Unit–1

INTRODUCTION TO SCIENCE

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Introduction

Since its recognition as an independent field of study science has been given a higher status as a field of knowledge. Science, as you may know, provides the knowledge and understanding of nature and natural phenomena. Scientists, through systematic study of the natural phenomena, gather information to understand the nature and how it works. So we can say that science is a process of investigation which results in new discoveries about the nature. It is the process of scientific investigation which gives science a higher status in the realm of knowledge. This process or as it is more often termed "scientific Method" is an organized and systematic method of solving problems, finding answers and generating new knowledge about the nature and how it works. Knowledge acquired through application of scientific method is considered more reliable and accurate. It is often believed that scientific knowledge is final and unchangeable truths about the nature. Scientific method is described as a step by step method of investigation which culminates in knowledge generation. In this unit, you will read about the scientific method and characteristics of science which make it different from the non science fields. You will also study about scientific method and nature of scientific knowledge. In this era of knowledge explosion the boundaries between different fields of science and even between science and other fields of knowledge are diminishing. Many fields of knowledge which were previously categorized as non science, is now considered as branches of science; psychology is just one example. In this unit you will read about the relationship between different disciplines of science and relationship of science with other subjects.

Objectives

After studying this unit, you will be able to:

- Explain the scientific method.
- Discuss the difference between various branches of science.
- Appraise the contributions of Muslim scientists in the field of science and technology.
- Describe the relationship of science with technology and society

1.1 Scientific Method

We adopt different methods in order to acquire new knowledge, integrating new knowledge with previous knowledge, correcting any information, or investigating certain phenomena. Two different persons can view the same incident, and each one can report it differently. You have possibly had a number of experiences with this phenomenon. Have you ever had two friends who observed the same incident, give you completely different reports of what happened? The reason for these conflicting viewpoints is that we all see the world differently. All of our biases, beliefs, and perceptions that cause us to view things the way we do play a role in the way we solve problems or acquire new information.

Over the centuries scientists have faced the problems regarding sorting out facts from non facts. They tried to bring objectivity and to reduce the biasness in the interpretation of results. They worked to device a uniform method of verifying the "truth". To solve this problem, they developed a methodical framework to work. This framework is known as the "scientific method". The term "scientific" refers to a well organized and planned procedure of inquiry in which scientists try to control the effect of all sorts of personal biases, beliefs and perceptions. This method is based on gathering empirical and measurable evidences and follows specific principles of reasoning.

The scientific method is the foundation of every science investigation. The results of such experiments which follow scientific method are considered more reliable and valid. The success of science experiments or scientific inquiries is based upon the method used for investigation.

According to Oxford English Dictionary scientific method is:

> "a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement and experiment and the formulation, testing and modification of hypotheses."

We can say that scientific method is a tool to assist all of us and scientists to solve problems and find the answers of questions in a logical format. It provides general directions to solve the problems.

Steps of Scientific Method

Generally in the literature, scientific method is described as a step by step procedure of conducting investigation. Different sources list slightly different steps, though they all have many commonalities. Some experts have described it as a five step method while others have included more than five steps. However, there is one commonality among all of these. They all begin with the identification of a problem or a question to be answered based on observations of the world around us and provides an organized method for conducting and analyzing an experiment. In the physical sciences, following are the steps of scientific method of investigation.

- Identification of a problem
- Background research
- Formulation of a hypothesis
- Designing and planning the experiment.
- Conducting experiments
- Collecting the data
- Analysis of the data
- Drawing conclusions
- Reporting the results

Here is the detail of each step.

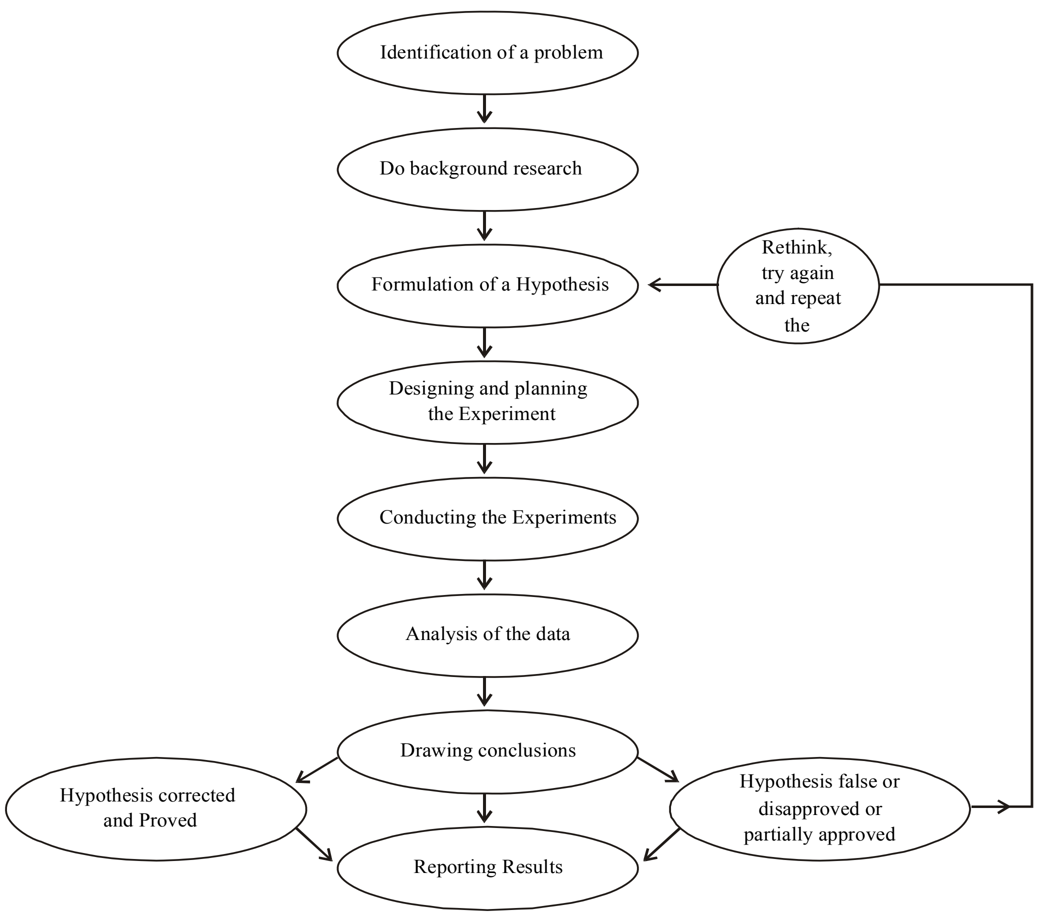


Figure 1 Scientific Method

1. Identification of a Problem

The first step of scientific method is identification of a problem. Something is considered a problem, if its solution is not obvious. Some crucial information is missing. Solving the problem involves finding this missing information.

A problem is something which has a solution. A problem can be in the form of a question. To find a solution of the problem it should be clearly stated in testable and measurable terms.

Take the following example. In an area many people died of an unknown disease. On publics request Government hired a team of scientists to look into the problem. All that was communicated to the scientists' team was that an unknown disease has caused many deaths and the government needs to solve the problem. This was the first step of identification of the problem that there is a disease which has caused many deaths which needs to be controlled. To find the solution the team needed to state the problem in a manner that provides guidelines to find a solution. The problem was that there was a fatal disease killing many people and the cause of the disease was not known hence the Government needed to find the cause of the disease and take measures to control it by eliminating the disease. So the problem was "what was the cause of disease X and how it could be controlled"?

The problem should not be too broad or too narrow. A broader question/problem is unmanageable. For example consider the following problem; what types of conditions are best for growing green plants? It is too broad and does not provide any guide line to search the solution. However, if restated in following terms it helps to design the research or experiment. Do the green plants grow better under direct sunlight or under the shade? This problem can be further narrowed down taking just any one type of green plants. The problem should be stated in clear, precise and specific terms.

2. Background Research

Background research is the research related to the problem and it is basically a review of the literature on related research. After identifying the problem scientists collect more information on the problem before taking steps to find the solution. The literature review helps the researcher to narrow down the problem and to state it more precisely. It also helps in finding the best way to plan and design his/her research. This will also ensure that the mistakes made by the others are not repeated.

3. Formulate a Hypothesis

In scientific terminology an intelligent guess based on observations is called hypothesis. In order to solve the problem a hypothesis is stated. Hypothesis is an educated guess towards the solution of problem. Hypothesis must be stated in a way that it can easily be tested. Hypothesis should be constructed in such a way that it help to answer the original question.

4. Conduct an Experiment

Experiments are conducted to test whether the hypothesis is true or false. An experiment is designed to provide a means to make a solid conclusion about the hypothesis.

Therefore experiment must be planned and designed in a manner to control any factor that may cause inaccuracy in the results. For this purpose experiments are conducted in a way that only the variable, the effect of which is to be studied, is changed keeping all the other variables constant or same. For example, if an experiment is conducted to study the effect of light on plant growth then only the intensity of light is changed to see at which intensity plant growth is maximum. Except light all the other factors or variables such as amount of water or soil type, that might have an effect on plant growth, are kept the same. Experiments are repeated many times in order to ensure the results.

5. Collect the Data

Data is collected during the experiment. The data must be collected with accuracy and precision. The collected data can be presented in the form of table, graphs or both.

6. Analyze the Data and Draw a Conclusion

Data analysis entails finding patterns, recognizing relationship between cause and effect. After the collection of data, it is analyzed. For analysis, statistics formulae are applied to see if hypothesis is true or false. In other words with the help of data analysis it can be verified whether the findings of the experiment support the hypothesis or not. On the basis of the data analysis, conclusions are drawn.

7. Report the Results

The communication of results is very important and significant step in scientific research. Your results explain how experiment can be applied to real life.

Activity 1

Where is the best place to store apples? Solve this problem using scientific method. Write down different steps of scientific method for this problem.

Key Points

- The scientific method is the process by which scientists, collectively and over time, attempt to construct an accurate (that is, reliable, consistent and non-arbitrary) representation of the world.
- The scientific method attempts to minimize the influence of bias or prejudice in the experimenter when testing a hypothesis or a theory.
- The scientific method is often described as steps. The steps of scientific method include:
  - Ask a question or identify a problem
    - A problem is something you are trying to solve. A problem can be in the form of a question. A good problem or question is measureable and testable.
  - Background research
    - Sensibly use library and Internet research to have information on research related to the problem under study help you to find the best way to plan and conduct the experiment.
  - Formulate a hypothesis.
    - Hypothesis is an educated guess towards the solution of problem. Hypothesis must be stated in a way that it can easily be measured.
  - Conduct an experiment.
    - Experiment must be well planned and conducted with accuracy and precision.
  - Collect the data
    - The findings of the experiment are recorded several times.
  - Analyze the data and draw conclusion
    - The collected data is analyzed to indentify patterns and to see cause and effect relationship. On the basis of the results of data analysis conclusions are drawn.
  - Report the results
    - The reporting of results is an important step in scientific research.

Self Assessment Exercise No. 1.1

Q.1 Answer the following questions:

i. What are the advantages of scientific method?
ii. What is the relationship between hypothesis and conclusion?
iii. Why the communication of results of scientific method is important?
iv. What is data?

1.2 Classification of Sciences

The word science has been derived from the Latin word “scientia”, meaning "knowledge". Science is a systematic activity that builds and organizes knowledge in the form of testable theories and laws about the universe. It also refers to the body of reliable knowledge itself that can be logically and rationally explained. Before the 17^{th} century science was considered as a type of knowledge closely linked to philosophy. From the 17th century onwards the term science was used to denote reliable knowledge about the phenomena of the material universe and their laws. In modern era, "science" is often used to refer to a specific type of knowledge and also a way of pursuing knowledge. Since the 19th century, the word "science" has been used in a specific meanings referring to a disciplined way to study the natural world. In the 19th century, the term scientist was introduced by the naturalist-theologian William Whewell, to distinguish those who study nature from those who sought knowledge about other disciplines. According to the Oxford English Dictionary, the origin of the word "scientist" dates back to 1834.

