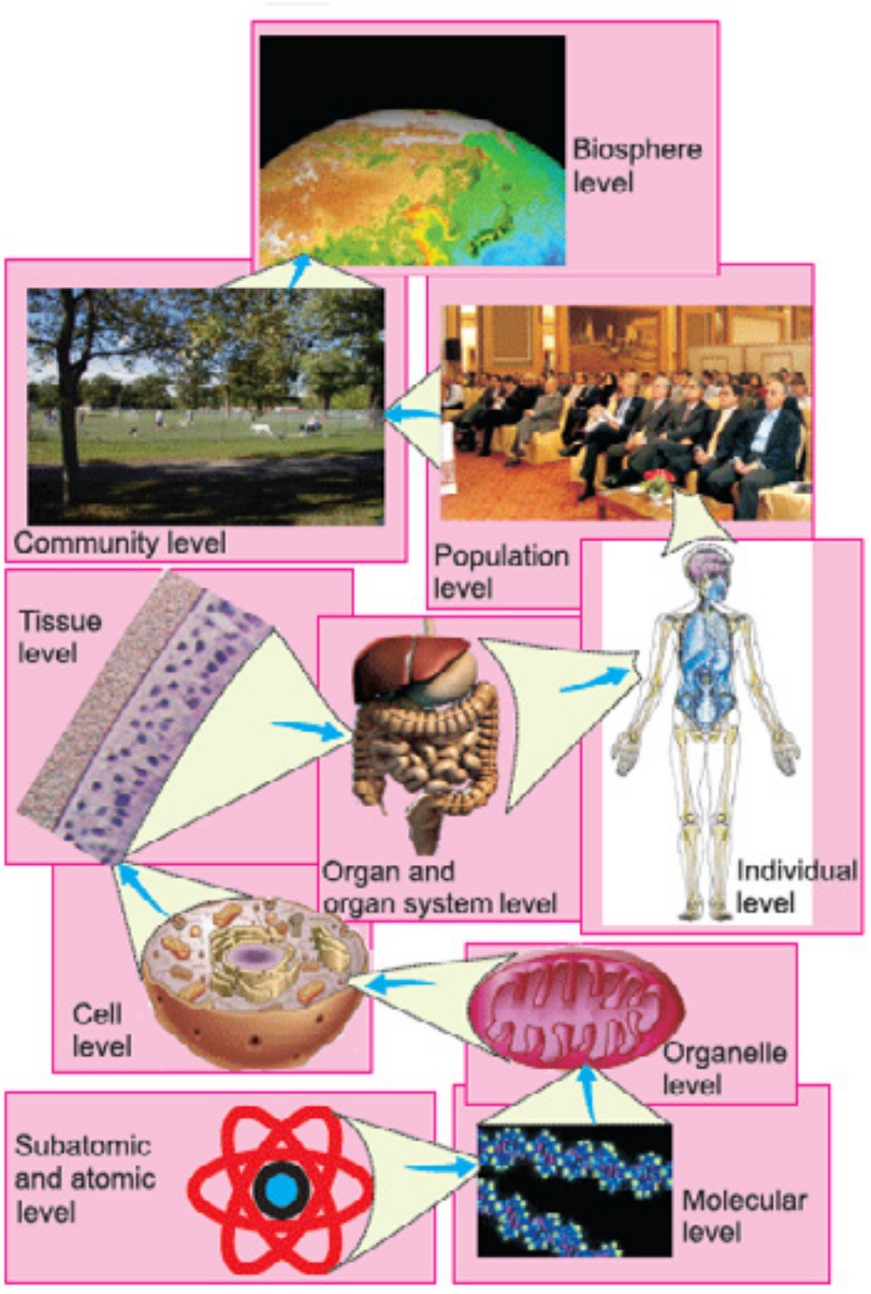


Figure 1.3: Levels of organization

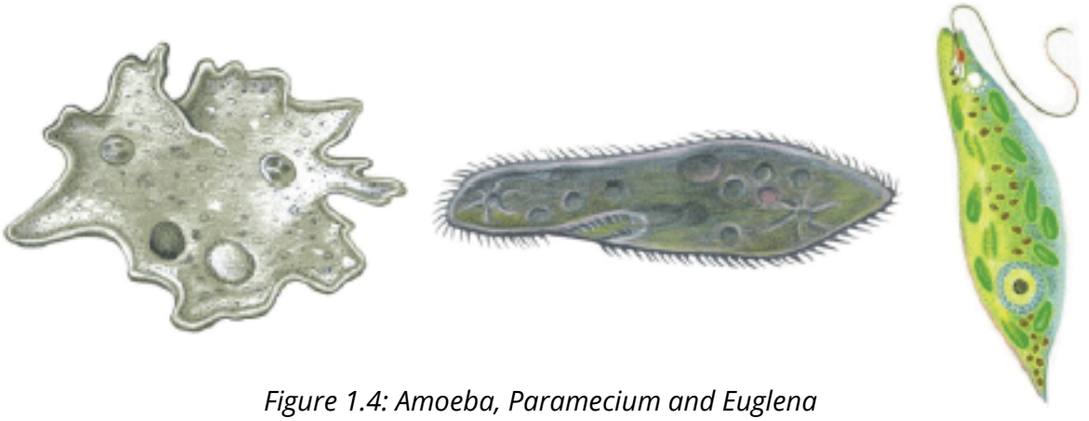


Figure 1.4: Amoeba, Paramecium and Euglena

In colonial type of cellular organization, many unicellular organisms live together but do not have any division of labour among them. Each unicellular organism in a colony lives its own life and does not depend on other cells for its vital requirements. Volvox is a green alga found in water that shows colonial organization. Hundreds of Volvox cells make a colony (Figure 1.5).

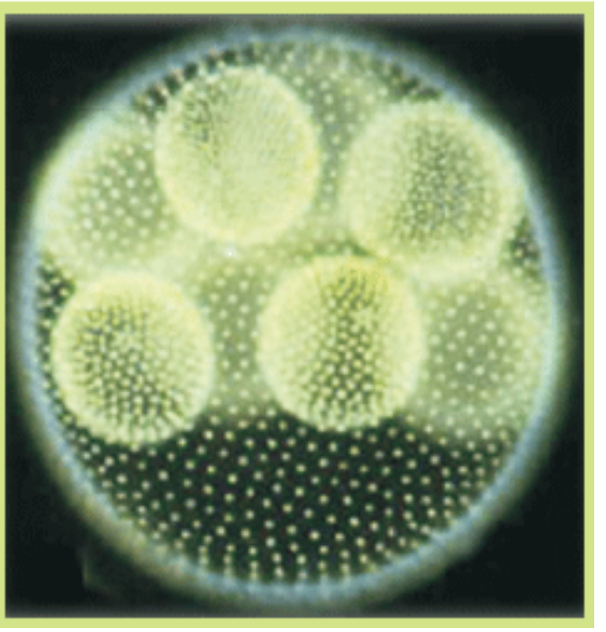


Figure 1.5: Volvox colony

In multicellular organization, cells are organized in the form of tissues, organs and organ systems. Frog and mustard are the familiar examples of multicellular organization.

Mustard plant

Mustard plant (scientific name: *Brassica campestris*) is sown in winter and it produces seeds at the end of winter. The plant body is used as vegetable and its seeds are used for extracting oil. The organs of the body can be divided into two groups on the basis of their functions. Root, stem, branches and leaves are the vegetative organs, which do not take part in the sexual reproduction of the plant. Flowers are the reproductive parts of the plant because they take part in sexual reproduction and produce fruits and seeds. (Figure 1.6)

Frog

Frog (scientific name: *Rana tigrina*) shows the multicellular organization. The body is made of organ systems and each organ system consists of related organs. All the organs are made of specific tissues (epithelial, glandular, muscular, nervous etc). Some organs and organ systems of frog have been described in the practical activity given next.

Figure 1.7: Frog

Analyzing and Interpreting:

Describe the main organs of the mustard by observing a specimen.

