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

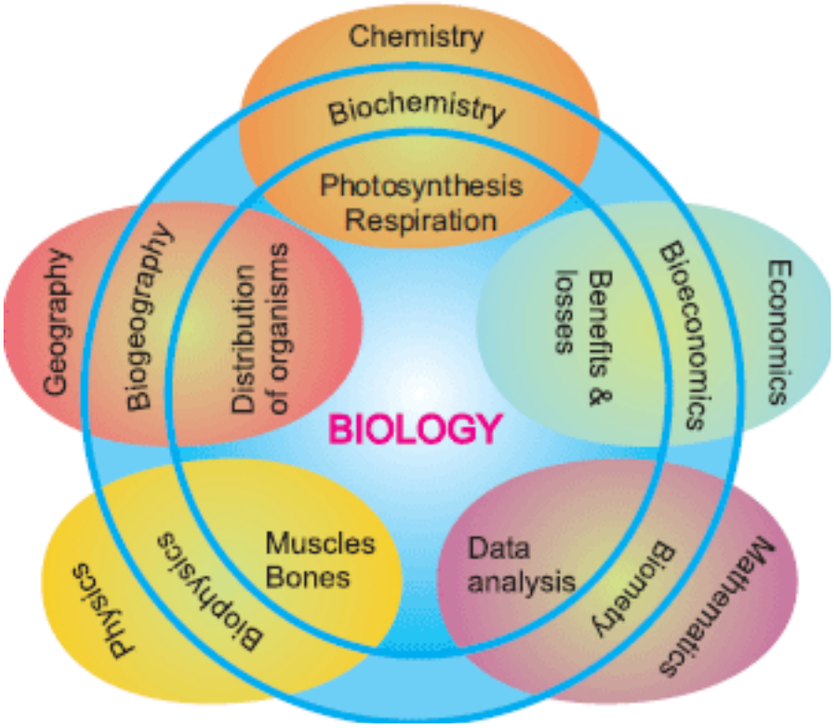


Figure 1.1: Relationship of biology with other sciences

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".

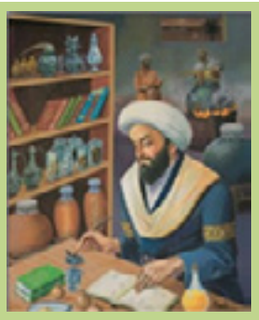
Abdul Malik Asmai (740 - 828 AD):

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.