Today there are several other major areas of disciplined study and knowledge classified as science.

In the literature on science we find different classifications of sciences based on different criteria of classification for example some classifications are based on the subjects which are studied, while others are based on the method of study, still others are based on the purpose of the study. According to one classification that we often read in the literature, sciences have been grouped under two major categories: pure sciences and applied sciences. Pure science is systematic study of natural or physical phenomena by observation and experiment, critical testing and review, and ordering by general principles. Applied science is the search for practical uses of scientific knowledge; technology is the application of applied science. As you may have noticed this classification is based on the purpose of the science, for example the purpose of pure science is to understand natural phenomena, while the purpose of applied science is to solve practical problems through the application of the scientific knowledge.

According to another classification of scientific knowledge has been grouped under three major categories: formal science, natural sciences, and social sciences. Each of these is again subdivided into many branches.

The branches of knowledge with abstract concepts such as logic, mathematics, theoretical computer science, information theory, systems theory, decision theory, statistics, and some aspects of linguistics are named as formal sciences. They are different from other sciences in that they are not concerned with gathering empirical data and making hypotheses but are concerned with the systems themselves.

Natural science is the study of the rules that govern the natural world by applying an empirical and scientific method.

The disciplines included in social sciences are concerned with the study of human behaviour in its social and cultural perspective. Social sciences also apply the scientific method to study human behaviour and social patterns for example the humanities, which use a critical or analytical approach to the study of the human condition. Social science includes a number of fields for example, anthropology, archaeology, business administration, communication, criminology, economics, education, government, linguistics, international relations, political science, and sociology and, in some contexts, geography, history, law, and psychology.

There are many other classifications of sciences also. Here we have given only a few to give you the idea that sciences can be classified in many different ways using different criteria and for different purposes. Each major category of science has been further classified into sub disciplines.

Since this is a science course, therefore we shall give detail of only the sub categories of natural sciences.

1.2.1 Branches of Natural Sciences

Natural science has many branches, some deal with matter. To give you some idea of sciences which have been classified as natural science below and on the following pages brief description of different natural sciences is given.

Astronomy

Astronomy is the study of heavenly bodies such as stars, planets, comets, and galaxies. Under this science the phenomena that originate outside the atmosphere of earth such as cosmic background radiation is also studied. Astronomy is a vast science which deals with not only the subjects such as evolution, physical and chemical properties; meteorology, and motion of heavenly bodies, but also the formation and development of the universe.

It is one of the oldest sciences. Prehistoric civilizations have used different astronomical objects for studying the night sky. However, real development in the field of astronomy was made after the invention of the telescope, before that astronomical study was limited to noting and predicting the positions of the moon, sun, and planets.

Biology

Like most of the scientific names and terms, the term biology is a derivative of the Greek word "bios" meaning life and "logos" meaning study. So biology is the study of living organisms.

Biology has a very wide scope. Under this discipline we study living organisms at different levels and from different perspectives. For example we may study organisms of different types such as unicellular organisms or multicellular organisms. We can study their structure, life processes, their behaviour, and we can study the living organisms from cellular level to organism level. Biology is a vast field and is divided into many branches.

Botany and zoology are the main subdivisions of biology. Botany is the study of plants whereas zoology is the study of animals. With the advancements in science, the field of biology has been further subdivided into specializations like genetics, morphology, biochemistry, taxonomy, biophysics, ecology, biotechnology and biochemistry and so on.

Chemistry

Chemistry is the study of composition, properties and chemical reactions of matter. Chemistry is concerned with not only the smallest basic unit of structure of matter which is called atom but also with the study of matter at subatomic level.

Chemistry is concerned with the properties of atoms and the laws governing their combinations and with how the knowledge of these properties can be used to achieve specific purposes.

Chemistry is also concerned with the utilization of natural substances and the creation of artificial ones. Cooking, fermentation, glass making, and metallurgy are all chemical processes that dates back to beginning of civilization.

Chemistry has also been divided into many sub disciplines e.g. organic chemistry, physical chemistry, inorganic chemistry, analytical chemistry and nuclear chemistry.

Physics

Physics is the scientific study of matter and energy and their relationship. There are many forms of this energy such as light, motion, radiation, light, electricity, gravity and so on. Physics is concerned with matter on scales ranging from sub-atomic particles to stars and even entire galaxies. The living systems are also composed of fundamental particles and are studied in biophysics and biochemistry. These particles follow the same types of laws as the simpler particles traditionally studied by a physicist.

Before 19th century, physics was studied as a branch of philosophy. Now a day's physics is part of nearly all sciences such as engineering, medical, computer, and other fields of science. The laws of physics are used in many branches of science.

The scope of physics is not only restricted to the study of objects under the action of given forces but also the origin and nature of force (gravitational, magnetic, nuclear etc) fields.

There are many branches of physics named as biophysics, astrophysics, geophysics, and even psychophysics.

Geology

Geology is the scientific study of the earth, including its surface, composition, physical properties, and origin. The study of the formation and distribution of minerals and rocks is also included in geology. Geology is serving the society in a practical ways.

The discovery of the deposits of valuable minerals is guided by geologic principles and is done by geophysical and geochemical methods.

The findings of seismological research are helping engineers to design structures that are better able to hold up earthquakes.

Meteorology

Meteorology is the scientific study of the changes in air pressure, temperature, humidity, and wind direction in the troposphere. Meteorology is divided into two major branches, dynamic and synoptic. Dynamic meteorology deals primarily with the motions of the atmosphere and the physical processes involved in air flow.
Research in the meteorology involves the extensive use of computer models of general global circulation and of small-scale motion systems such as tornadoes and hurricanes.
These mathematical models contribute much to the understanding of the physics and structure of the lower atmosphere.

The Medicine and Health Sciences

Medicine is the science and art of healing. In the promotion of health, medicine is playing vital role. It includes a variety of health care practices evolved to maintain and restore health by the prevention and treatment of illness. Development and research in science and technology has extended the scope of health science and a number of sub disciplines have been developed under health sciences for example, forensic medicine, pathology, nutrition and so on.

Computer Sciences

This field of study deals with the operation, structure, and application of computers and computer systems.

Computer science also includes engineering activities, such as the design of computers and of the hardware and software of computer systems, and theoretical, mathematical activities, such as the analysis of algorithms and performance studies of systems.

It also involves experimentation with new computer systems and their potential applications.

Engineering

Engineering is the practical application of science and mathematics to solve problems, and it is everywhere in the world around you. It is an example of applied science. Our days begin and end with engineering technologies which are continuously improving our ways of communication, working, travelling, stay healthy, and entertain ourselves. Two types of natural resources are used by engineers; materials and energy.

Engineers are making things work more efficiently and quickly and less expensively.

Key Points

1. Science is a systematic activity that builds and organizes knowledge in the form of testable theories and laws about the universe
2. different classifications of sciences based on different criteria of classification
3. According to one classification that we often read in the literature, sciences have been grouped under two major categories: pure sciences and applied sciences. Another classification is formal science, natural sciences, and social sciences
4. Pure science is systematic study of natural or physical phenomena by observation and experiment, critical testing and review, and ordering by general principles.
5. Applied science is the search for practical uses of scientific knowledge; technology is the application of applied science.
6. Social sciences are concerned with the study of human behaviour in its social and cultural perspective.
7. Branches of natural sciences are astronomy, biology, chemistry, physics, geology, meteorology, medicine and health sciences, computers and engineering.

Self Assessment Exercise 1.2

Q.1 Answer the following questions:
   - i. What is science?
   - ii. How science has been classified into different branches?
   - iii. Discuss five branches of science.

1.3 Scientific Discoveries

Before we discuss “scientific discoveries”, it is necessary that you must know the difference between discovery and an invention. Discovery is completely different thing. It is to detect something new. Note the verb ‘to detect’. It does not necessarily mean to create or produce the object of discovery, but rather it is to make it known. Most importantly, discoveries apply to any natural occurrence.

On the other hand an invention is an original concept or thing that has not been existent prior to actual invention. To invent is similar to creating something completely distinct and was non-existent prior to the act. In natural sciences, a thing or an instance is considered as such when it is embodied in artifacts, tools, machinery, man-made artifacts, tools, processes etc.

Discovery and invention work hand in hand. Inventions are an integration of things that have already been discovered in the same way that new discoveries can be found through the help of inventions.

Science has great impact on us and there are thousands of scientific discoveries. We directly or indirectly benefit from these discoveries. These discoveries have opened up the new avenues for further discoveries. Undoubtedly, we can say that the, the progress in the world is due to the scientific discoveries. In the following lines, there are scientific discoveries which have changed the entire world. These discoveries are arranged in the order they were made.

1.3.1 The Solar System

Earlier than 1543, astronomers assumed that at the center of the universe was “earth”. In 1543, Polish astronomer Nicholas Copernicus introduced “Copernicum system”. In his published theory, he discovered that earth is not at the centre of solar system. He described that “sun” is the unmoving body and there are planets which are revolving around sun.

1.3.2 Gravity

Sir Isaac Newton, physicist and mathematician, is known as the most famous scientist of the time. Law of universal gravitation is the one of his most important discoveries. Newton discovered (in 1664) that gravity is the force of attraction that exists between the objects. It explains the reason of falling objects. It also explains the reason of motion of planets in orbits around the sun.

1.3.3 Electricity

The discovery of electricity has changed our lives. Various functions of our everyday life are dependent on electricity. Michael Faraday (in 1821) discovered that the current carrying wire is rotated if it is placed near to a magnetic pole. Electric motor is invented as a result of this discovery. Ten years after this discovery, he turned out to be the first one to generate electric current by moving a wire through a magnetic field. The first generator was created as a result of Faraday's experiment.

1.3.4 Germ Theory of Disease

Before 1860's, people did not know what was the cause of diseases. Louis Pasteur started experimenting with bacteria. He made two discoveries. First he discovered that diseases are caused by microorganisms. Secondly he recognized that heating and sterilizing can be helpful in killing the bacteria. Due to this discovery, doctors started sterilizing their instruments and washing their hands, which leads to life saving of millions of people.

1.3.5 X-Rays

In 1895, Wilhelm Roentgen discovered X-rays. X-rays can pass through certain substances, like wood and flesh, but are blocked by others substances such as lead and bones. X-rays are useful in medical field and for security purposes. The discovery of X-rays could make possible to examine broken bones or explosive within bags. In 1901, Roentgen was awarded with Nobel Prize in Physics.

1.3.6 Theory of Relativity

Albert Einstein's theory of special relativity was published in 1905. This theory gave detailed relationships between time, speed, and distance. This theory describes that the speed of light remains always the same i-e 86,000 miles/second (300,000 km/second) in spite of how fast someone or something is moving toward or away from it. This theory turned out to be the foundation for much of modern science.

1.3.7 The Big Bang Theory

Nobody knows exactly how the universe came into existence, but many scientists believe that it happened about 13.7 billion years ago with a massive explosion, called the Big Bang. In 1927, Georges Lemaître proposed the Big Bang theory of the universe. The theory says that all the matter in the universe was originally compressed into a tiny dot. In a fraction of a second, the dot expanded, and all the matter instantly filled what is now our universe. The event marked the beginning of time. Scientific observations seem to confirm the theory.

1.3.8 Penicillin

In 1928, Dr. Alexander Fleming discovered penicillin accidentally. In his lab, he grew mold and fungi. He noticed that some mold stopped bacteria from growing. Prior to the discovery of penicillin, even slight infections could cause death. Now a day, we get to know that antibiotics are powerful drugs that can kill all those dangerous bacteria within our bodies that are the cause of our sickness. The first antibiotic penicillin was discovered by Alexander Fleming. The infections like sour throat could not be treated without antibiotics.