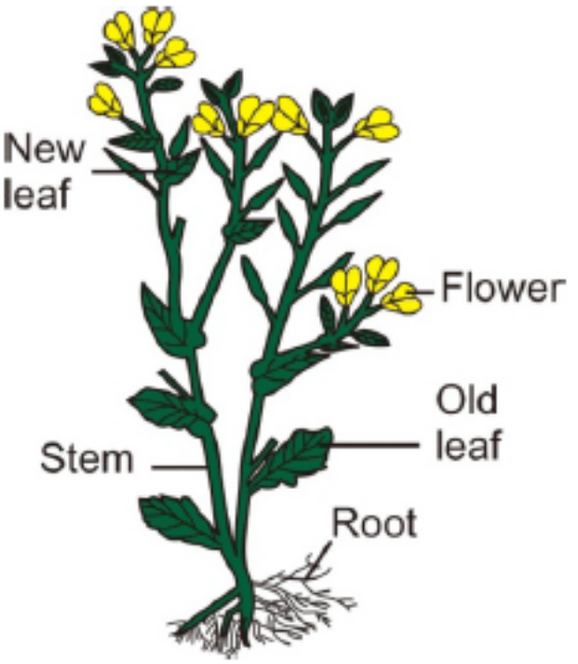


Figure 1.6: Mustard

Analyzing and Interpreting

Identify different tissues in the photomicrographs of different organs.

Practical Work:

Identification of organs and organ systems in a dissected frog

The multicellular organization can be studied in a dissected frog. Different organs and organ systems can be identified and compared with the diagrams or figures given in books or charts.

Problem:

Identify the organs that make up the internal systems of the frog.

Purpose:

In laboratory, the teacher will dissect a frog in order to expose its external and internal structures.

Background information:

Frog belongs to the class amphibia of the animal kingdom. It possesses multicellular organization consisting of tissues, organs and organ systems.

- On the outside of the frog's head are two external nostrils; two tympani, or eardrums; and two eyes, each of which has three lids. The third lid, called the nictitating membrane, is transparent.
- The digestive system consists of the organs of the digestive tract and the digestive glands.
- The respiratory system consists of the nostrils and the larynx, which opens into two lungs.
- The circulatory system consists of the heart, blood vessels, and blood.
- The urinary system consists of the kidneys, ureters, bladder, and cloaca.
- The organs of the male reproductive system are testes, sperm ducts, and cloaca. The female system consists of ovaries, oviducts, uteri, and cloaca.
- The central nervous system of frog consists of the brain, which is enclosed in the skull, and the spinal cord, which is enclosed in the backbone. Nerves branch out from brain and spinal cord.
- The frog's skeletal and muscular systems consist of its framework of bones, to which all the skeletal muscles of the body are attached.

Material Required: Preserved frog, dissecting tray, paper towels and dissecting kit

Procedure:

The teacher will place an unconscious frog on a dissection tray on its back and pin down the legs. From the ventral side, he / she will lift the skin and use scissors to cut along the center of the body from the cloaca to the lip. He / she will turn back the skin, cut toward the side at each leg, and pin the skin flat. Then he / she will lift and cut through the muscles and breast bone to open up the body cavity.

1. Use the diagram below (Figure 1.8) to locate and identify the organs of the digestive system: esophagus, stomach, small intestine, large intestine, cloaca, liver, gallbladder, and pancreas.
2. Again refer to the diagram below to identify the parts of the circulatory and respiratory systems that are in the chest cavity. Find the left atrium, right atrium , and ventricle of the heart. Find the two lungs.
3. Use a probe and scissors to lift and remove the intestines and liver. Identify the parts of the urinary and reproductive systems. Find the ureters; the urinary bladder; the testes and sperm ducts in the male; and the ovaries, oviducts, and uteri in the female.
4. Remove the kidneys and look for threadlike spinal nerves that extend from the spinal cord.
5. Dispose of your materials according to the directions from your teacher.
6. Clean up your work area and wash your hands before leaving the lab.

Observation: After identifying the important organs and organ systems, draw your observation in the form of diagrams.

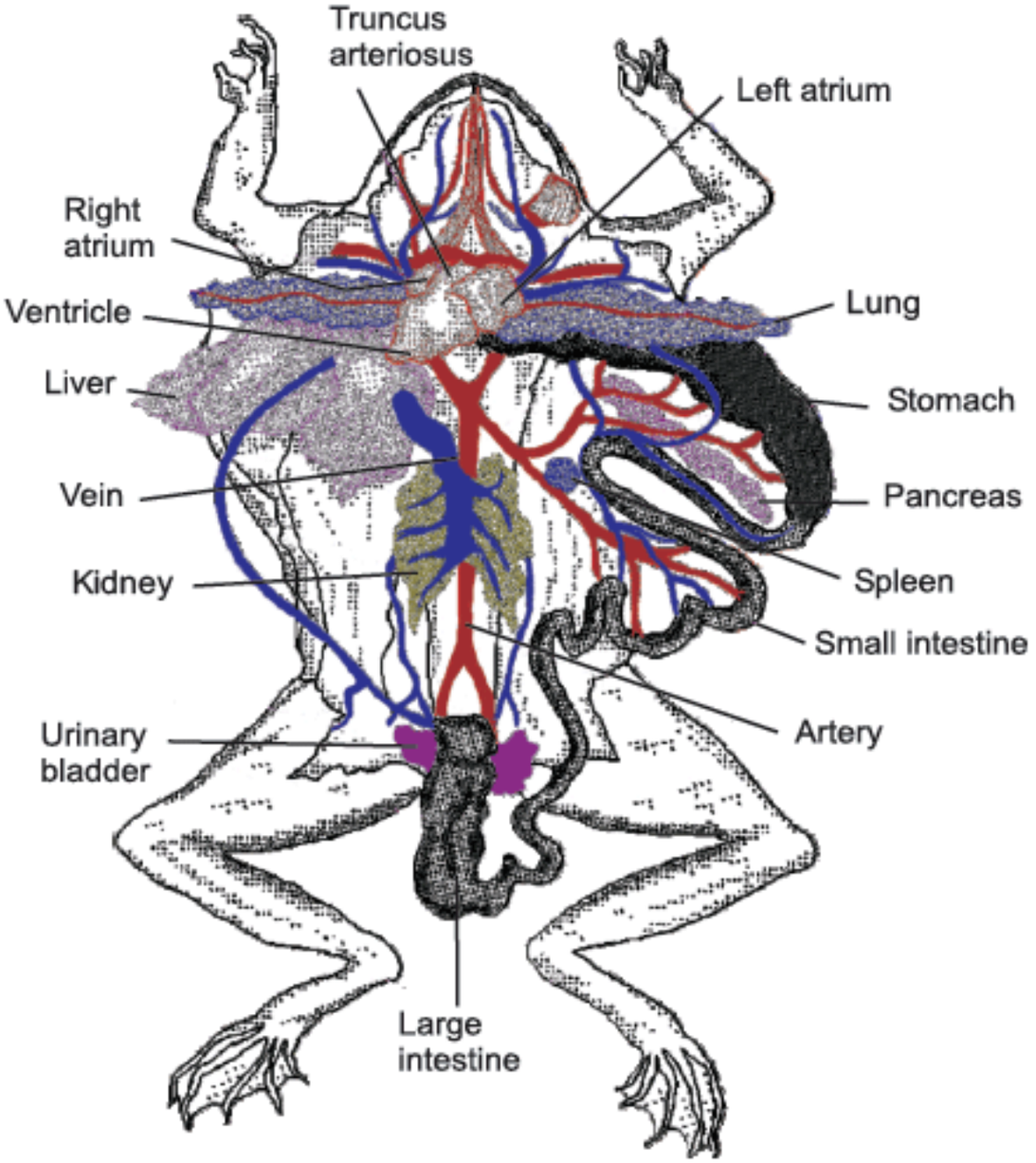


Figure 1.8: Anatomy of dissected frog

Evaluation:

1. What may be the purpose of nictitating membrane in frog?
2. On which side of body did you see the kidneys? Dorsal or ventral?
3. Which part is the common passage in the digestive, excretory and reproductive systems?
4. What was the sex of the dissected frog? How would you differentiate male and female frogs while looking at their anatomy?

UNDERSTANDING THE CONCEPTS

1. Arrange these structures in order of lower level of organization to upper level and write the level against each structure. Neuron, nervous system, electron, man, mass of neurons, carbon, mitochondria, brain, protein
2. How would you define biology and relate it with its major divisions?
3. Draw a table showing the branches of biology and the studies these deal with.
4. Give points to advocate that Biology is linked with physics, chemistry, mathematics, geography and economics.
5. How would you distinguish the biomolecules from other molecules? What is the criterion for classifying a biomolecule as micromolecule or macromolecule?
6. Describe the levels of organization of life.
7. Is there any division of labour among the cells of a colony? If you find division of labour among the cells and tissue what level of cellular organization is it?