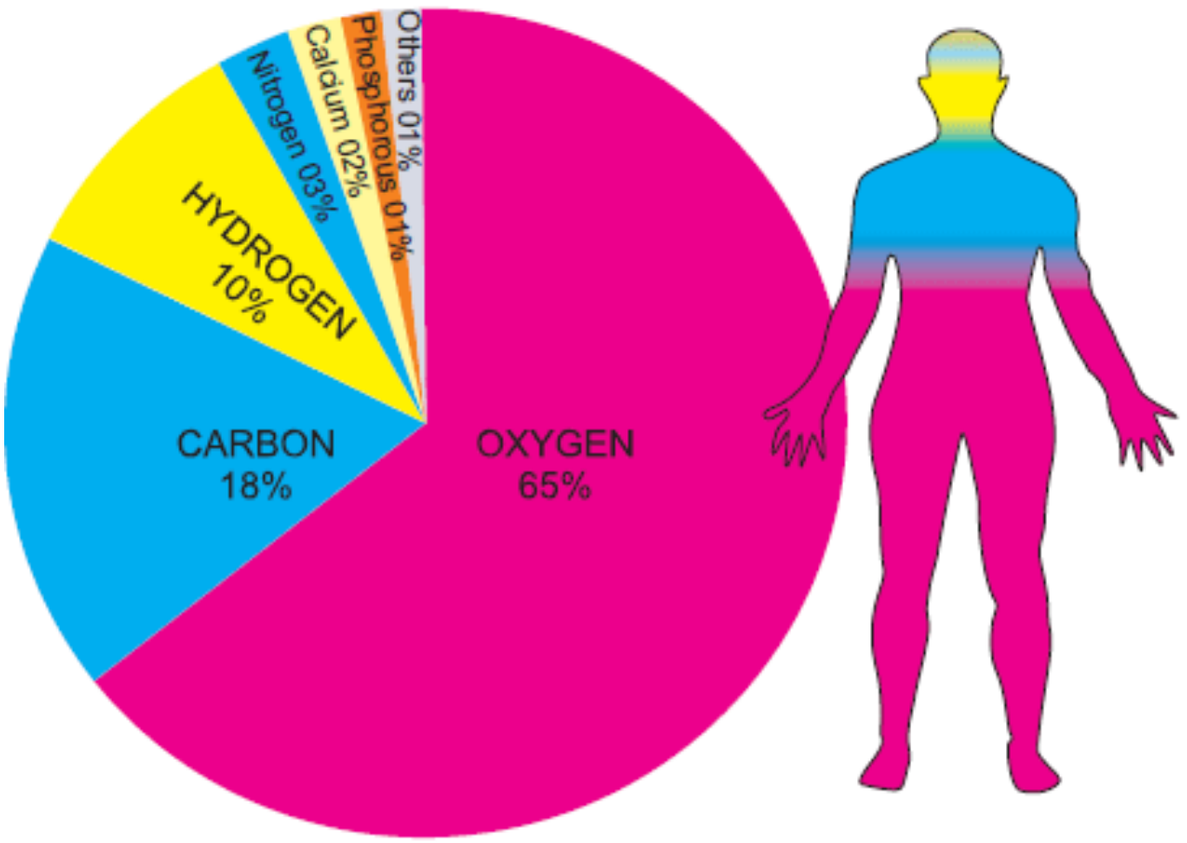


Figure 1.2: Percentage composition (by mass) of bioelements in the protoplasm of living organisms

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).