1.3.9 DNA

Genes are composed of DNA (**Deoxyribonucleic acid is** a nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms). This is the DNA which determines individual's characteristics for example eyes color, hair and height. On February 28, 1953, James Watson of the United States and Francis Crick of England made one of the greatest scientific discoveries in history. The two scientists found the double-helix structure of DNA. It is made up of two strands that twist around each other and have an almost endless variety of chemical patterns that create instructions for the human body to follow. In 1962, they were awarded the Nobel Prize for this work. The discovery has helped doctors understand diseases and may someday prevent some illnesses like heart disease and cancer.

1.3.10 HIV/AIDS

Now a day HIV/AIDS (**Human immunodeficiency virus infection / Acquired immunodeficiency syndrome)** is considered the most dangerous disease. This disease of the human immune system is caused by the human immunodeficiency virus-HIV. The illness interferes with the immune system, making people with AIDS much more likely to get infections, including opportunistic infections and tumors that do not affect people with working immune systems. This susceptibility gets worse as the disease continues

In 1983 and 1984, Luc Montagnier of France and Robert Gallo of the United States discovered the HIV virus and determined that it was the cause of AIDS. Scientists have since developed tests to determine if a person has HIV. People who have positive test are urged to take precautions to prevent the spread of the disease. Drugs are available to keep HIV and AIDS under control. The hope is that further research will lead to the development of a cure.

Dear students, after going through these discoveries, you can very well realize that in the progress, prosperity and development of the world, these discoveries have played significant role. Modern world could not attain the triumph of progress if these discoveries were not made.

Key Points

1. Scientific discoveries which have changed the entire world.
2. In 1543, Polish astronomer_Nicholas Copernicus introduced "Copernicum system", according to that system the sun was considered a motionless object at the middle of the solar system and the planets were revolving around it.
3. In 1664, Newton discovered that gravity is the force of attraction that exists between the objects
4. In 1821, Michael Faraday discovered that when a current carrying wire is placed near to a magnetic pole, the wire will rotate.
5. In 1860 Louis Pasteur discovered that disease came from microorganisms, and that bacteria could be killed by heat and sanitizer.
6. In 1895 Roentgen discovered X-rays.
7. In 1927, Georges Lemaître proposed the Big Bang theory of the universe.
8. In 1927, Georges Lemaître proposed the Big Bang theory of the universe. The theory says that all the matter in the universe was originally compressed into a tiny dot.
   The first antibiotic, penicillin was discovered in 1928 by Alexander Fleming. Which he grew in his lab using mold and fungi.
9. In 1953, James Watson and Francis Crick made one of the greatest scientific discoveries in history. The two scientists found the double-helix structure of DNA.
10. In 1983 and 1984, Luc Montagnier of France and Robert Gallo of the United States discovered the HIV virus and determined that it was the cause of AIDS.

Self Assessment Exercise 1.3

Q.1 Fill in the blanks.

1. Solar system was discovered in ___________________
2. ______________discovered the force of gravity.
3. Faraday discovered that when a ______________carrying wire is placed next to a single ________________________, the wire will rotate.
4. French chemist Louis Pasteur began experimenting with ______________________
5. Roentgen was awarded _____________________for his discovery of __________________.
6. _________________discovered the first antibiotic named as ____________.
7. People who have positive test of _______________are urged to take precautions to prevent the spread of the disease.

1.4 Contribution of Muslim Scientists and Thinkers

Dear students, it is often emphasized that Muslims received inherited Greek knowledge with great consideration. Muslims however did not limit themselves to saving it and then passing it intact to future generations. They has enlarged and enriched it with new and original ideas. It can be said, without any doubt, that the whole of Greek learning was completely rethought by the Muslims and that without this renovation, the Western renaissance could not have come about.

In our present time, it is very astonishing to note that the Islamic contribution to civilization is often undermined by the West despite the fact that in several cases, medieval Western scholars diligently imitated, copied and plagiarized the works of Muslim scientists.

Medieval Islam was technologically advanced and open to innovation. The achievements of Muslim scientists in astronomy, physics, biology, medicine, chemistry, and mathematics were tremendous. Their inventions include windmills, trigonometry, lateen sails and made major advances in metallurgy, mechanical and chemical engineering and irrigation methods. In the middle- ages the flow of technology was overwhelmingly from Islam to Europe rather from Europe to Islam. Only after the 1500's did the net direction of flow begin to reverse.

Here are the contributions of famous Muslim scientists and thinkers of all times.

1.4.1 ABU ABDULLAH AL-BATANI (858 - 929 A.D.)

Abu Abdallah Muhammad Ibn Jabir Ibn Sinan al-Battani al-Harrani was born around 858 A.D. in Harran. Battani was first educated by his father Jabir Ibn San'an al-Battani, who was also a well-known scientist. He then moved to Raqqa, situated on the bank of the Euphrates, where he received advanced education and later on flourished as a scholar. At the beginning of the 9th century, he migrated to Samarra, where he worked till the end of his life in 929 A.D. He was of Sabian origin, but was himself a Muslim.

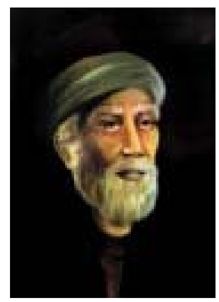
Battani was a famous astronomer, mathematician and astrologer. He has been held as one of the greatest astronomers of Islam. He is responsible for a number of important discoveries in astronomy, which was the result of a long career of 42 years of research beginning at Raqqa when he was young. His well-known discovery is the remarkably accurate determination of the solar year as being 365 days, 5 hours, 46 minutes and 24 seconds, which is very close to the latest estimates. He found that the longitude of the sun's apogee had increased by 16^o, 47' since Ptolemy. This implied the important discovery of the motion of the solar apsides and of a slow variation in the equation of time. He did not believe in the trapidation of the equinoxes, although Copernicus held it.
AL-Battani determined with remarkable accuracy the obliquity of the ecliptic, the length of the seasons and the true and mean orbit of the sun.

His excellent observations of lunar and solar eclipses were used by Dunthorne in 1749 to determine the secular acceleration of motion of the moon. He also provided very neat solutions by means of orthographic projection for some problems of spherical trigonometry.

In mathematics, he was the first to replace the use of Greek chords by sines, with a clear understanding of their superiority. He also developed the concept of cotangent and furnished their table in degrees.

He wrote a number of books on astronomy and trigonometry. His most famous book was his astronomical treatise with tables, which was translated into Latin in the l2th century. His treatise on astronomy was extremely influential in Europe till the Renaissance, with translations available in several languages. His original discoveries both in astronomy and trigonometry were of great consequence in the development of these sciences.

1.4.2 ABU RAIHAN AL-BIRUNI (973 - 1048 A.D.)



Abu Raihan Mohammad Ibn Ahmad al-Biruni was one of the well-known figures associated with the court of King Mahmood Ghaznavi, who was one of the famous Muslim kings of the 11th century A.D. Al-Biruni was a versatile scholar and scientist who had equal facility in physics, metaphysics, mathematics, geography and history. Born in the city of Kheva near "Ural" in 973 A.D., he was a contemporary of the well-known physician Ibn Sina. At an early age, the fame of his scholarship went around and when Sultan Mahmood Ghaznavi conquered his homeland, he took al-Biruni along with him in his journeys to India several times and thus he had the opportunity to travel all over India during a period of 20 years. He learnt Hindu philosophy, mathematics, geography and religion from the Pandits to whom he taught Greek and Arabic science and philosophy. He died in 1048 A.D. at the age of 75, after having spent 40 years in thus gathering knowledge and making his own original contributions to it.

He recorded observations of his travels through India in his well-known book *Kitab al-Hind* which gives a graphic account of the historical and social conditions of the sub-continent.

On his return from India, al-Biruni wrote his famous book *Qanun-i Masoodi* (*al-Qanun al-Masudi, fi al-Hai'a wa al-Nujum*), which he dedicated to Sultan Masood. The book discusses several theorems of astronomy, trigonometry, solar, lunar, and planetary motions and relative topics. In another well-known book *al-Athar al-Baqia*, he has attempted a connected account of ancient history of nations and the related geographical knowledge. In this book, he has discussed the rotation of the earth and has given correct values of latitudes and longitudes of various places. He has also made considerable contribution to several aspects of physical and economic geography in this book.

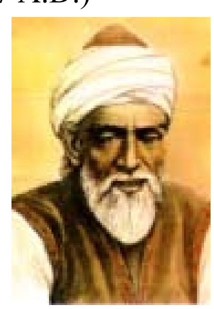
His other scientific contributions include the accurate determination of the densities of 18 different stones. He also wrote the *Kitab-al-Saidana*, which is an extensive materia medica that combines the then existing Arabic knowledge on the subject with the Indian medicine. His book the *Kitab-al-Jamahir* deals with the properties of various precious stones. He was also an astrologer and is reputed to have astonished people by the accuracy of his predictions.

He developed a method for trisection of angle and other problems which cannot be solved with a ruler and a compass alone. Al-Biruni discussed, centuries before the rest of the world, the question whether the earth rotates around its axis or not. He was the first to undertake experiments related to astronomical phenomena. His scientific method, taken together with that of other Muslim scientists, such as Ibn al-Haitham, laid down the early foundation of modern science. He ascertained that as compared with the speed of sound the speed of light is immense. He explained the working of natural springs and artesian wells by the hydrostatic principle of communicating vessels. His investigations included description of various monstrosities, including that known as "Siamese" twins. He observed that flowers have 3,4,5,6, or 18 petals, but never 7 or 9.

He wrote a number of books and treatises named as k*itab-al-Hind* (History and Geography of India), *al-Qanun al-Masudi* (Astronomy, Trigonometry), *al-Athar al-Baqia* (Ancient History and Geography), *Kitab al-Saidana* (Materia Medica) and Kitab al-Jamahir (Precious Stones) as mentioned above, his book *al-Tafhim-li-Awail Sina'at at-Tanjim* gives a summary of mathematics and astronomy.

He has been considered as one of the very greatest scientists of Islam, and, all considered, one of the greatest of all times. His critical spirit, love of truth, and scientific approach were combined with a sense of toleration.

1.4.3 ABUL WAFA MUHAMMAD AL-BUZJANI (940 - 997 A.D.)



Abul Wafa Muhammad Ibn Muhammad Ibn Yahya Ibn Ismail al-Buzjani was born in Buzjan, Nishapur in 940 A.D. He flourished as a great mathematician and astronomer at Baghdad and died in 997/998 A.D. He learnt mathematics in Baghdad. In 959 A.D. he migrated to Iraq and lived there till his death.

Abul Wafa's main contribution lies in several branches of mathematics, especially geometry and trigonometry. In geometry, his contribution comprises solution of geometrical problems with opening of the compass; construction of a square equivalent to other squares; regular polyhedra; construction of regular hectagon taking for its side half the side of the equilateral triangle inscribed in the same circle; constructions of parabola by points and geometrical solution of the equations:

$x^4 = a$ and $x^4 + ax^3 = b$

Abul Wafa's contribution to the development of trigonometry was extensive. He was the first to show the generality of the sine theorem relative to spherical triangles. He developed a new method of constructing sine tables, the value of sine 30 being correct to the eighth decimal place. He also developed relations for sine (a + b) . In addition, he made a special study of the tangent and calculated a table of tangents. He introduced the secant and cosecant for the first time, knew the relations between the trigonometric lines, which are now used to define them, and undertook extensive studies on conics.

Apart from being a mathematician, Abul Wafa also contributed to astronomy. In this field he discussed different movements of the moon, and discovered 'variation'. He was also one of the last Arabic translators and commentators of Greek works.

He wrote a large number of books on mathematics and other subjects, most of which have been lost or exist in modified forms. His contribution includes *Kitab 'Ilm al-Hisab*, a practical book of arithmetic, *al-Kitab al-Kamil* (the Complete Book), *Kitab al-Handsa* (Applied Geometry). Apart from this, he wrote rich commentaries on Euclid, Diophantos and al-Khawarizmi, but all of these have been lost. His books now extant include *Kitab 'Ilm al-Hisab*, *Kitab al-Handsa* and *Kitab al-Kamil*.