SHORT QUESTIONS

1. Define biotechnology.
2. What do you mean by horticulture and how is it related to agriculture?

THE TERMS TO KNOW

Agriculture
Anatomy
Animal husbandry
Biochemistry
Bioeconomics
Bioelement
Biogeography
Biology
Biomathematics
Biomolecule
Biophysics
Biotechnology
Botany
Cell
Cell biology
Colony
Community
Embryology
Entomology
Environmental biology
Farming
Fisheries
Forestry
Fossil
Genetics
Histology
Horticulture
Immunology
Inheritance
Macromolecule
Microbiology
Micromolecule
Microorganism
Morphology
Organ
Organ system
Organelle
Palaeontology
Parasite
Parasitology
Pharmacology
Physiology
Population
Prokaryote
Protist
Science
Socio-biology
Surgery
Taxonomy
Tissue
Volvox
Zoology

INITIATING AND PLANNING

1. Draw a linkage chart connecting different organs with the relative organ systems.

ANALYZING AND INTERPRETING

1. Identify different tissues in the photomicrographs of different organs.

ACTIVITIES

1. Identify major organs and organ systems in a dissected frog (Dissection by teacher / demonstrator).

SCIENCE, TECHNOLOGY AND SOCIETY

1. Identify and evaluate the impact of scientific ideas and/or advancements in technology on society.
2. List organs of human body that some notorious diseases of today damage and specify the ones, which can be transplanted.

ON-LINE LEARNING:

1. www.biology-online.org/dictionary/Branches_of_biology
2. en.allexperts.com/q/Biology-664/
3. www.usoe.k12.ut.us/curr/Science/sciber00/7th/cells/sciber/levelorg.htm
4. www.ofsd.k12.wi.us/science/frogdiss.htm

CHAPTER

2 Solving A Biological Problem

Animation 2.1: Solving A Biological Problem
Source & Credit: Wikispace

Science is the systemized knowledge derived from observations and experiments.These experiments are carried out to determine the principles about how nature operates. Scientists like chemists, biologists and physicists use the same scientific method to make and test new theories.

In this chapter, we will study the steps of biological method. We will study malaria as an example to understand the steps in detail.

2.1 Biological Method

Questions about living things have provided problems that man has investigated to aid his own survival and to satisfy his desire to know. The scientific method in which biological problems are solved, is termed as biological method. It comprises the steps a biologist adopts in order to solve a biological problem.

Biological method has played an important part in scientific research for almost 500 years. From Galileo's experiment (in the 1590s) to current research, the biological method has contributed to the advancements in medicine, ecology, technology etc. Biological method also ensures the quality of data for public use

Man has always been a biologist. He had to be a biologist in order to live. Early in history, he was a hunter of animals and a gatherer of fruits, seeds, roots etc. The more he knew about animals and their habitat, the more successful hunter he was. The more he knew about plants, the better he distinguished between edible and non-edible plants.

2.1.1 Biological problem, hypothesis, deductions and experiments

In biology (like other sciences), new things are being discovered and long-held theories are being modified or replaced with better ones as more data/knowledge is accumulated. This happens when biologists recognize some biological problem and go for its solution. In solving a biological problem, biologist takes following steps;

- Recognition of biological problem
- Observations
- Hypothesis formulation
- Deductions

- Experimentation
- Summarization of results (create tables, graphics etc)
- Reporting the results

The details of these steps are as under:

1. Recognition of the Biological Problem

Biologists go for adopting biological method when they encounter some biological problem. A biological problem is a question related to living organisms that is either asked by some one or comes in biologist's mind by himself.

2. Observations

As the first step in solving a biological problem, biologist recalls his/her previous observations or makes new ones. Observations are made with five senses of vision, hearing, smell, taste and touch. Observations may be both qualitative and quantitative. Quantitative observations are considered more accurate than qualitative ones because the former are invariable and measurable and can be recorded in terms of numbers. Examples of qualitative and quantitative observations are given below.

Qualitative observations	Quantitative observations
• The freezing point of water is colder than the boiling point. • A liter of water is heavier than a liter of ethanol.	• The freezing point of water 0 °C and the boiling point is 100 °C. • A liter of water weighs 1000 grams and a liter of ethanol weighs 789 grams.

Observations also include reading and studying what others have done in the past because scientific knowledge is ever-growing.

Biologists can't usually check every situation where a hypothesis might apply. Let's consider a hypothesis:
"All plant cells have a nucleus". Biologist cannot examine every living plant and every plant that has ever lived to see if this hypothesis is false. Instead, biologists generate deduction using reasoning. From the above hypothesis, a biologist can make the following deduction: "If examine cells from a blade of grass, then each one will have a nucleus".

3. Formulation of Hypotheses

Observations do not become scientific observations until they are organized and related to a question.Biologist organizes his/her and others' observations into data form and constructs a statement that may prove to be the answer of the biological problem under study. This tentative explanation of observations is called a hypothesis. It may be defined as a proposition that might be true. A hypothesis should have the following characteristics:

- It should be a general statement.
- It should be a tentative idea.
- It should agree with available observations.
- It should be kept as simple as possible.
- It should be testable and potentially falsifiable. In other words, there should be a way to show the hypothesis is false; a way to disprove the hypothesis.

A great deal of careful and creative thinking is necessary for the formulation of a hypothesis. Biologists use reasoning to formulate a hypothesis.

4. Deductions

In the next step, biologist draws deductions from hypotheses. Deductions are the logical consequences of hypotheses. For this purpose, a hypothesis is taken as true and expected results (deductions) are drawn from it.

Generally in biological method, if a particular hypothesis is true then one should expect (deduction) a certain result. This involves the use of "if-then" logic.

5. Experimentation

The most basic step of biological method is experimentation. Biologist performs experiments to see if hypotheses are true or not. The deductions, which are drawn from hypotheses, are subjected to rigorous testing. Through experimentations, biologist learns which hypothesis is correct.

The incorrect hypotheses are rejected and the one which proves correct is accepted. An accepted hypothesis makes further predictions that provide an important way to further test its validity.

6. Summarization of results

Biologist gathers actual, quantitative data from experiments. Data for each of the groups are then averaged and compared statistically. To draw conclusions, biologist also uses statistical analysis.

What is "Control" in experiments?

In science when doing the experiment, it must be a controlled experiment. The scientist must contrast an "experimental group" with a "control group". The two groups are treated exactly alike except for the one variable being tested. For example, in an experiment to test the necessity of carbon dioxide for photosynthesis, one can contrast the control group (a plant with freely available carbon dioxide) with an experimental group (a plant with no carbon dioxide available). The necessity of carbon dioxide will be proved when photosynthesis occurs in the control group and does not occur in the experimental group.

7. Reporting the results

Biologists publish their findings in scientific journals and books, in talks at national and international meetings and in seminars at colleges and universities. Publishing of results is an essential part of scientific method. It allows other people to verify the results or apply the knowledge to solve other problems.

Study Of Malaria - An Example Of Biological Method

We know malaria is a common disease in many countries including Pakistan. We will go through the history of this disease to know how biology solved the biological problem concerning the cause and transmission of malaria. In ancient times (more than 2000 years ago), physicians were familiar with malaria. They described it as a disease of chills and fevers with recurring attacks. They also observed that the disease was more common among people living in low, marshy areas. It was thought that the stagnant water of marshes poisoned the air and as a result of breathing in this "bad air", people got malaria. This belief led to the name of this disease. The Italian words **"mala"** means bad and **"aria"** means air. For further clarification of the observation, some volunteers drank stagnant water from the marshes. They did not develop malaria.

In the 17th century when the New World (America) was discovered, many plants from America were sent back to Europe to be used as medicines. The bark of a tree known as **quina-quina** was very suitable for curing fevers. It was so beneficial that soon it was impossible to carry enough bark to Europe. Some dishonest merchants began to substitute the bark of another tree, **cinchona** which closely resembled quina-quina. This dishonesty proved much valuable for mankind. Cinchona bark was found to be excellent for treating malaria. We now know the reason: cinchona bark contains **quinine** that is effective in treating the disease

At that time, physicians treated malaria with cinchona without understanding the cause of malaria. Two hundred years later, it was found that some diseases are caused by tiny living organisms. After this discovery, it also became a belief that malaria, too, might be caused by some microorganism. In 1878, a French army physician **Laveran** began to search for the "cause" of malaria. He took a small amount of blood from a malarial patient and examined it under microscope. He noticed some tiny living creatures. His discovery was not believed by other scientists. Two years later, another physician saw the same creatures in the blood of another malarial patient. Three years after the second discovery, the same creatures were observed for third time. The organism was given a name ***Plasmodium***.

In the last part of nineteenth century, many different causes of malaria were being suggested. By that time, there were four major **observations** about malaria.