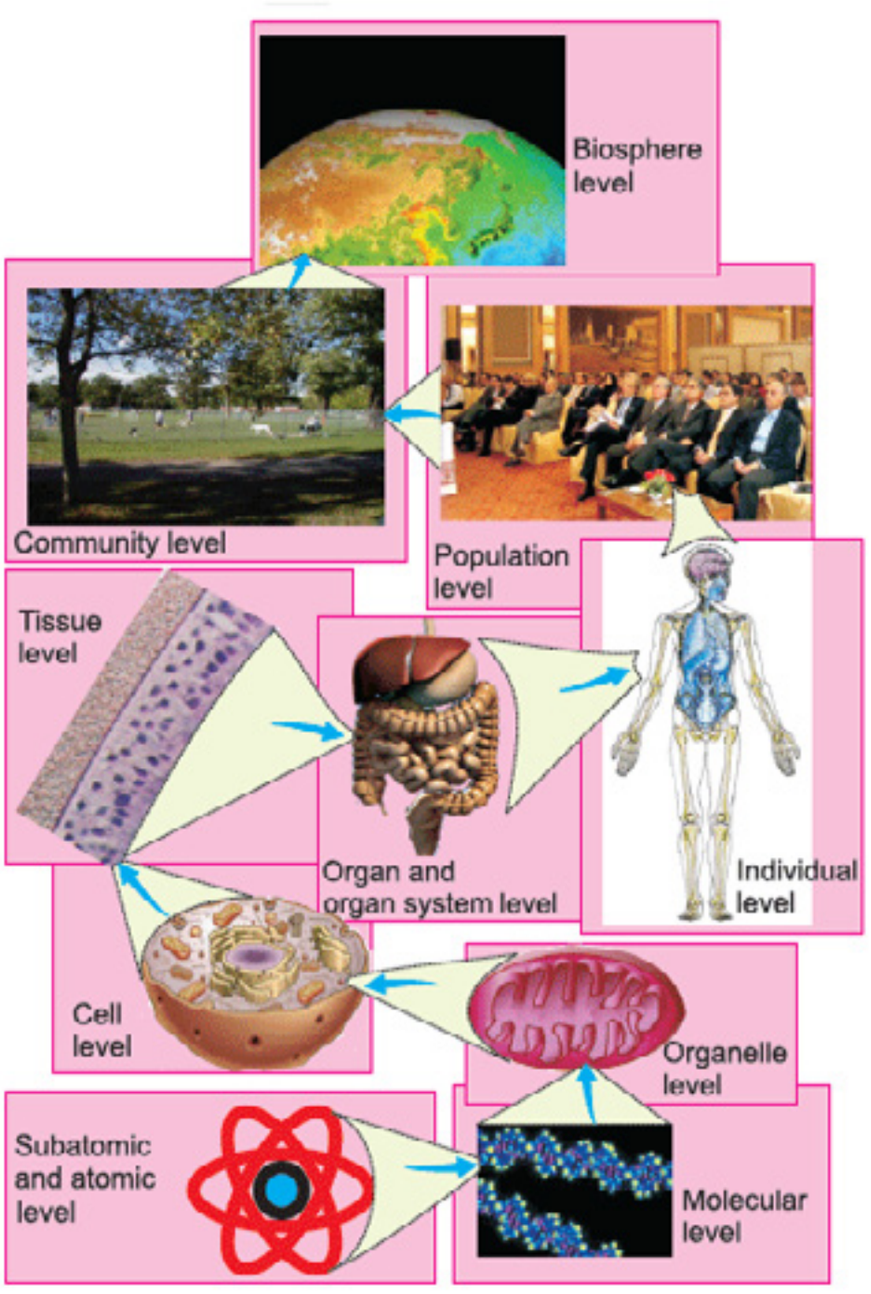


Figure 1.3: Levels of organization

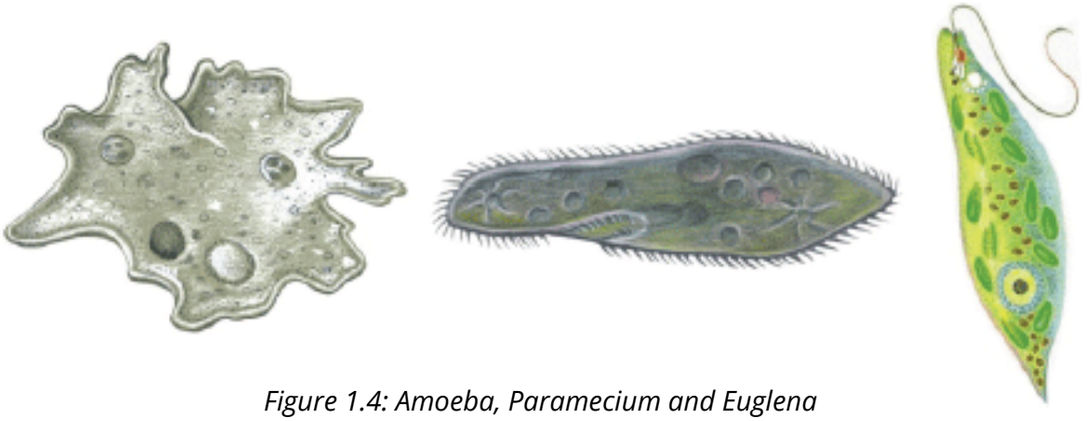


Figure 1.4: Amoeba, Paramecium and Euglena

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).

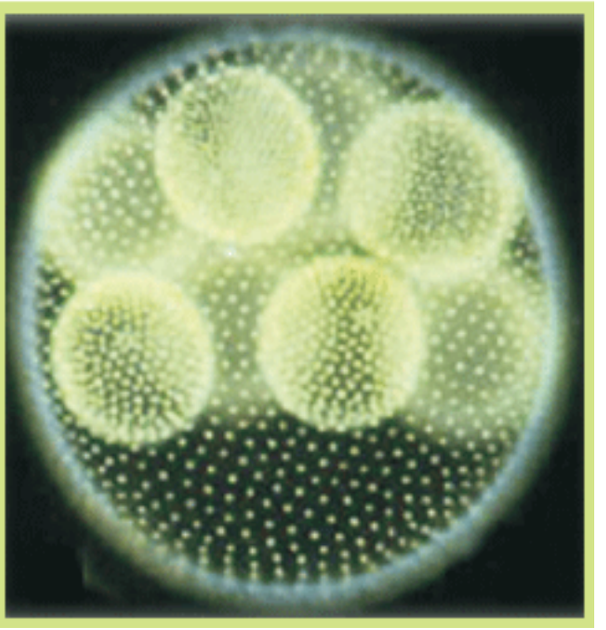


Figure 1.5: Volvox colony

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.

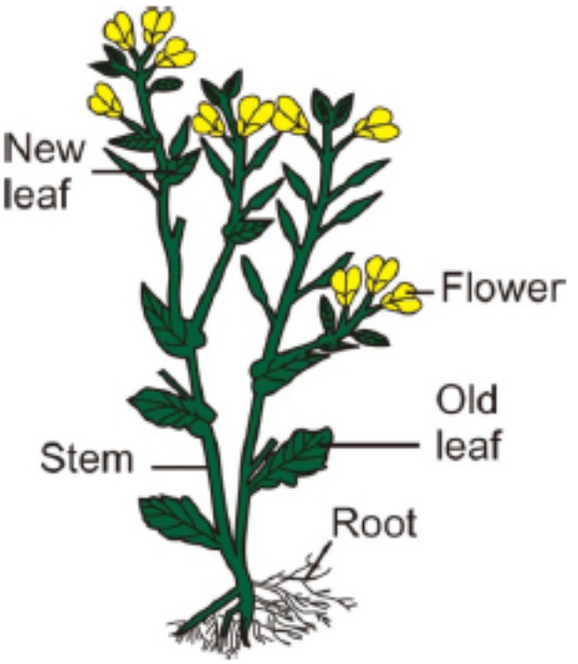


Figure 1.6: Mustard

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.