Nonetheless, his contribution to trigonometry was extremely significant in that he developed the knowledge on the tangent and introduced the secant and cosecant for the first time; in fact a sizable part of today's trigonometry can be traced back to him.

1.4.4 ABU AL-NASR AL-FARABI (870 - 950 A.D.)

Abu Nasr Mohammad Ibn al-Farakh al-Farabi was born in a small village Wasij, near Farab in Turkistan in 259 A.H. (870 A.D.). His parents were originally of Persian descent, but his ancestors had migrated to Turkistan. Known as al-Phrarabius in Europe, Farabi was the son of a general. He completed his earlier education at Farab and Bukhara but, later on, he went to Baghdad for higher studies, where he studied and worked for a long time viz., from 901 A.D. to 942 A.D. During this period he acquired mastery over several languages as well as various branches of knowledge and technology. He lived through the reign of six Abbasid Caliphs. As a philosopher and scientist, he acquired great proficiency in various branches of learning and is reported to have been an expert in different languages.

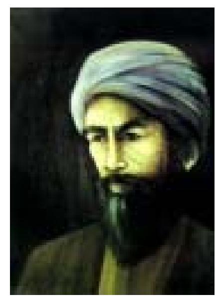
Farabi contributed considerably to science, philosophy, logic, sociology, medicine, mathematics and music. His major contributions seem to be in philosophy, logic and sociology and, of course, stands out as an Encyclopedist. He was a great expert in the art and science of music and invented several musical instruments, besides contributing to the knowledge of musical notes.

1.4.5 AL-FARGHANI (c. 860)

Abu'l-Abbas Ahmad ibn Muhammad ibn Kathir al-Farghani, born in Farghana, Transoxiana, was one of the most distinguished astronomers in the service of al-Mamun and his successors. He wrote "Elements of Astronomy" (*Kitab fi al-Harakat al-Samawiya wa Jawami Ilm al-Nujum* i.e. the book on celestial motion and thorough science of the stars), which was translated into Latin in the l2th century and exerted great influence upon European astronomy before Regiomontanus. He accepted Ptolemy's theory and value of the precession, but thought that it affected not only the stars but also the planets. He determined the diameter of the earth to be 6,500 miles, and found the greatest distances and also the diameters of the planets.

The Jawami, or 'The Elements' as we shall call it, was Al-Farghani's best-known and most influential work. The influence of 'The Elements' on mediaeval Europe is clearly vindicated by

1.4.6 IBN AL-BAITAR (DIED 1248 A.D.)



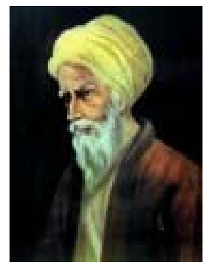
Abu Muhammad Abdallah Ibn Ahmad Ibn al-Baitar Dhiya al-Din al-Malaqi was one of the greatest scientists of Muslim Spain and was the greatest botanist and pharmacist of the Middle Ages. He was born in the Spanish city of Malaqa (Malaga) towards the end of the l2th century. He learned botany from Abu al-Abbas al-Nabati, a learned botanist, with whom he started collecting plants in and around Spain. In 1219 he left Spain on a plant-collecting expedition and traveled along the northern coast of Africa as far as Asia Minor. The exact modes of his travel (whether by land or sea) are not known, but the major stations he visited include Bugia, Qastantunia (Constantinople), Tunis, Tripoli, Barqa and Adalia. After 1224 he entered the service of al-Kamil, the Egyptian Governor, and was appointed chief herbalist. In 1227 al-Kamil extended his domination to Damascus, and Ibn al-Baitar accompanied him there which provided him an opportunity to collect plants in Syria. His researches on plants extended over a vast area including Arabia and Palestine, which he either visited or managed to collect plants from stations located there. He died in Damascus in 1248.

Ibn Baitar's major contribution, *Kitab al-Jami fi al-Adwiya al-Mu frada*, is one of the greatest botanical compilations dealing with medicinal plants in Arabic. It enjoyed a high status among botanists up to the l6th century and is a systematic work that embodies earlier works, with due criticism, and adds a great part of original contribution. The encyclopedia comprises some 1,400 different items, largely medicinal plants and vegetables, of which about 200 plants were not known earlier. The book refers to the work of some 150 authors mostly Arabic, and it also quotes about 20 early Greek scientists. It was translated into Latin and published in 1758.

His second monumental treatise *Kitab al-Mughni fi al-Adwiya al-Mu frada* is an encyclopedia of medicine. The drugs are listed in accordance with their therapeutical value. Thus, its 20 different chapters deal with the plants bearing significance to diseases of head, ear, eye, etc. On surgical issues he has frequently quoted the famous Muslim surgeon, Abul Qasim Zahravi. Besides Arabic, Baitar, has given Greek and Latin names of the plants, thus facilitating transfer of knowledge.

Ibn Baitar's contributions are characterized by observation, analysis and classification and have exerted a profound influence on Eastern as well as Western botany and medicine. Though the Jami was translated/published late in the western languages as mentioned above, yet many scientists had earlier studied various parts of the book and made several references to it.

1.4.7 ABU ALI HASAN IBN AL-HAITHAM (965 - 1040 A.D.)



Abu Ali Hasan Ibn al-Haitham was one of the most eminent physicists, whose contributions to optics and the scientific methods are outstanding. Known in the West as Alhazen, Ibn aI-Hautham was born in 965 A. D. in Basrah, and was educated in Basrah and Baghdad. Thereafter, he went to Egypt, where he was asked to find ways of controlling the flood of the Nile. Being unsuccessful in this, he feigned madness until the death of Caliph al-Hakim. He also traveled to Spain and, during this period, he had ample time for his scientific pursuits, which included optics, mathematics, physics, medicine and development of scientific methods on each of which he has left several outstanding books.

He made a thorough examination of the passage of light through various media and discovered the laws of refraction. He also carried out the first experiments on the dispersion of light into its constituent colors. His book *Kitab-at-Manazir* was translated into Latin in the Middle Ages, as also his book dealing with the colors of sunset. He dealt at length with the theory of various physical phenomena like shadows, eclipses, the rainbow, and speculated on the physical nature of light. He is the first to describe accurately the various parts of the eye and give a scientific explanation of the process of vision. He also attempted to explain binocular vision, and gave a correct explanation of the apparent increase in size of the sun and the moon when near the horizon. He is known for the earliest use of the camera obscura. He contradicted Ptolemy's and Euclid's theory of vision that objects are seen by rays of .light emanating from the eyes; according to him the rays originate in the object of vision and not in the eye. Through these extensive researches on optics, he has been considered as the father of modern optics.

The Latin translation of his main work, *Kitab-at-Manazir*, exerted a great influence upon Western science e.g. on the work of Roger Bacon and Kepler. It brought about a great progress in experimental methods. His research in catoptrics centered on spherical and parabolic mirrors and spherical aberration. He made the important observation that the radio between the angle of incidence and refraction does not remain constant and investigated the magnifying power of a lens. His catoptrics contain the important problem known as Alhazen's problem. It comprises drawing lines from two points in the plane of a circle meeting at a point on the circumference and making equal angles with the normal at that point. This leads to an equation of the fourth degree.

In his book *Mizan al-Hikmah* Ibn al-Haitham has discussed the density of the atmosphere and developed a relation between it and the height. He also studied atmospheric refraction. He discovered that the twilight only ceases or begins when the sun is 19^{o} below the horizon and attempted to measure the height of the atmosphere on that basis. He has also discussed the theories of attraction between masses, and it seems that he was aware of the magnitude of acceleration due to gravity.

His contribution to mathematics and physics was extensive. In mathematics, he developed analytical geometry by establishing linkage between algebra and geometry. He studied the mechanics of motion of a body and was the first to maintain that a body moves perpetually unless an external force stops it or changes its direction of motion. This would seem equivalent to the first law of motion.

The list of his books runs to 200 or so, very few of which have survived. Even his monumental treatise on optics survived through its Latin translation. During the Middle Ages his books on cosmology were translated into Latin, Hebrew and other languages. He has also written on the subject of evolution a book that deserves serious attention even today.

In his writing, one can see a clear development of the scientific methods as developed and applied by the Muslims and comprising the systematic observation of physical phenomena and their linking together into a scientific theory. This was a major breakthrough in scientific methodology, as distinct from guess and gesture, and placed scientific pursuits on a sound foundation comprising systematic relationship between observation, hypothesis and verification.

Ibn al-Haitham's influence on physical sciences in general, and optics in particular, has been held in high esteem and, in fact, it ushered in a new era in optical research, both in theory and practice.

1.4.8 IBN SINA (980 - 1037 A.D.)

Abu Ali al-Hussain Ibn Abdallah Ibn Sina was born in 980 A.D. at Afshana near Bukhara. The young Bu Ali received his early education in Bukhara, and by the age of ten had become well versed in the study of the Qur'an and various sciences. He started studying philosophy by reading various Greek, Muslim and other books on this subject and learnt logic and some other subjects from Abu Abdallah Natili, a famous philosopher of the time. While still young, he attained such a degree of expertise in medicine that his reknown spread far and wide. At the age of 17, he was fortunate in curing Nooh Ibn Mansoor, the King of Bukhhara, of an illness in which all the well-known physicians had given up hope. On his recovery, the King wished to reward him, but the young physician only desired permission to use his uniquely stocked library.

He was the most famous physician, philosopher, encyclopedist, mathematician and astronomer of his time. His major contribution to medical science was his famous book *al-Qanun*, known as the "Canon" in the West. The *Qanun fi al-Tibb* is an immense encyclopedia of medicine extending over a million words. this book is rich with the author's original contribution. His important original contribution includes such advances as recognition of the contagious nature of phthisis and tuberculosis; distribution of diseases by water and soil, and interaction between psychology and health. In addition to describing pharmacological methods, the book described 760 drugs and became the most authentic materia medica of the era. He was also the first to describe meningitis and made rich contributions to anatomy, gynaecology and child health.

Ibn Sina also contributed to mathematics, physics, music and other fields. He explained the "casting out of nines" and its application to the verification of squares and cubes. He made several astronomical observations, and devised a contrivance similar to the vernier, to increase the precision of instrumental readings. In physics, his contribution comprised the study of different forms of energy, heat, light and mechanical, and such concepts as force, vacuum and infinity. He made the important observation that if the perception of light is due to the emission of some sort of particles by the luminous source, the speed of light must be finite. He propounded an interconnection between time and motion, and also made investigations on specific gravity and used an air thermometer.

In the field of music, his contribution was an improvement over Farabi's work and was far ahead of knowledge prevailing elsewhere on the subject. Doubling with the fourth and fifth was a 'great' step towards the harmonic system and doubling with the third' seems to have also been allowed. Ibn Sina observed that in the series of consonances represented by $(n + 1)/n$, the ear is unable to distinguish them when $n = 45$. In the field of chemistry, he did not believe in the possibility of chemical transmutation because, in his opinion, the metals differed in a fundamental sense. These views were radically opposed to those prevailing at the time.

1.4.9 JABIR IBN HAIYAN (Died 803 A.D.)

Jabir Ibn Haiyan, the alchemist Geber of the Middle Ages, is generally known as the father of chemistry. In his early days, he practiced medicine and was under the patronage of the Barmaki Vizir during the Abbasid Caliphate of Haroon al-Rashid.

Jabir's major contribution was in the field of chemistry. He introduced experimental investigation into alchemy, which rapidly changed its character into modern chemistry. On the ruins of his well-known laboratory remained after centuries, but his fame rests on over 100 monumental treatises, of which 22 relate to chemistry and alchemy. His contribution of fundamental importance to chemistry includes perfection of scientific techniques such as crystallization, distillation, calcination, sublimation and evaporation and development of several instruments for the same. The fact of early development of chemistry as a distinct branch of science by the Arabs, instead of the earlier vague ideas, is well-established and the very name chemistry is derived from the Arabic word *al-Kimya*, which was studied and developed extensively by the Muslim scientists.