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

We know that a scientist uses whatever information and observation he has and makes one or more hypotheses. The **hypothesis** made in this case was;

"Plasmodium is the cause of malaria."

Scientist does not know whether his hypothesis is true or not, but he accepts it may be true and makes **deductions**. One of the deductions from the above hypothesis was;

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

The next step was to test the deduction through **experiments** which were designed as;

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

The results of experiments showed that almost all malarial patients had Plasmodium in their blood while 07 out of 100 healthy persons also had Plasmodium in their blood (now we know that Plasmodium in the blood of healthy people was in incubation period i.e. the period between the entry of parasite in host and the appearance of symptoms). The results were quite convincing and proved that the hypothesis "Plasmodium is the cause of malaria" was true.

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

Next biological problem was to learn about "How *Plasmodium* gets into the blood of man". Biologists were having following observations;

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

From these observations, it can be concluded that Plasmodium was not in the marsh water. But it must be carried by something that comes to marsh water. In 1883, a physician **A. F. A**. King, listed 20 observations. Some important observations of King were:

- People who slept outdoors were more likely to get malaria than those who slept indoors;
- People who slept under fine nets were less likely to get malaria than those who did not use such nets; and
- Individuals who slept near a smoky fire usually did not get malaria.
-

On the basis of these observations King suggested a hypothesis:

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

Following deductions were made considering the hypothesis as true i.e. If mosquitoes are involved in the spread of malaria then;

"Plasmodium should be present in mosquitoes."

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

In fact quinine was the only effective remedy for malaria from the 17th to the 20th century.

In order to test the above deductions, **Ronald Ross:** a British army physician working in India in 1880's; performed important experiments. 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.

The next logical experiment was to allow an infected mosquito (having Plasmodium) to bite a healthy person. If hypothesis was true, the healthy person would have got malaria. But scientists avoid using human beings for experiments when results can be so serious. Ross used sparrows and redesigned his experiments. He allowed a female **Culex** mosquito to bite on the sparrows suffering from malaria. Some of the mosquitoes were killed and studied at various times. Ross found that Plasmodium multiplied in the wall of mosquito's stomach and then moved into mosquito's salivary glands. He kept some mosquitoes alive and allowed them to bite healthy sparrows. Ross found that the saliva of the infected mosquito contained Plasmodia (plural of Plasmodium) and these entered the sparrow's blood. When he examined the blood of these previously healthy sparrows, he found many *Plasmodia* in it.

In the end, the hypothesis was tested by direct experimentation on human beings. In 1898, Italian biologists allowed an *Anopheles* mosquito to bite a malarial patient. The mosquito was kept for a few days and then it was allowed to bite a healthy man. This person later became ill with malaria. In this way, it was confirmed that mosquitoes transmit Plasmodium and spread malaria. (Figure 2.1)

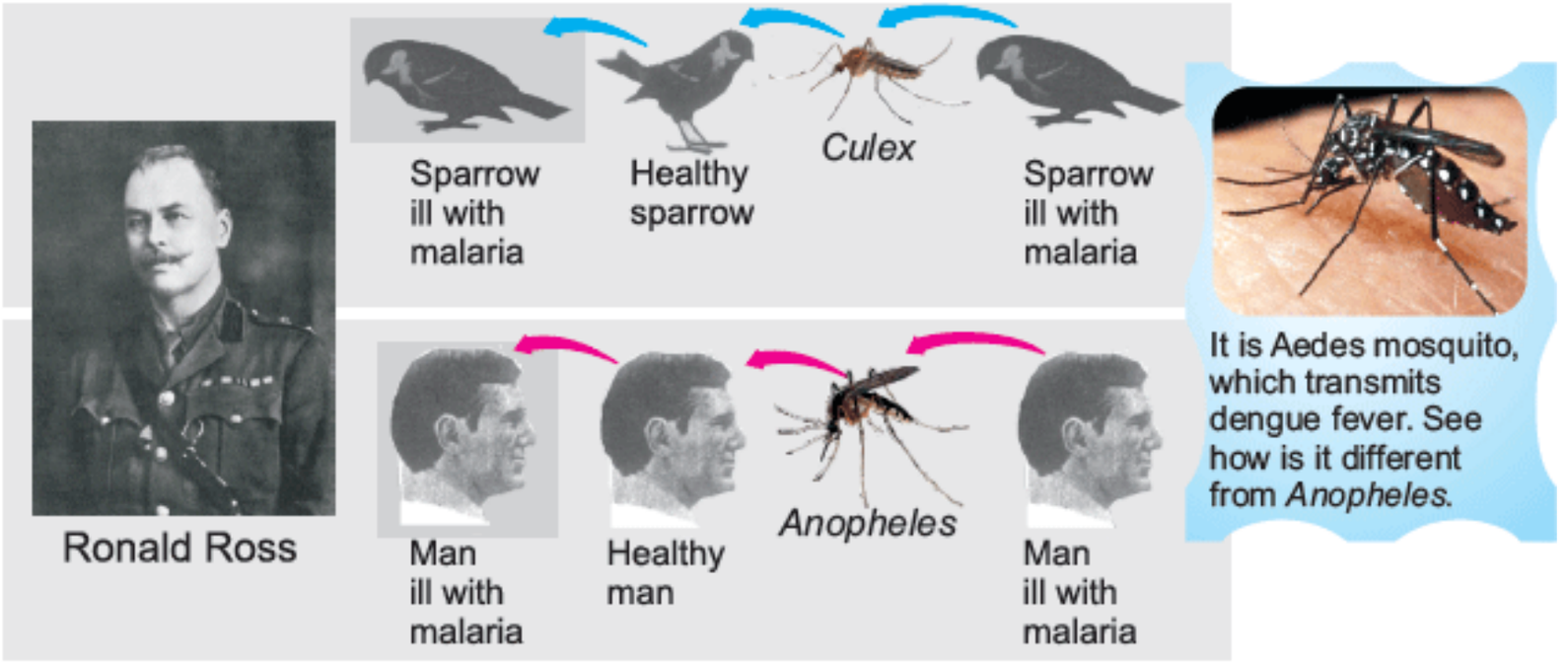


Figure 2.1 : Malaria in sparrow and man is transmitted by *Culex* and *Anopheles* mosquitoes respectively

? While testing the hypothesis that plasmodium is the cause of malaria, what would be the control group of the experiment? Blood of malarial patients or blood of healthy persons?

Blood of healthy persons

2.1.2 Theory, law and principle

When a hypothesis is given a repeated exposure to experimentation and is not falsified, it increases biologists' confidence in hypothesis. Such well-supported hypothesis may be used as the basis for formulating further hypotheses which are again proved by experimental results. The hypotheses that stand the test of time (often tested and never rejected), are called **theories**. A theory is supported by a great deal of evidence.

Productive theory keeps on suggesting new hypotheses and so testing goes on. Many biologists take it as a challenge and exert greater efforts to disprove the theory. If a theory survives such doubtful approach and continues to be supported by experimental evidence, it becomes a **law or**

principle. A scientific law is a uniform or constant fact of nature. It is an irrefutable theory. Examples of biological laws are Hardy-Weinberg law and Mendel's laws of inheritance.