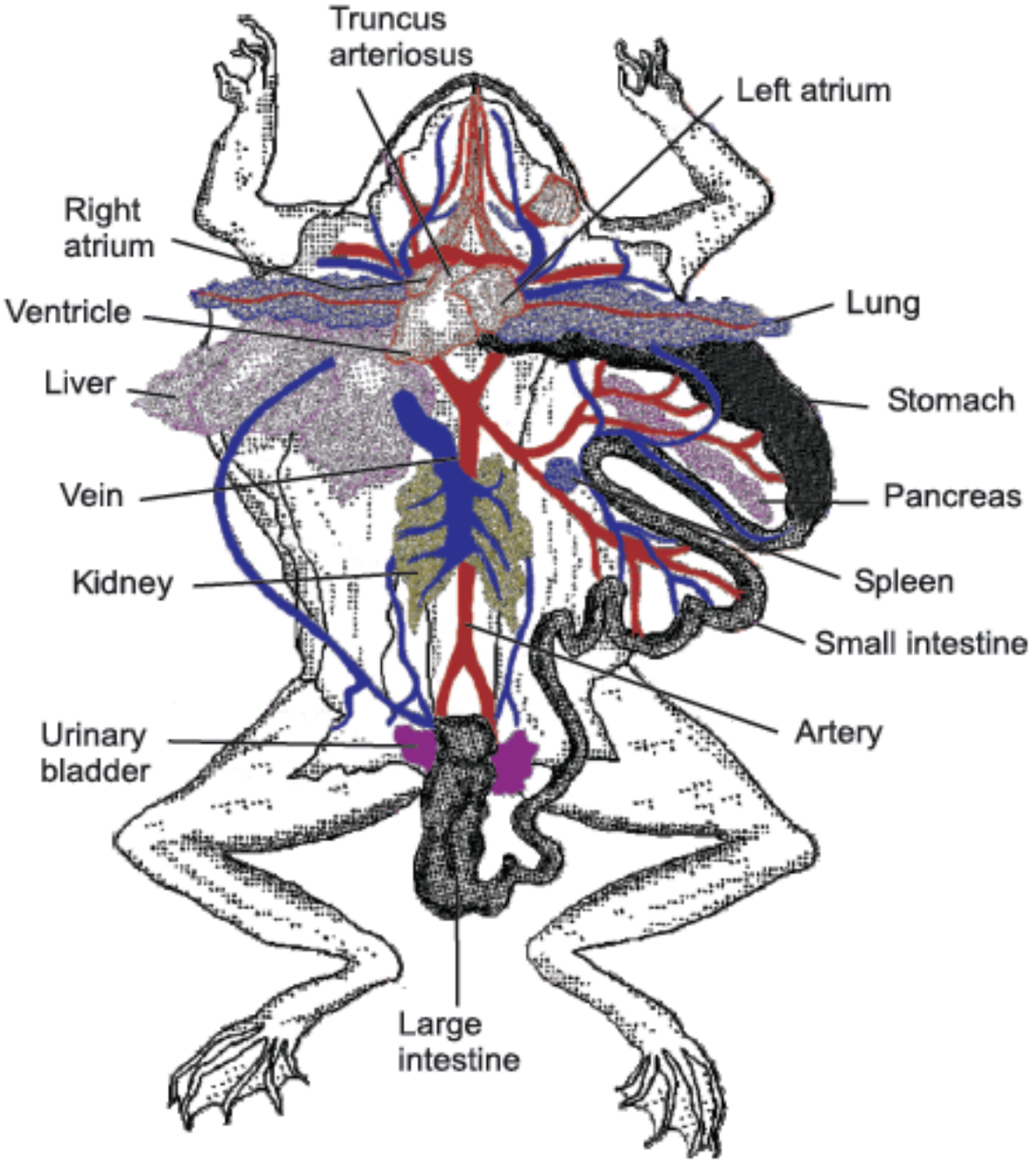


Figure 1.8: Anatomy of dissected frog

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