Perhaps Jabir's major practical achievement was the discovery of mineral and others acids, which he prepared for the first time in his alembic (*Anbique*). Apart from several contributions of basic nature to alchemy, involving largely the preparation of new compounds and development of chemical methods, he also developed a number of applied chemical processes, thus becoming a pioneer in the field of applied science. His achievements in this field include preparation of various metals, development of steel, dyeing of cloth and tanning of leather, varnishing of water-proof cloth, use of manganese dioxide in glass-making, prevention of rusting, lettering in gold, identification of paints, greases, etc. During the course of these practical endeavours, he also developed aqua regia to dissolve gold. The alchemi in his great invention, which made easy and systematic the process of distillation. Jabir laid great stress on experimentation and accuracy in his work.

Based on their properties, he has described three distinct types of substances. First, spirits i.e. those which vaporize on heating, like camphor, arsenic and ammonium chloride; secondly, metals, for example, gold, silver, lead, copper, iron; and thirdly, the category of compounds which can be converted into powders. He thus paved the way for such later classification as metals, non-metals and volatile substances.

Although known as an alchemist, he did not seem to have seriously pursued the preparation of noble metals as an alchemist; instead he devoted his effort to the development of basic chemical methods and study of mechanisms of chemical reactions in themselves and thus helped evolve chemistry as a science from the legends of alchemy. He emphasized that, in chemical reactions, definite quantities of various substances are involved and thus can be said to have paved the way for the law of constant proportions.

A large number of books are included in his corpus. Apart from chemistry, he also contributed to other sciences such as medicine and astronomy. His books on chemistry, including his *Kitab-al-Kimya*, and *Kitab al-Sab'een* were translated into Latin and various European languages. These translations were popular in Europe for several centuries and have influenced the evolution of modern chemistry. Several technical terms devised by Jabir, such as alkali, are today found in various European languages and have become part of scientific vocabulary. Only a few of his books have been edited and published, while several others preserved in Arabic have yet to be annotated and published.
Doubts have been expressed as to whether all the voluminous work included in the corpus is his own contribution or it contains later commentaries/additions by his followers. it is to be emphasized that the major contribution of Jabir lies in the field of chemistry and not in religion. His various breakthroughs e.g., preparation of acids for the first time, notably nitric, hydrochloric, citric and tartaric acids, and emphasis on systematic experimentation are outstanding and it is on the basis of such work that he can justly be regarded as the father of modern chemistry.

1.4.10 MOHAMMAD BIN MUSA AL-KHAWARIZMI (Died 840 A. D.)

Abu Abdullah Mohammad Ibn Musa al-Khawarizmi was born at Khawarizm (Kheva), south of Aral sea. Very little is known about his early life, except for the fact that his parents had migrated to a place south of Baghdad. The exact dates of his birth and death are also not known, but it is established that he flourished under Al-Mamun at Baghdad through 813-833 and probably died around 840 A.D.

Khawarizmi was a mathematician, astronomer and geographer. He was perhaps one of the greatest mathematicians who ever lived, as, in fact, he was the founder of several branches and basic concepts of mathematics. His work on algebra was outstanding, as he not only initiated the subject in a systematic form but he also developed it to the extent of giving analytical solutions of linear and quadratic equations, which established him as the founder of Algebra. The very name Algebra has been derived from his famous book *Al-Jabr wa-al-Mfuqabilah*. His arithmetic synthesized Greek and Hindu knowledge and also contained his own contribution of fundamental importance to mathematics and science. Thus, he explained the use of zero, a numeral of fundamental importance developed by the Arabs. Similarly, he developed the decimal system so that the overall system of numerals 'algorithm' or 'algorizm' is named after him. In addition to introducing the Indian system of numerals (now generally known as Arabic numerals), he developed at length several arithmetical procedures, including operations on fractions. It was through his work that the system of numerals was first introduced to Arabs and later to Europe, through its translations in European languages. He developed in detail trigonometric tables containing the sine functions, which were probably extrapolated to tangent functions by Maslama. He also perfected the geometric representation of comic sections and developed the calculus of two errors, which practically led him to the concept of differentiation. He is also reported to have collaborated in the degree measurements ordered by Mamun al-Rashid were aimed at measuring of volume and circumference of the earth.

The development of astronomical tables by him was a significant contribution to the science of astronomy, on which he also wrote a book. The contribution of Khawarizmi to geography is also outstanding, in that not only did he revise Ptolemy's views on geography, but also corrected them in detail as well as his map of the world. His other contributions include original work related to clocks, sun-dials and astrolabes.

His book on algebra, *Al-Maqala fi Hisab-al Jabr wa-al-Muqabilah*, was also translated into Latin in the l2th century, and it was this translation which introduced this new science to the West "completely unknown till then". He astronomical tables were also translated into European languages and, later, into Chinese. His geography captioned *Kitab Surat-al-Ard*, together with its maps, was also translated. In addition, he wrote a book on the Jewish calendar *Istihhraj Tarikh al-Yahud*, and two books on the astrolabe. He also wrote *Kitab al-Tarikh* and his book on sun-dials was captioned *Kitab al-Rukhmet*, but both of them have been lost.

The influence of Khawarizmi on the growth of science, in general, and mathematics, astronomy and geography in particular, is well established in history. Several of his books were readily translated into a number of other languages, and, in fact, constituted the university text-books till the l6th century. His approach was systematic and logical, and not only did he bring together the then prevailing knowledge on various branches of science, particularly mathematics, but also enriched it through his original contribution. No doubt he has been held in high repute throughout the centuries since then.

1.4.11 OMAR AL-KHAYYAM (1044 - 1123 A. D.)

Ghiyath al-Din Abul Fateh Omar Ibn Ibrahim al-Khayyam was born at Nishapur, the provincial capital of Khurasan around 1044 A.D. (c. 1038 to 1048). Persian mathematician, astronomer, philosopher, physician and poet, he is commonly known as Omar Khayyam.

Algebra would seem to rank first among the fields to which he contributed. He made an attempt to classify most algebraic equations, including the third degree equations and, in fact, offered solutions for a number of them. This includes geometric solutions of cubic equations and partial geometric solutions of most other equations. His book *Maqalat fi al-Jabr wa al-Muqabila* is a masterpiece on algebra and has great importance in the development of algebra. His remarkable classification of equations is based on the complexity of the equations, as the higher the degree of an equation, the more terms, or combinations of terms, it will contain. Thus, Khayyam recognizes 13 different forms of cubic equation. His method of solving equations is largely geometrical and depends upon an ingenious selection of proper conics. He also developed the binomial expansion when the exponent is a positive integer. In fact, he has been considered to be the first to find the binomial theorem and determine binomial coefficients. In geometry, he studied generalities of Euclid and contributed to the theory of parallel lines.

Khayyam introduced a calendar that was remarkably accurate, and was named as *Al-Tarikh-al-Jalali*. It had an error of one day in 3770 years and was thus even superior to the Georgian calendar (error of 1 day in 3330 years).

His contributions to other fields of science include a study of generalities of Euclid, development of methods for the accurate determination of specific gravity, etc. He was also a renowned astronomer and a physician.

Khayyam wrote a large number of books and monographs on mathematics, physics, metaphysics, one algebra and one geometry.

His influence on the development of mathematics in general and analytical geometry, in particular, has been immense. His work remained ahead of others for centuries till the times of Descartes, who applied the same geometrical approach in solving cubics. His frame as a mathematician has been partially eclipsed by his popularity as a poet;

nonetheless his contribution as a philosopher and scientist has been of significant value in furthering the frontiers of human knowledge.

1.4.12 YAQUB IBN ISHAQ AL-KINDI (800 - 873 A.D.)

Abu Yousuf Yaqub Ibn Ishaq al-Kindi was born at Kufa around 800 A.D. His father was an official of Haroon al-Rashid. Al-Kindi was a contemporary of al-Mamun, al-Mu'tasim and al-Mutawakkil and flourished largely at Baghdad. He was formally employed by Mutawakkil as a calligrapher. On account of his philosophical views, Mutawakkil was annoyed with him and confiscated all his books. These were, however, returned later on. He died in 873 A.D. during the reign of al-M'utamid.

Al-Kindi was a philosopher, mathematician, physicist, astronomer physician, geographer and even an expert in music. It is surprising that he made original contributions to all of these fields. On account of his work he became known as the philosopher of the Arabs.

In mathematics, he wrote four books on the number system and laid the foundation of a large part of modern arithmetic. No doubt the Arabic system of numerals was largely developed by al-Khawarizmi, but al-Kindi also made rich contributions to it. He also contributed to spherical geometry to assist him in astronomical studies.

In chemistry, he opposed the idea that base metals can be converted to precious metals. In contrast to prevailing alchemical views, he was emphatic that chemical reactions cannot bring about the transformation of elements. In physics, he made rich contributions to geometrical optics and wrote a book on it. This book later on provided guidance and inspiration to such eminent scientists as Roger Bacon.

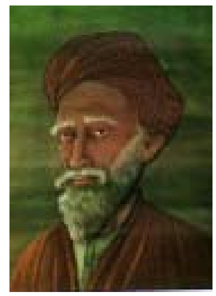
In medicine, his chief contribution comprises the fact that he was the first to systematically determine the doses to be administered of all the drugs known at his time. This resolved the conflicting views prevailing among physicians on the dosage that caused difficulties in writing recipes.
Very little was known on the scientific aspects of music in his time. He pointed out that the various notes that combine to produce harmony, have a specific pitch each. Thus, notes with too low or too high a pitch are non-pleasant. The degree of harmony depends on the frequency of notes, etc. He also pointed out the fact that when a sound is produced, it generates waves in the air which strike the ear-drum. His work contains a notation on the determination of pitch.

He was a prolific writer: the total number of books written by him was 241, the prominent among which were divided as follows:

Astronomy 16, Arithmetic 11, Geometry 32, Medicine 22, Physics 12, Philosophy 22, Logic 9, Psychology 5, and Music 7.

Al-Kindi's influence on development of science and philosophy was significant in the revival of sciences in that period. In the Middle Ages, Cardano considered him as one of the twelve greatest minds. His works, in fact, lead to further development of various subjects for centuries, notably physics, mathematics, medicine and music.

1.4.13 ABUL HASAN ALI AZ-MASU'DI (DIED 957 A.D.)



Abul Hasan Ali Ibn Husain Ibn Ali AL-Masu'di was a descendant of Abdallah Ibn Masu'd, a companion of the Holy Prophet (peace be upon him). An expert geographer, a physicist and historian, Masu'di was born in the last decade of the 9th century A.D., his exact date of birth being unknown. He was a Mutazilite Arab, who explored distant lands and died at Cairo, in 957 A.D.

He traveled to Fars in 915 A.D. and, after staying for one year in Istikhar, he proceeded via Baghdad to India, where he visited Multan and Mansoora before returning to Fars. From there he traveled to Kirman and then again to India. Mansoora in those days was a city of great renown and was the capital of the Muslim state of Sind. Around it, there were many settlements/townships of new converts to Islam. In 918 A.D., Masu'di traveled to Gujrat, where more than 10,000 Arab Muslims had settled in the sea-port of Chamoor. He also traveled to Deccan, Ceylon, Indo-China and China, and proceeded via Madagascar, Zanjibar and Oman to Basra.

At Basra he completed his book *Muruj-al-Zahab*, in which he has described in a most absorbing manner his experience of various countries, peoples and climates. He gives accounts of his personal contacts with the Jews, Iranians, Indians and Christians. From Basra he moved to Syria and from there to Cairo, where he wrote his second extensive book *Muruj al-Zaman* in thirty volumes. In this book he has described in detail the geography and history of the countries that he had visited. His first book was completed in 947 A.D. He also prepared a supplement, called *Kitab al-Ausat*, in which he has compiled historical events chronologically. In 957 A.D., the year of his death, he completed his last book *Kitab al-Tanbih wa al-Ishraf*, in which he has given a summary of his earlier book as well as an errata.