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

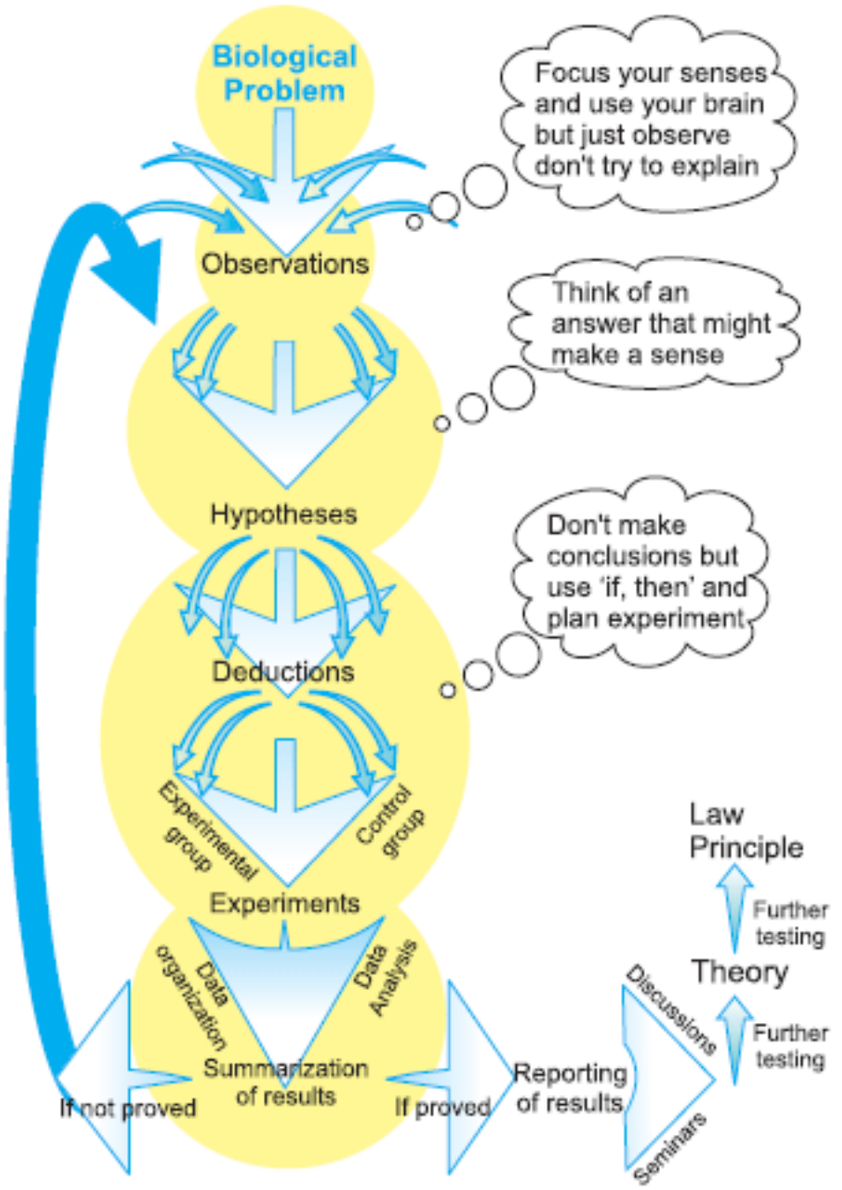


Figure 2.2: Biological method

Female mosquitoes need the blood of mammals or birds for the maturation of their eggs.

The welts that appear after the mosquito leaves is not a reaction to the wound but an allergic reaction to the saliva. In most cases, the itching sensation and swellings subside within several hours.

2.2 Data Organization And Data Analysis

Data organization and data analysis are important steps in biological method. Data can be defined as the information such as names, dates or values made from observations and experimentation.

Data organization

In order to formulate and then to test hypotheses, scientists collect and organize data. Prior to conducting an experiment, it is very important for a scientist to describe data collection methods. It ensures the quality of experiment. Data is organized in different formats like graphics, tables, flow charts, maps and diagrams.

Data analysis

Data analysis is necessary to prove or disprove a hypothesis by experimentation. It is done through the application of statistical methods i.e. ratio and proportion. When a relation between two numbers e.g. ‘a’ and ‘b’ is expressed in terms of quotient (a/b), it is called the ratio of one number to the other. Ratio may be expressed by putting a division (÷) or colon (:) mark between the two numbers. For example the ratio between 50 malarial patients and 150 normal persons is 1:3.

Proportion means to join two equal ratios by the sign of equality (=). For example; a:b = c:d is a proportion between the two ratios. This proportion may also be expressed as a:b::c:d. When three values in a proportion are known, the fourth one (X) can be calculated.

For example, a biologist can calculate how many birds will get malaria when he allows infected mosquitoes to bite 100 healthy sparrows. In the previous experiment he noted that when he allowed mosquitoes to bite 20 sparrows, 14 out of them got malaria. Now he uses the proportion rule.

1st Ratio 14:20 (14 out of 20)
2nd Ratio X:100 (How many out of 100) ⟵ Proportion 14:20 :: X:100

$$\frac{X}{100} = \frac{14}{20} \longrightarrow X \times 20 = 100 \times 14 \longrightarrow X = \frac{100}{20} \times 14 \longrightarrow X = 70$$

It means 70 out of 100 sparrows get malaria

Statistics are thus a means of summarizing data through the calculation of mean value. This step is very important as it transforms raw data into information, which can be used to summarize and report results

2.3 Mathematics: As An Integral Part Of Scientific Process

Biological method also involves the use of applied mathematics to solve biological problems. Major biological problems in which knowledge of mathematics is used include gene finding, protein structure, and protein-protein interactions etc. Bioinformatics refers to the computational and statistical techniques for the analysis of biological data.

UNDERSTANDING THE CONCEPTS

1. Describe the steps involved in biological method taking malaria as an example.
2. If a test shows that some people have Plasmodium in their blood but they do not show any symptoms of malaria, what hypothesis would you formulate to answer this problem?
3. How the principles of ratio and proportion are used in biological method.
4. Justify mathematics as an integral part of the scientific process.

SHORT QUESTIONS

1. Differentiate between theory and law.
2. Quantitative observations are better in biological method. How?

THE TERMS TO KNOW		
Bioinformatics	Deduction	Law
Biological Method	Experiment	Observation
Biological Problem	Experimental Group	Theory
Control Group	Hypothesis	

INITIATING AND PLANNING

1. Identify and pose meaningful, answerable scientific questions.
2. For a given biological problem;
3. Formulate and test a working hypothesis.
4. Write instructions for conducting investigations.
5. Organize data appropriately using techniques such as tables and graphs.
6. Analyze data to make predictions, decisions, or draw conclusions.
7. Confirm, modify, or reject a hypothesis using data analysis.
8. Use ratio and proportion in appropriate situations to solve problems.

ON-LINE LEARNING

1. en.wikipedia.org/wiki/Scientific_method
2. www.sciencebuddies.org/science-fair
3. www.visionlearning.com/library
4. www.scientificmethod.com/www.scientificmethod.com

CHAPTER

3 Biodiversity

Animation 3.1 : Ecology- Man and his environment
Source & Credit: Wikispaces

At least 10 million kinds of organisms inhabit the Earth but less than one third of these have been studied and catalogued (put in record) by biologists. Diversity among the Earth's organisms is more obvious than the fundamental unity of life. We see that all organisms share many biological characteristics. Five principal groups of organisms are prokaryotes, protists, fungi, plants, and animals. In this chapter we will focus on the differences among different groups of organisms. We will also see how are organisms classified and named and what are the concerns with the existence of biodiversity.

3.1 Biodiversity

The term "biodiversity" has been derived from 'bio' and 'diversity'. "Diversity" means variety within a species and among species. Biodiversity is a measure of the variety of organisms present in different ecosystems.

The diversity of plants' (flora) and animals' (fauna) in a region depends on climate, altitude, soils and the presence of other species. Biodiversity is not distributed evenly on Earth. It is richest in the tropics. Temperate regions also have many species while there are fewer species in the polar regions. Biodiversity found on Earth today is the result of 4 billion years of evolution. The origin of life is not well known to science, though limited evidence suggests that until 600 million years ago, all life consisted of bacteria and similar unicellular organisms.

Importance of biodiversity

Biodiversity provides food for humans. A significant proportion of drugs are derived, directly or indirectly, from biological sources. A wide range of industrial materials e.g. building materials, fibres, dyes, resins, gums, adhesives, rubber and oil are derived directly from plants.

Biodiversity plays important role in making and maintaining ecosystems. It plays a part in regulating the chemistry of our atmosphere and water supply. Biodiversity is directly involved in recycling nutrients and providing fertile soils.

Figure 3.1: Variety of plant life in a tropical (left) and temperate (right) region

3.2 Classification - Aims And Principles

There is a large collection of very dissimilar forms of organisms, found on Earth. Over 1.5 million types of animals and over 0.5 million types of plants are known to biologists and these are only a small percentage of the total types estimated to live on Earth. They range in complexity from small and simple bacteria to large and complex human beings. Some of them live in sea, some on land; some walk, others fly, and still others are stationary. Each has its own way of life i.e. getting food, avoiding unfavourable environmental conditions, finding a place to live, and reproducing its kind. When there are so many diverse kinds of organisms, it becomes difficult to learn about the characteristics of each.

To study such a large collection, biologists classify the organisms into groups and subgroups and for this task they require some system. Biological classification is a method by which biologists divide organisms into groups and subgroups.

Figure 3.2: Variety of animal life in polar regions

Aims of Classification

The branch of biology which deals with classification is called **taxonomy** and the branch which deals with classification and also traces the evolutionary history of organisms is known as **systematics**. The main aims of both these branches are;

- To determine similarities and differences among organisms so that they can be studied easily.
- To find the evolutionary relationships among organisms.

Basis of Classification

Classification is based on relationship amongst organisms and such relationship is got through similarities in characteristics. These similarities suggest that all organisms are related to one another at some point in their evolutionary histories.