Masu'di is referred to as the Herodotus and Pliny of the Arabs. By presenting a critical account of historical events, he initiated a change in the art of historical writing, introducing the elements of analysis, reflection and criticism, which was later on further improved by Ibn Khaldun. In particular, in *Al-Tanbeeh* he makes a systematic study of history against a perspective of geography, sociology, anthropology and ecology. Masu'di had a deep insight into the causes of rise and fall of nations.

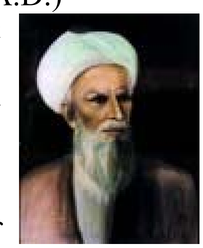
With his scientific and analytical approach he has given an account of the causes of the earthquake of 955 A.D., as well as the discussions of the water of the Red Sea and other problems in the earth sciences. He is the first author to make mention of windmills, which were invented by the Muslims of Sijistan.

Masu'di also made important contributions to music and other fields of science. In his book *Muruj al-Zahab* he provides important information on early Arab music as well as music of other countries.

His book *Muruj al-Zahab wa al-Ma'adin al-Jawahir* (Meadows of Gold and Mines of Precious Stones) has been held as 'remarkable' because of the 'catholicity of its author, who neglected no source of information and of his truly scientific curiosity'. As mentioned above, it was followed by his treatise *Muruj al-Zaman*. In addition to writing a supplement *Kitab al-Ausat*, he completed *Kitab al-Tanbih wa al-Ishraf* towards the end of his career. It is, however, unfortunate that, out of his 34 books as mentioned by himself in *Al-Tanbih*, only three have survived, in addition to *Al-Tanbih* itself.

Some doubts have been expressed about some claims related to his extensive traveling e.g., up to China and Madagascar, but the correct situation cannot be assessed due to the loss of his several books. Whatever he has recorded was with a scientific approach and constituted an important contribution to geography, history and earth sciences. It is interesting to note that he was one of the early scientists who propounded several aspects of evolution viz., from minerals to plant, plant to animal and animal to man. His researches and views extensively influenced the sciences of historiography, geography and earth sciences for several countries.

1.4.14 MOHAMMAD IBN ZAKARIYA AL-RAZI (864 - 930 A.D.)



Abu Bakr Mohammad Ibn Zakariya al-Razi (864-930 A.D.) was born at Ray, Iran, Initially, he was interested in music but later on he learnt medicine, mathematics, astronomy, chemistry and philosophy from a student of Hunayn Ibn Ishaq, who was well versed in the ancient Greek, Persian and Indian systems of medicine and other subjects. He also studied under Ali Ibn Rabban. The practical experience gained at the well-known Muqtadari Hospital helped him in his chosen profession of medicine. At an early age he gained eminence as an expert in medicine and alchemy, so that patients and students flocked to him from distant parts of Asia.

He was first placed in-charge of the first Royal Hospital at Ray, from where he soon moved to a similar position in Baghdad where he remained the head of its famous Muqtadari Hospital for a long time. He moved from time to time to various cities, especially between Ray and Baghdad, but finally returned to Ray, where he died around 930 A.D. His name is commemorated in the Razi Institute near Tehran.

Razi was a Hakim; an alchemist and a philosopher. In medicine, his 'contribution was so significant that it can only be compared to that of Ibn Sina. Some of his works in medicine e.g. *Kitab al-Mansoori*, *Al-Havi*, *Kitab al-Mulooki* and *Kitab al-Judari wa al-Hasabah* earned everlasting fame. *Kitab al-Mansoori*, which was translated into Latin in the l5th century A.D., comprised ten volumes and dealt exhaustively with Greco-Arab medicine. Some of its volumes were published separately in Europe. His *al-Judari wal Hasabah* was the first treatise on smallpox and chicken-pox, and is largely based on

Razi's original contribution. It was translated into various European languages. Through this treatise he became the first to draw clear comparisons between smallpox and chicken-pox. *Al-Havi* was the largest medical encyclopedia composed by then. It contained on each medical subject all important information that was available from Greek and Arab sources, and this was concluded by him by giving his own remarks based on his experience and views. A special feature of his medical system was that he greatly favored cure through correct and regulated food. This was combined with his emphasis on the influence of psychological factors on health. He also tried proposed remedies first on animals in order to evaluate in their effects and side effects. He was also an expert surgeon and was the first to use opium for anesthesia.

In addition to being a physician, he compounded medicines and, in his later years, gave himself over to experimental and theoretical sciences. It seems possible that he developed his chemistry independently of Jabir Ibn Hayyan. He has portrayed in great detail several chemical reactions and also given full descriptions and designs for about twenty instruments used in chemical investigations. His description of chemical knowledge is in plain and plausible language. One of his books called *Kitab-al-Asrar* deals with the preparation of chemical materials and their utilization. Another one was translated into Latin under the name *Liber Experimentorum*, He went beyond his predecessors in dividing substances into plants, animals and minerals, thus in a way opening the way for inorganic and organic chemistry. By and large, this classification of the three kingdoms still holds. As a chemist, he was the first to produce sulfuric acid together with some other acids, and he also prepared alcohol by fermenting sweet products.

His contribution as a philosopher is also well known. The basic elements in his philosophical system are the creator, spirit, matter, space and time. He discusses their characteristics in detail and his concepts of space and time as constituting a continuum are outstanding. His philosophical views were, however, criticized by a number of other Muslim scholars of the era.

He was a prolific author, who has left monumental treatises on numerous subjects. He has more than 200 outstanding scientific contributions to his credit, out of which about half deal with medicine and 21 concern alchemy. He also wrote on physics, mathematics, astronomy and optics, but these writings could not be preserved. A number of his books, including *Jami-fi-al-Tib*, *Mansoori*, *al-Havi, Kitab al-Jadari wa at-Hasabah*, *al-Malooki*, *Maqalah fi al-Hasat fi Kuli wa al-Mathana*, *Kitab al-Qalb*, *Kitab al-Mafasil*, *Kitab-al-'Ilaj al-Ghoraba*, *Bar al-Sa'ah*, and *al-Taqseem wa al-Takhsir*, have been published in various European languages. About 40 of his manuscripts are still extant in the museums and libraries of Iran, Paris, Britain, Rampur, and Bankipur. His contribution has greatly influenced the development of science, in general, and medicine, in particular.

1.4.15 THABIT IBN QURRA (836 - 901 A.D.)

Thabit Ibn Qurra Ibn Marwan al-Sabi al-Harrani was born in the year 836 A.D. at Harran (present Turkey). The great Muslim mathematician Muhammad Ibn Musa Ibn Shakir, impressed by his knowledge of languages, and realizing his potential for a scientific career, selected him to join the scientific group at Baghdad that was being patronized by the Abbasid Caliphs. There, he studied under the famous Banu Musa brothers. It was in this 'setting that Thabit contributed to several branches of science, notably mathematics, astronomy and mechanics, in addition to translating a large number of works from Greek to Arabic. After a long career of scholarship, Thabit died at Baghdad in 901 A.D.

Thabit's major contribution lies in mathematics and astronomy. He was instrumental in extending the concept of traditional geometry to geometrical algebra and proposed several theories that led to the development of non-Euclidean geometry, spherical trigonometry, integral calculus and real numbers. He criticized a number of theorems of Euclid's elements and proposed important improvements. He applied arithmetical terminology to geometrical quantities, and studied several aspects of conic sections, notably those of parabola and ellipse. A number of his computations aimed at determining the surfaces and volumes of different types of bodies and constitute, in fact, the processes of integral calculus, as developed later.

In astronomy he was one of the early reformers of Ptolemic views. He analyzed several problems related to the movements of sun and moon and wrote treatises on sun-dials.

In the fields of mechanics and physics, he may be recognized as the founder of statics. He examined conditions of equilibrium of bodies, beams and levers.

In addition to translate a large number of books himself, he founded a school of translation and supervised the translation of a further large number of books from Greek to Arabic.

Among Most of the books are on mathematics, followed by astronomy and medicine. The books have been written in Arabic but some are in Syriac. In the Middle Ages, some of his books were translated into Latin by Gherard of Cremona. In recent centuries, a number of his books have been translated into European languages and published.

1.4.16 NASIR AL-DIN AL-TUSI (1201 - 1274 A.D.)

Abu Jafar Muhammad Ibn Muhammad Ibn al-Hasan Nasir al-Din al-Tusi was born in Tus, Khurasan, (now Iran) in 1201 A.D. Al-Tusi was appointed astrologer for the State by Isma'ili governor Nasir ad-Din 'Abd ar-Rahim. He learnt sciences and philosophy from Kamal al-Din Ibn Yunus, Shaikh al-Mufid, and the two brothers, members of Ahl al-bait and both outstanding scholars, al-Sharif al-Murtada and al-Sharif al-Radi.

He was instrumental in the establishment of an observatory at Maragha. It became operational in 1262 and housed many scientific instruments used for astronomy, designed by al-Tusi. Al-Tusi wrote many books, some of which are improved translations of Euclid, Ptolemy, Theodosius and Apollonius.

He also made important original contributions to astronomy and mathematics. One of his most important mathematical contributions was the creation of trigonometry as a mathematical discipline in its own right rather than as just a tool for astronomical applications. Another mathematical contribution was his teaching about Pascal's triangle relating binomial coefficients, long before the time of Pascal.

Al-Tusi put his observatory to good use, making a very accurate table of planetary movements. He published Ilkhanic Tables after making observations for 12 years. These contain tables for computing the positions of the planets. They also contain a star catalogue.

Al-Tusi calculated the value of 51' for the precession of the equinoxes. He also wrote works on instruments, for example on constructing and using an astrolabe.

One of his pupils Qutb ad-Din ash-Shirazi gave the first satisfactory mathematical explanation of the rainbow. Nasir al-Din was one of the greatest scientists, philosophers, mathematicians, astronomers, theologians and physicians of the time and was a prolific writer. He made significant contributions to a large number of subjects, and it is indeed difficult to present his work in a few words. He wrote one or several treatises on different sciences and subjects including those on geometry, algebra, arithmetic, trigonometry, medicine, metaphysics, logic, ethics and theology. In addition he wrote poetry in Persian.

In mathematics, his major contribution would seem to be in trigonometry, which was compiled by him as a new subject in its own right for the first time. Also he developed the subject of spherical trigonometry, including six fundamental formulas for the solution of spherical right-angled triangles.

As the chief scientist at the observatory established under his supervision at Maragha, he made significant contributions to astronomy. The observatory was equipped with the best possible instruments, including those collected by the Mongol armies from Baghdad and other Islamic centers. The instruments included astrolabes, representations of constellations, epicycles, shapes of spheres, etc. He himself invented an instrument 'turquet' that contained two planes. After the devoted work of 12 years at the observatory and with the assistance of his group, he produced new astronomical tables called 'Al-Zij-Ilkhani' dedicated to Ilkhan (Halagu Khan). Although Tusi had contemplated completing the tables in 30 years, the time required for the completion of planetary cycles, but he had to complete them in 12 years on orders from Halagu Khan. The tables were largely based on original observations, but also drew upon the then existing knowledge on the subject. The 'Zij Ilkhani' became the most popular tables among astronomers and remained so till the 15th century. Nasir al-Din pointed out several serious shortcomings in Ptolemy's astronomy and foreshadowed the later dissatisfaction with the system that culminated in the Copernican reforms.

The list of his known treatises is on mathematics, astronomy, philosophy and religion. and other subjects. The books, though originally written in Arabic and Persian, were translated into Latin and other European languages in the Middle Ages and several of these have been printed.

Tusi's influence has been significant in the development of science, notably in mathematics and astronomy. His books were widely consulted for centuries and he has been held in high repute for his rich contributions.