However, some organisms are more closely related than others. For example sparrows are more closely related to pigeons than to insects. It means that the former two have common evolutionary histories. When biologists classify organisms into groups and subgroups, the similarities are seen in external and internal structures and stages of development. Modern genetics provides another type of information to taxonomists. The similarities and differences in the DNA of two studied organisms can be used for getting idea about similarities and differences in their structures and functions.

Taxonomic Hierarchy

The groups into which organisms are classified are known as taxonomic categories or taxa (singular "taxon"). The taxa form a ladder, called taxonomic hierarchy. All organisms are divided into five kingdoms. So kingdom is the largest taxon. On the basis of similarities, 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 a 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 consists of similar organisms.

Members of lower taxon resemble one another more than do the members of a higher taxon. Table 3.1 illustrates the classifications of humans (*Homo sapiens*) and pea (*Pisum sativum*).

Table 3.1: Simple classification of two organisms

Taxa	Human	Pea
Kingdom	Animalia	Plantae
Phylum	Chordata	Magnoliophyta
Class	Mammalia	Magnoliopsida
Order	Primates	Fabales
Family	Hominidae	Fabaceae
Genus	*Homo*	*Pisum*
Species	*H. sapiens*	*P. sativum*

Species - The Basic Unit of Classification

Species is the basic unit of classification. "A species is a group of organisms which can interbreed freely among them and produce fertile offspring, but are reproductively isolated from all other such groups in nature." Each species possesses its own distinct structural, ecological and behavioural characteristics.

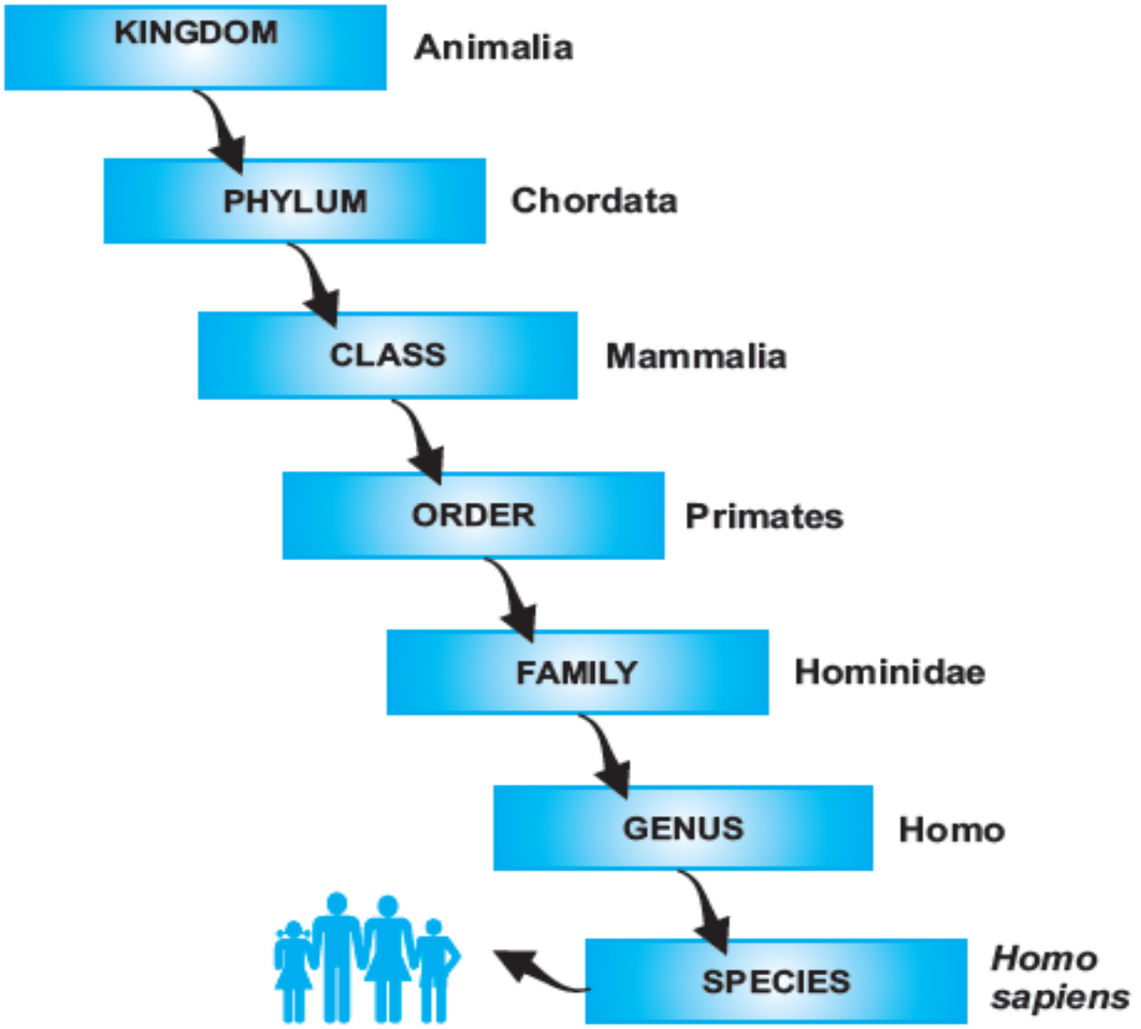


Figure 3.3: Taxonomic hierarchy

In the definition of species we must emphasize "in nature" because two organisms related to two different but closely related species can cross-breed under artificial conditions. In such unnatural crosses they produce infertile offspring. For example, a cross between a male donkey and a female horse produces an infertile offspring i.e. mule (Figure 3.4).

The criteria of interbreeding cannot be used for species recognition in organisms who reproduce asexually and do not interbreed with one another (for example many unicellular organisms).

Use internet and find the classification schemes of a fungus and a bacterium.

Figure 3.4: Infertile mule

3.3 History Of Classification Systems

The earliest known system of classification of organisms comes from the Greek philosopher **Aristotle.** He classified all living organisms known at that time as either in the group 'plantae' or in 'animalia'.
In 700s, **Abu-Usman Umer Aljahiz** described the characteristics of 350 species of animals in his book. He wrote a lot about the life of ants. In 1172, **Ibn Rushd (Averroes)** translated Aristotle's book "de Anima (On the Soul)" in Arabic. In the end of 15th century, many biologists had started work on classification methods e.g.

Carolus Linnaeus divided nature into three kingdoms: mineral, vegetable and animal. Linnaeus used five ranks in classification: class, order, genus, species, and variety. Linnaeus is best known for his introduction of the method still used to formulate the scientific name of every species.

Andrea Caesalpino (1519-1603 AD)	Divided plants into fifteen groups and called them "genera".
John Ray (1627-1705 AD)	Published important works on plants' classification.
Augustus Rivinus (1652-1723 AD)	Introduced the taxon of "order".
Tournefort (1656-1708 AD)	Introduced the taxa of "class" and "species".
Carolus Linnaeus (1707-1778 AD)	Grouped species according to similar physical characteristics.

Biologists prefer such a system that can provide maximum information about the basic differences and similarities among different organisms. According to earlier classification system, organisms were classified into two kingdoms but now taxonomists agree on five-kingdom classification system. We will see the basis of these classification systems and the drawbacks in the two-kingdom and three-kingdom classification systems.

3.3.1 Two-Kingdom Classification System

It is the oldest system and classifies all organisms into two kingdoms i.e. Plantae and Animalia. According to it, all organisms that can prepare food from simple inorganic materials and thus can store energy, are autotrophs and are included in kingdom plantae. On the other hand, the organisms that cannot synthesize their food and depend on autotrophs or others are heterotrophs and are included in kingdom animalia. According to this system, bacteria, fungi and algae were included in kingdom plantae.

Some taxonomists found this system unworkable because; 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) characters. So there should be a separate kingdom for such organisms. This system also ignores the difference between organisms having prokaryotic and those having eukaryotic cells.

3.3.2 Three-Kingdom Classification System

In 1866, **Ernst Hacke**l solved the first objection and proposed a third kingdom i.e. protista to accommodate euglena-like organisms. He also included bacteria in kingdom protista. In this system, fungi were still included in the kingdom plantae.

This system did not clear the difference between prokaryotes and eukaryotes. Some biologists disagreed about the position of fungi in kingdom plantae. Fungi resemble plants in many ways but are not autotrophs. They are special form of heterotrophs that get their food by absorption. They do not have cellulose in their cell walls rather possess chitin.