Key Points

1. The whole of Greek learning was completely rethought by the Muslims and that without this renovation; the Western renaissance could not have come about.
2. The achievements of Muslim scientists in astronomy, physics, biology, medicine, chemistry, and mathematics were tremendous. Their inventions include windmills, trigonometry, lateen sails and made major advances in metallurgy, mechanical and chemical engineering and irrigation methods.
3. Abu Abdullah Al-Battani was a famous astronomer, mathematician and astrologer. He has been held as one of the greatest astronomers of Islam.
4. Al-Biruni was a versatile scholar and scientist who had equal facility in physics, metaphysics, mathematics, geography and history.
5. Abul Wafa Muhammad Ibn Muhammad Ibn Yahya Ibn Ismail al-Buzjani was a great mathematician and astronomer at Baghdad.
6. Al- Farabi contributed considerably to science, philosophy, logic, sociology, medicine, mathematics and music. His major contributions seem to be in philosophy, logic and sociology and, of course, stands out as an Encyclopedist.
7. Al-Farghani determined the diameter of the earth to be 6,500 miles, and found the greatest distances and also the diameters of the planets.
8. Ibn Baitar's major contribution is one of the greatest botanical compilations dealing with medicinal plants in Arabic.
9. Al-Idrisi made original contributions to geography, especially as related to economics, physical factors and cultural aspects.
10. Abu Ali Hasan Ibn Al-Haitham contributed in Optics, mathematics, physics, medicine and development of scientific methods on each of which he has left several outstanding books.He made a thorough examination of the passage of light through various media and discovered the laws of refraction. He also carried out the first experiments on the dispersion of light into its constituent colors.
11. Ibn Sina was the most famous physician, philosopher, encyclopedist, mathematician and astronomer of his time. His major contribution to medical science**.** He made several astronomical observations, and devised a contrivance similar to the vernier, to increase the precision of instrumental readings. In physics, his contribution comprised the study of different forms of energy, heat, light and mechanical, and such concepts as force, vacuum and infinity. He made the important observation that if the perception of light is due to the emission of some sort of particles by the luminous source, the speed of light must be finite.
12. Jabir Ibn Haiyan, the alchemist Geber of the Middle Ages, is generally known as the father of chemistry. He introduced experimental investigation into alchemy, which rapidly changed its character into modern chemistry. His contribution of fundamental importance to chemistry includes perfection of scientific techniques such as crystallization, distillation, calcination, sublimation and evaporation and development of several instruments for the same.
13. Khawarizmi was a mathematician, astronomer and geographer. He was perhaps one of the greatest mathematicians who ever lived, as, in fact, he was the founder of several branches and basic concepts of mathematics. His work on algebra was

outstanding, as he not only initiated the subject in a systematic form but he also developed it to the extent of giving analytical solutions of linear and quadratic equations, which established him as the founder of Algebra.

14. Omar Al-Khayyam was mathematician, astronomer, philosopher, physician and poet, he is commonly known as Omar Khayyam. Khayyam introduced a calendar that was remarkably accurate, and was named as *Al-Tarikh-al-Jalali*. It had an error of one day in 3770 years and was thus even superior to the Georgian calendar (error of 1 day in 3330 years).
15. Al-Kindi was a philosopher, mathematician, physicist, astronomer physician, geographer and even an expert in music. It is surprising that he made original contributions to all of these fields. On account of his work he became known as the philosopher of the Arabs.
16. Abul Hasan Ali Az-Masu'di was an expert geographer, a physicist and historian. With his scientific and analytical approach he has given an account of the causes of the earthquake of 955 A.D., as well as the discussions of the water of the Red Sea and other problems in the earth sciences. He is the first author to make mention of windmills, which were invented by the Muslims of Sijistan.
17. Abu Bakr Mohammad Ibn Zakariya al-Razi (864-930 A.D.) was interested in music, medicine, mathematics, astronomy, chemistry and philosophy. A special feature of his medical system was that he greatly favured cure through correct and regulated food. This was combined with his emphasis on the influence of psychological factors on health.
18. Thabit Ibn Qurra contributed to several branches of science, notably mathematics, astronomy and mechanics, in addition to translating a large number of works from Greek to Arabic.
19. Nasir Al-Din Al-Tusi made important original contributions to astronomy and mathematics. One of his most important mathematical contributions was the creation of trigonometry as a mathematical discipline in its own right rather than as just a tool for astronomical applications. Another mathematical contribution was his teaching about Pascal's triangle relating binomial coefficients, long before the time of Pascal.

Self Assessment Exercise 1.4

Q.1 Fill in the blanks:

1. __________________discovery is the remarkably accurate determination of the solar year as being 365 days, 5 hours, 46 minutes and 24 seconds.
2. ____________________________discussed the rotation of the earth and has given correct values of latitudes and longitudes of various places.
3. __________________________made a thorough examination of the passage of light through various media and discovered the laws of refraction.
4. Scientific and analytical approach of ________________________________has given an account of the causes of the earthquake of 955 A.D. He was the first to undertake experiments related to astronomical phenomena.
5. ________________made astronomical observations, and devised a contrivance similar to the vernier, to increase the precision of instrumental readings.

Answers of Self Assessment Exercise 1.1
Q.1
For answers read section 1.1

Answers of Self Assessment Exercise 1.2
Q.1
For answers read section 1.2

Answers of Self Assessment Exercise 1.3
Q.1
1. 1543
2. Newton
3. Current, magnetic pole
4. Microorganisms
5. Nobel Prize, X-rays
6. Alexander Fleming, penicillin
7. HIV

Answers to Self Assessment 1.4
Q.1
1. Abu Abdullah Sl-Batani
2. Abu Raihan Al-Biruni
3. Abu Ali Hasan Ibn Al-Haitham
4. Abul Hasan Ali Az-Masu'di
5. Ibn Sina

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Unit–2

THE EARTH AND THE UNIVERSE

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Arshad Mehmood Qamar
Reviewed by: Prof. Dr. Tanveer Uz Zaman

CONTENTS

Introduction

The Earth and the Universe is the second unit of The General Science Course. It is observed that teachers and students are not clear about the concepts of Earth and the Universe Sciences. It is important to discuss the concepts related to the Earth and the Universe. So the aim of this unit is to present the basic knowledge about Astronomical bodies, the Solar system ,theories of origin of Earth, the lithosphere, the hydrosphere, the Galaxies, the Black holes and about the Space. The writer intends to create motivation and curiosity and the students may be able to gain the knowledge about the Universe. Major purpose of this course is to enhance knowledge competence of prospective teachers to enable them to teach science effectively. The content of this unit is comprised of basic concepts of earth sciences and astronomy. This unit also helps the teacher to gain the skills for meaningful teaching.

For many centuries, our forefathers thought that "Our Earth is the center of the Universe". Now, science has enabled us to know that it is not so. The Earth is located in the Orion Super off the Perseus arm in the Milky Way Galaxy. Where the Milky Way falls in the scope of the entire Universe is still to be determined .In fact Astronomy and Geography has become very vast and comprehensive disciplines prehistorically. All concepts are interlinked and they provide a self explanatory text. The aim of this chapter is to create a love and curiosity for Geography and Astronomy among the students of ADE.

Objectives

After studying this unit, the reader will be able to.

- describe basic concepts regarding astronomical bodies.
- illustrate solar system.
- explain the theories of origin of earth.
- discuss motion of the earth.
- appraise the importance of lithosphere and Hydrosphere.
- differentiate and compare Oxygen, Ozone, and Ozone layer.
- distinguish galaxies, black holes and the space.

2.1 Astronomical Bodies: An introduction

Astronomical bodies are naturally occurring physical structures or associations that can be found in the Universe.

If we count all the stars, there are trillions of trillions stars and our Sun is one of them. Astronomers are those people who study astronomical bodies. Our Universe is continuously expanding, and exact location of the Sun is not exactly known. Astronomers are also not able to see everything in the universe.

If we take example of our solar system, then the Sun and all those bodies (entities) which revolve around the Sun are called astronomical bodies. They include the sun, stars, planets, moons, asteroids, comets, meteoroids and meteors.

2.1.1 Stars

A star is an astronomical body which emits light produced in its interior by nuclear 'burning'. Stars are hot bodies of glowing gas. e. g The SUN.

2.1.2 Planets

Planets are astronomical bodies which do not have their own light, they are cold bodies. Planets revolve around the sun and shine by reflecting light. Earth is an example of a planet.

2.1.3 Moon

Moon is also called a natural satellite, which revolve around the planets. The planets have different number of moons; for example, Mercury and Venus have none, the Earth has one moon, and Jupiter has seventeen or more, Saturn has nine, Uranus has five, Mars and Neptune each have two moons. The moons also shine by reflected light.

2.1.4 Asteroid

Asteroids are heavenly bodies that orbit the Sun between mars and Jupiter. They are composed of carbon, metals, or rocks.

2.1.5 Comet

Beside planets and Asteroids some other objects also orbit the sun. They are called Comets. A Comet is a heavenly body made up of ice and dust particles. They are only seen when they come near to the Sun. During orbiting near the sun, a long tail of gases and dust particles is formed behind the comet. Far from the Sun it is difficult to distinguish between asteroid and a Comet. A Comet is a heavenly body, looking like a star with a bright head and a less bright tail.

2.1.6 Meteoroid

There are other bodies smaller than Asteroids called Meteoroids. A meteoroid may be the size of a grain to the size of a boulder. (Boulder is a large piece of rock or stone, especially one that has been rounded by water). When a meteoroid enters the atmosphere of our earth, it is called a meteor. Its size may be equal to the size of a grain of sand. Meteors are small bodies rushing from outer space into the Earth's atmosphere and becoming bright as a shooting star or falling star as it bursts. Something the size of a football would be extremely bright, and could potentially hit the ground. Extremely bright Meteors, or meteors that explode are known as **bolides**.

2.1.7 Meteor

A trail of light seen when a meteoroid is burnt by friction with the earth's atmosphere. They are also called *falling star*, *meteor burst*, or *shooting star*.

Key Points

1. All the physical structures which can be seen in the universe are called Astronomical bodies.
2. Stars, planets, moons, asteroids, comets, meteoroid and meteor are astronomical bodies.
3. Star is an astronomical body which has its own light.
4. Planets are those astronomical bodies which do not have their own light. Planets revolve round the stars/sun.
5. Moons are also called natural satellites, which revolve around the planets. They also shine with the reflected light.
6. Asteroids are astronomical bodies that revolve around the sun between Mars and Jupiter.
7. A comet is an astronomical body which form a long trial of dust and gases when it is orbiting the Sun.

Self Assessment Exercise 2.1

Q.1 Fill in the blanks with suitable words.

i. The Sun has its own__________ ,so the sun is called a Star.

ii. When a ______________ enters the earth's atmosphere it is called a meteor.

iii. Asteroids are heavenly bodies that orbit the Sun between ________ and Jupiter.

Q.2 Answer the following questions

i. Write names of all astronomical bodies, and write a detailed note on any three of them?

ii. Define the followings. Astronomical bodies, Stars and Planets.

Q.3 Choose the correct answers.

i. The are nine in number and shine by reflecting light.

a. moons b. stars
c. planets d. comets

ii. A piece of rock or stone, rounded by water is called.

a. satellite b. bolides
c. boulder d. comet

iii. Moons revolve around the planets, the number of moons that revolve around the Mars is.

a. 2 b. 3
c. 1 d. 8

2.2 The Solar System and Heavenly Bodies

The Solar system consists of the Sun, the nine Planets which orbit round the Sun and some smaller bodies like moons and comets.