3.3.3 Five-Kingdom Classification System

In 1937, **E-Chatton** suggested the terms of, "Procariotique" to describe bacteria and "Eucariotique" to describe animal and plant cells. In 1967, **Robert Whittaker** introduced the five-kingdom classification system. This system is based on;

- The levels of cellular organization i.e. prokaryotic, unicellular eukaryotic and multicellular eukaryotic
- The principal modes of nutrition i.e. photosynthesis, absorption, and ingestion.

On this basis, organisms are classified into five Kingdoms: monera, protista, fungi, plantae and animalia.

In 1988, **Margulis and Schwartz** modified the five-kingdom classification of Whittaker. They considered genetics along with cellular organization and mode of nutrition in classification. They classified the organisms into the same five kingdoms as proposed by Whittaker.

3.4 The Five Kingdoms

The general characteristics of the five kingdoms are as follows (See Table 3.2 also);

1. **Kingdom monera:** It includes prokaryotic organisms i.e. they are made of prokaryotic cells. Monerans are unicellular, although some types form chains, clusters, or colonies of cells. Prokaryotic cells are radically different from eukaryotic cells. Most are heterotrophic but some perform photosynthesis because they have chlorophyll in their cytoplasm. Within this kingdom, there are two different kinds of organisms i.e. bacteria and cyanobacteria.

2. **Kingdom protista:** It includes eukaryotic unicellular and simple multicellular organisms. There are three main types of protists.
   - Algae are unicellular, colonial or simple multicellular. They resemble plant cells with cell walls and chlorophyll in chloroplasts. Simple multicellular means that they do not have multicellular sex organs and do not form embryos during their life cycles.
   - **Protozoans** resemble animals whose cells lack chlorophyll and cell walls.
   - Some protists are **fungi-like.**

3. Kingdom fungi: It includes eukaryotic multicellular heterotrophs which are absorptive in their nutritional mode e.g. mushrooms. Most fungi are decomposers. They live on organic material, secrete digestive enzymes and absorb small organic molecules formed by the digestion by enzymes.

4. Kingdom Plantae: It includes eukaryotic multicellular autotrophs. Plants are autotrophic in nutritional mode, making their own food by photosynthesis. They have multicellular sex organs and form embryos during their life cycles. Mosses, ferns and flowering plants are included in this kingdom.

5. Kingdom Animalia: It includes eukaryotic multicellular consumers. Animals live mostly by ingesting food and digesting it within specialized cavities. They lack cell wall and show movements.

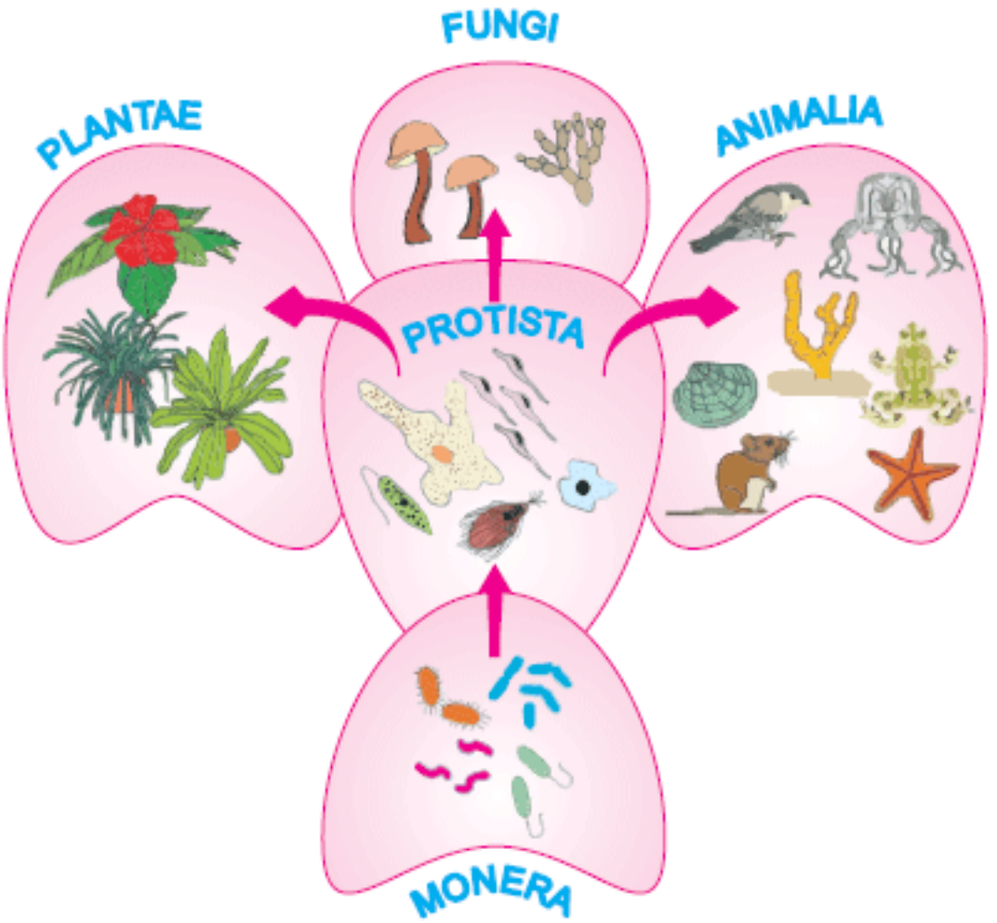


Figure 3.5: The Five kingdoms of classification

How can you divide the five Kingdoms into two groups on the basis of types of cells?

(a) Kingdom monera including organism with prokaryotic cells and

(b) Kingdom protista, fungi,plantae and animalia include organisms with eukaryotic cells

Table 3.2: Distinguishing characteristics of the five kingdoms of life

Kingdom	Cell Type	Nuclear Envelope	Cell Wall	Mode of Nutrition	Multi-Cellularity
Monera	Prokaryotic	Absent	Non-cellulose (polysaccharide plus amino acids)	Autotroph or heterotroph	Absent
Protista	Eukaryotic	Present	Present in some forms, various types	Photosynthetic or heterotroph, or combination	Absent in most forms
Fungi	Eukaryotic	Present	Chitin	Absorptive heterotroph	Present in most forms
Plantae	Eukaryotic	Present	Cellulose and other polysaccharides	Photosynthetic	Present in all forms
Animalia	Eukaryotic	Present	Absent	Ingestive heterotroph	Present in all forms

Status of Viruses

Viruses are at the borderline of living and nonliving. Due to their crystalline nature, they are considered as non-living. They are acellular i.e. they do not have cellular organization yet show some characters of living organisms (e.g. they possess DNA). Viruses contain either RNA or DNA, normally encased in protein coat. They reproduce only in living cells, where they cause a number of diseases. They are not considered as organisms and thus are not included in the five-kingdom classification system. Prions and viroids are also acellular particles and are not included in the five-kingdom classification system.

3.5 Binomial Nomenclature

Binomial nomenclature is the method of giving scientific names to living organisms. As the word "binomial" suggests, the scientific name of a species consists of two names: the first is **genus** name and the second one is the name of **species**. Swedish biologist Carolus Linnaeus (1707-1778 AD) first introduced and adopted the system of binomial nomenclature. His system spread rapidly and became popular. Many of his names are in use today.

Some of the rules which are universally adopted while suggesting and documenting scientific names, are:

- Scientific names are usually printed in italics, such as *Homo sapiens*. When handwritten they are underlined.
- The first term (generic name) always begins with capital letter, while species name is never capitalized (even when derived from a proper name).
- The scientific name is generally written in full when it is first used. But when several species from the same genus are being listed, it may then be abbreviated by just using an initial for genus; for example Escherichia coli becomes E. coli.

Prions are composed of protein only and Viroids are composed of circular RNA only. Both these particles cause infectious diseases in certain plants.

Significance

In biological research, common names cause many problems. Different regions have different names for the same organism. For example; common name of onion in Urdu is 'Piyaz' but in different regions of Pakistan it is also known as 'ganda' or 'bassal' or 'vassal'. In other countries, it has other sets of names. In science, it is known with a single name as *Allium cepa*. In some cases, different organisms are called by the same common name. For example; the name 'black bird' is used for crow as well as for raven.

Common names have no scientific basis. For example; a fish is a vertebrate animal with fins and gills. But several common names of 'silver fish', 'cray fish', 'jelly fish', and 'star fish' do not fit the biologist's definition of a fish. To avoid all these confusions, organisms are given scientific names by using binomial nomenclature . The value of this system is due to its widespread use and the stability of its names. In binomial nomenclature, every species can be unambiguously identified with just two words. Same name can be used all over the world, in all languages, avoiding difficulties of translation.

Sometime organisms are named in honor of the research workers who described and classified them. For example; the Orchid tree (Mountain-ebony) was named as *Bauhinia variegata* after the Swiss botanists Bauhin. *Bauhinia variegata* is an ornamental tree found in southeast Asia.

Examples:

Common Name	Scientific Name
Onion	*Allium cepa*
Common sea star (starfish)	*Asterias rubens*
House crow	*Corvus splendens*

3.6 Conservation Of Biodiversity

During the last century, loss of biodiversity has been increasingly observed. In the modern era, due to human actions, species and ecosystems are threatened with destruction to an extent rarely seen in Earth history. A species that no longer lives in an ecosystem is called extinct in that ecosystem. When species of an ecosystem become extinct, the stability of ecosystem is harmed. Biologists warn that global ecosystem would collapse if biodiversity continues to be reduced at the same rate.

Many plant and animal species have gone extinct in Pakistan. Examples of endangered and extinct animal species are lion, tiger, Asiatic cheetah, Indian one-horned rhinoceros, swamp deer, Indian wild ass, hangul, blackbuck etc (Figure 3.6).

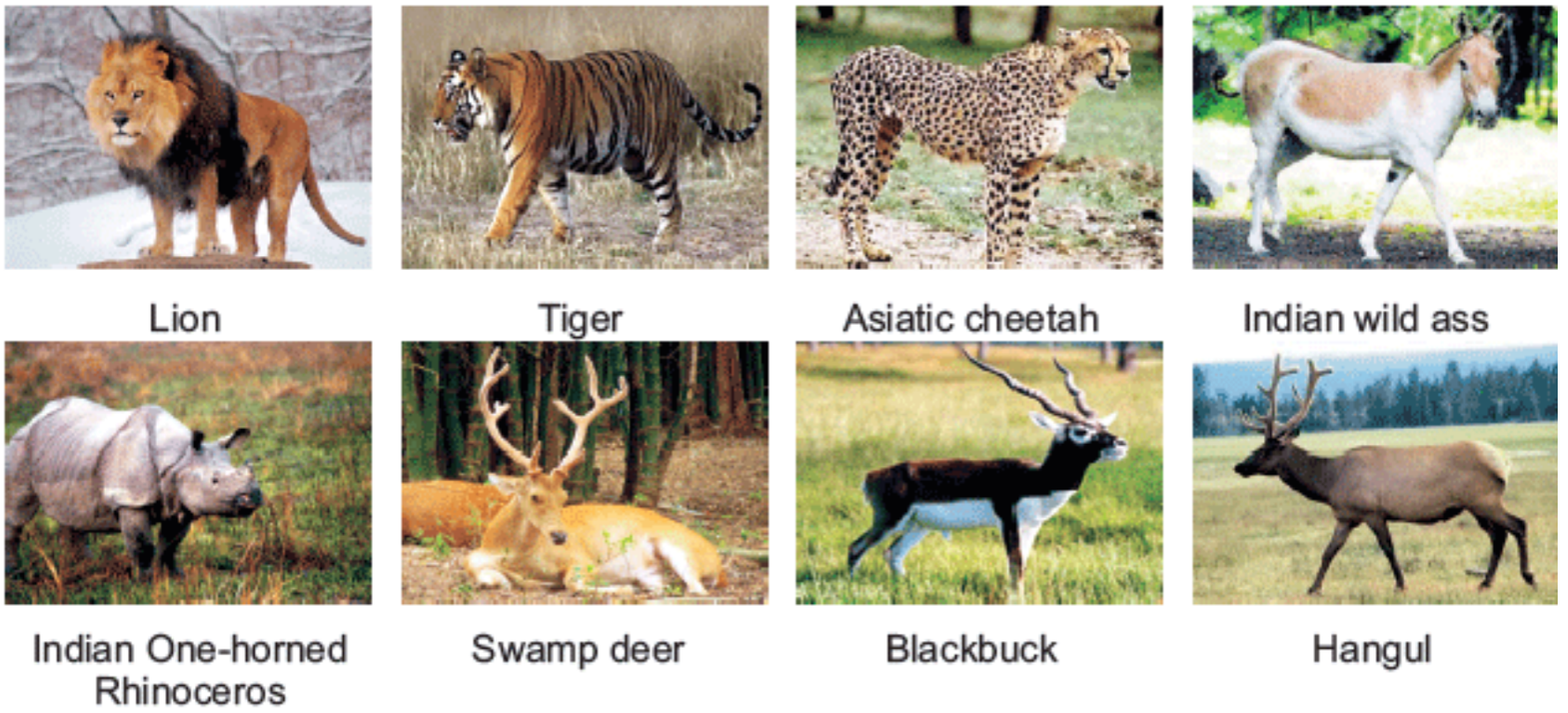


Figure 3.6: The animals that have gone extinct in Pakistan

3.6.1 Impact Of Human Beings On Biodiversity

By 10,000 years ago there were about 5 million people on Earth. With the advancement in agriculture and industry, human population began to grow rapidly. Today around 600 million people live on Earth.

To improve the living conditions for 600 million humans, we are imposing serious threats to the survival of biodiversity. Habitat loss, deforestation, over-hunting, introduction or removal of species, pollution and climate change are the major causes of species extinction.

In an ecosystem, a species is called extinct when there is no doubt that the last individual of that species has died in that ecosystem. A species is called endangered when it is at risk of extinction in near future.

More than 260,000 people are added to the world population each day, or more than 180 each minute!

Habitat loss is probably the greatest threat to biodiversity on Earth today.

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

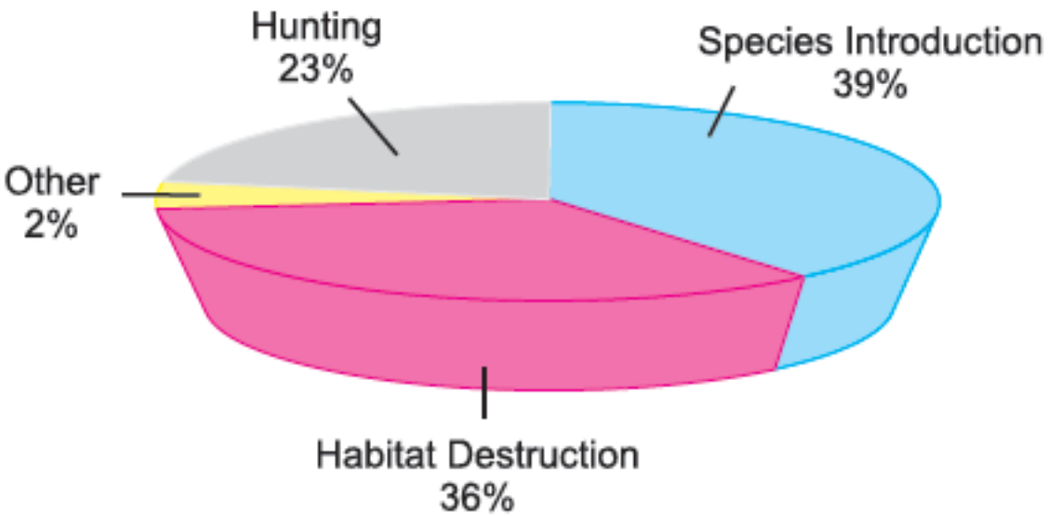


Figure 3.7: Known causes of species extinctions

Sea star (starfish) eats mussels. If sea stars are removed from a region in ocean, mussels rapidly increase in number. Large number of mussels prey on small animals and become dangerous for their existance.

The race to produce cash through fruits, spices, sugar, tobacco, soap, rubber, paper, and cloth has stimulated many to get them by using soil and by destroying the forests.

3.6.2 Deforestation And Over-Hunting

Deforestation means cutting down of trees for the conversion of a forest to non-forest land. The destruction of significant areas of forest has resulted in a degraded environment with reduced biodiversity.

Causes and effects of deforestation

Sometime there is slow forest degradation and sometime sudden and catastrophic clear-cutting for urban development. Deforestation can be the result of deliberate removal of forests for wood, agriculture or urban development.
Deforestation affects the amount of water in soil and moisture in atmosphere. When there are no trees to keep soil in place, there are more chances of soil erosion. Heavy rainfall washes soil into rivers (Figure 3.8). Essential nutrients are washed out of soil. Rivers become choked up with mud and silt, which can cause floods. The silted water gets stored in dams and it reduces their water storage capacity. Deforestation also contributes to decreased transpiration, which lessens cloud formation. This ultimately reduces the sources of rains.

In developing countries, almost 3 billion people rely on wood for heating and cooking.