The orbits of all except two planets, lie in nearly the same plane, so that we can say, the solar system is disc shaped. All planets revolve counter clock-wise round the Sun. The Solar system consists of these nine Planets

1.	**Pluto**	**2.**	**Neptune**	**3.**	**Uranus**
4.	**Saturn**	**5.**	**Jupiter**	**6.**	**Mars**
7.	**Earth**	**8.**	**Venus**	**9.**	**Mercury**

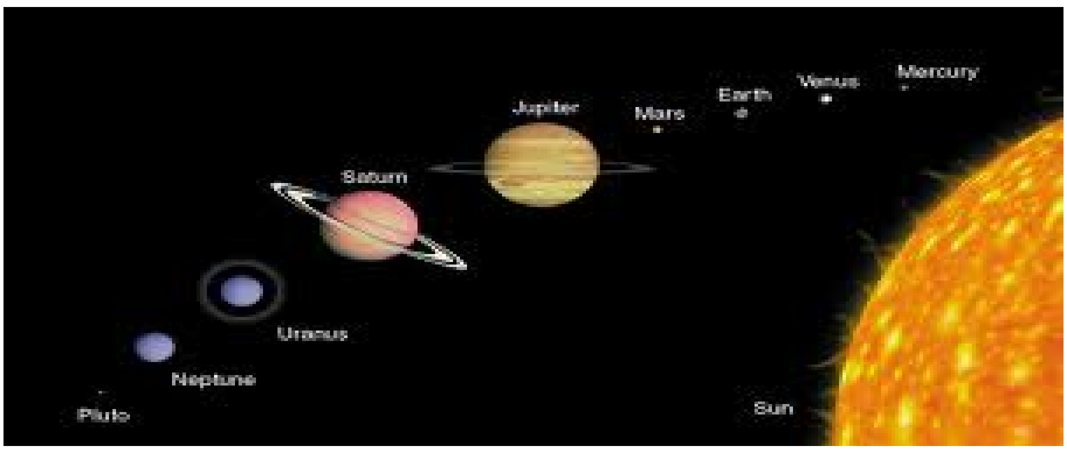

Fig.1 Our Solar System

1. Pluto

An interesting argument about Pluto is that some Astronoers hesitate to consider Pluto as a planet. Although it was discovered in 1930 by a famous Astronomist Claytomiag. Researches have shown that Pluto was a moon of Neptune. It escaped from the orbit of Neptune and adopted another orbit and became a planet. It is 5,900 million kilometers away from the sun. Its diameter is 3,00 kilometers. It completes its rotation around its axis in 6.4 days, and revolution around the Sun in 248 years. Its speed is 5 kilometers per Second.

2. Neptune

A French Scientist Leoprace and a British Mathematician Adems discovered this planet in 1846. Neptune is slightly smaller than Uranus. It is more massive and dense. It radiates internal energy. But this energy is less than Jupiter and Saturn. Neptune has 13 satellites. The largest, Triton, is geologically active, with geysers of liquids nitrogen. There are many smaller planets in its orbit called Neptune Trojans. It is 4,497 million kilometers away from the Sun. Its diameter is 48,600

Fig. 2 Neptune

kilometers. It rotates around its axis in 15 hours, and completes its revolution around the Sun in 165 years. Its speed is 5 kilometer per second.

3. Uranus

Uranus was discovered by famous Astronomist William Hershell in 1781. He called it George but later on Scientists changed this name into Uranus. Its average temperature is -217°C. Its core is much colder and radiates much less heat into space, as compared to other gas giants. Uranus has twenty seven satellites, the largest ones being, Titania, Oberon, Umbriel, Ariel and Miranda. The distance of the Uranus from the Sun is 2,870 million km .Its diameter is 50,800 km. It completes its rotation around its axis in 17.3 hours. It completes its revolution around the Sun in 84 years time. Its speed is 7 kilometers.

Fig.3 Uranus

4. Saturn

Saturn is the second biggest and third fastest planet. It has a ring system. This ring system extends outwards up to 400,000 kilometers and each ring is almost 15 kilometers thick. The ring system of Saturn contains rock particles and dusty gases. Saturn has 18 moons except rings. Two of which, Titan and Escalades. They have atmosphere of Nitrogen gas. Titan and Escalades (moons of Saturn) show geological activities. One interesting thing about Titan(moon) is ,that it is larger than Mercury (Planet).It is distinguished from other Satellites by atmosphere which other satellites do not have. Its distance from the Sun is 1,427 million km. Its diameter is 120,000 km. It completes its rotation around its axis in 10 hours. It completes its revolution around the Sun in 29.5 years. Its speed is 10 km per second.

Fig 4. Saturn

5. Jupiter

This is the 5th planet of the Sun. Its volume is greater than all other planets of the solar system. It is important to know that the mass of Jupiter is also heavier than the combined mass of all other planets. It is mainly composed of hydrogen and helium, which show that there might be a kind of reaction (fusion or fission) producing large amount of heat. This heat may have produced cloud bands and red soot. Jupiter has 16 satellites. It is 778.4million km away from the Sun. Its diameter is 142,800 kilometers. It revolves

Fig.5 Jupiter

around its axis and completes its rotation in 10 hours time. It completes its revolution around the Sun in 11.86 years. Its speed is 13 kilometer per second.

6. Mars

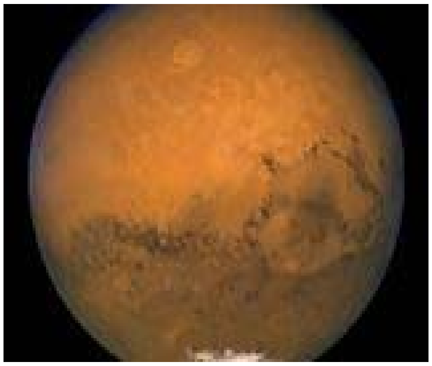

Fig.6 Mars

Have you ever read about the importance of Mars in Science magazines? Mars has been a sign of great interest for scientists and Gastronomists since a long time. Mars is considered smaller in size as compared to Earth and Venus. Carbon dioxide is present in its atmosphere. A great work has been done to find out the presence of Oxygen on Mars but no success in this respect. It surface contains rift valleys which show a kind of Geological activities which may have occurred almost two million years ago. Its surface looks red perhaps due to the presence of iron oxide. Mars has two moons. It is 228 million kilometers away from the sun. Its diameter is 6,790km. It completes its rotation around its axis in 24 hours. It completes its revolution around the Sun in 687 days. Its speed is 24 km per hour.

7. Earth

Fig.7 Earth

The place where we all live is also a part of our solar system. Earth is the largest and densest planet where life activities are going on. The presence of water and Oxygen is unique feature of this planet. Its atmosphere contains 21% free Oxygen, 78% Nitrogen, and .03-.04% Carbon dioxide It has one natural satellite, the Moon. It is 149.6 million kilometers far from the Sun. Its diameter is almost 12759 kilometers. It completes its rotation around its axis in 24 hours, and it completes its revolution around the Sun in 365.25 days. Its speed is 30 km per second.

8. Venus

Fig.8 Venus

Venus is often called twin of the Earth, because it is nearly equal to our Earth in size and volume. Internal geological activity has shown that its core is composed of iron while mantle is composed of silicate materials. It is much drier than Earth .Venus has no natural satellites. It is the hottest planet. The surface temperature of Venus is 400 °C. It is 108 million kilometers away from the Sun. Its diameter is 12,102 km. It completes its rotation around its axis in about 243 days. It completes its revolution around the Sun in 225 days. It is the sole planet whose revolution and rotation are opposite in direction. While seeing from the Earth it is third luminous body after the sun and the moon. Its speed is 3 km per hour.

9. Mercury

Mercury is the nearest to the Sun and is 57.9 million kilometers away from the Sun. It is the smallest planet in the Solar System. Mercury has no natural satellite. It is interesting that being closest to the Sun it is less hot than Venus. The reason is that its atmosphere is very thick. Its temperature rises up to 500 C. It completes its revolution around the Sun in 88days. It rises almost along with the Sun and sets along with the sun.

Fig.9 Mercury

The diameter of mercury is 4,880 kilometers. It rotates around its axis in 56.8 days. It is 57.9 million kilometers away from the Sun. Its speed is 48 km per hour. Its surface resembles to that of the surface of the Earth's moon.

Activity 1

What is the resemblance of our Solar System with the structure of an atom? Develop a model to support your arguments.

Key Points

1. Our solar system consists of The Sun, nine planets and some other bodies like moons and comets.
2. The names of nine planets are Pluto, Neptune, Uranus, Saturn, Jupiter, Mars, Earth, Venus and Mercury.
3. The Pluto is farthest planet and sometime not considered a planet. First it was a moon of Neptune. It completes its revolution around the sun in 248 years.
4. Neptune is smaller than Uranus. It radiates its internal energy but this energy is less than Jupiter and Saturn. Neptune has 13 moons. Its revolution time is 165 years.
5. Uranus is also a planet having very much colder core. It has 27 satellites. Its rotation time is 17.3 hours and revolution time is 84 years.
6. Saturn is the second biggest and third fastest planet. it has extensive ring system, which contain rock particles and dusty gases. Its rotation time is 10 hours and revolution time is 29.5 years.
7. The Jupiter is the most massive and bigger in size, mainly composed of hydrogen and helium. It has 16 satellites. Its rotation time is 10 hours and revolution time is 11.86 years.

8. Mars is smaller than earth, having atmosphere of carbon-dioxide. Its surface shows a kind of geological activities which have occurred 2 million years ago. its surface looks red due to the presence of iron oxide. Its rotation time is 24 hours and revolution time is 687 days.
9. Our earth is a only planet which have life activities. The presence of water and oxygen is a distinct feature of earth. Its rotation time is 24 hours and revolution time is 365.25 days.
10. Venus is also called twin of the earth but its surface is much drier. It has no natural satellites and is hottest planet.
11. Mercury is nearest to the sun having no natural satellite. Its revolution time is 88 days while its rotation time is 56.8 days. Its surface resembles to that of the surface of the earth's moon.

Self Assessment Exercise 2.2

Q.1 Fill in the blanks with correct words.

1. All Planets ______________ around the sun.
2. The largest moon of Neptune is __________which is also geologically active.
3. Uranus has 27 moons and it completes its revolution around the sun in________ time.
4. The planet _______________ is mainly composed of hydrogen and helium.
5. The surface of Mars is mainly composed of __________________, that's why Mars surface looks red.

Q.2. Choose the correct answer.

i. Which of the following planet has highest surface Temperature?
   a. Jupiter b. Mercury c. Pluto d. Saturn

ii. The following Planet has natural satellite except.
   a. Jupiter b. Uranus c. Neptune d. Venus

iii. Which one is in correct sequence from the Sun?
   a. Venus, mars, Saturn, Uranus b. Mars, Venus, Uranus, Saturn.
   c. Saturn, Venus, Mars, Uranus d. Venus, Saturn, Mars, Uranus.

Q3. Answer the following questions:

i. What is difference between a star and a planet? Write important characteristics of planets which belong to inner solar system?
ii. How our Solar System is important for further explorations, and why it has become necessary to explore the universe?

2.3 Theories of Origin of Earth

Before going to the theories let us understand what theory is? **A repeatedly tested or widely accepted statement is called theory. This statement is also used to make further predictions about a natural phenomenon.**

There are different theories about how earth was formed and no one theory can tell exactly how earth came into being. Scientists believe that the earth was formed more than 4 billion years ago. They found this by studying the radioactive elements contained in the rocks.

1. Creation theory or Mythical Theory

Muslims believe that our Earth and the whole universe is made by Almighty Allah. Christians also believe that the earth was made by God on seventh day. The Chinese believe that the earth was created by Pan Ku, a supernatural being.

An important man Anaximander suggested that the earth began from a ball of fire that covered a cold mass. When the ball of fire burst into pieces, these pieces became the bodies in space while the cold mass became the world.

2. Scientific theory

Scientists have better explanations, how earth came into being. These theories are based on long time studies, observations and researches made by expert scientists. Scientific theories have been developed by careful study of natural phenomenon and experimentations.

3. Tidal Theory

This theory was given by Sir James Jeans; an English mathematician and physicist.

According to him the earth was formed from materials pulled out from the sun. The theory explains that the Sun existed alone first, there came a wandering star near the Sun. The movement of the star created a tide that rose very high and it torn away some of the matter and gases from the suns outer layer. These matter and gases got together and formed bodies that became planets. Our earth is one of those planets.

4. Nebular Theory

This theory tells that how the sun and the planets were formed at the same time from a huge cloud of dust and gas floating in space. This material collapsed because of gravity and became a mass. With the passage of time the smaller mass begin to rotate and a disc was formed. There rotation caused a budge in the disc and this budge became hotter and hotter and energy was produced and shining (glow) started. This shining mass became the Sun and other smaller bodies became planets.

5. **Solar Disruption Theory and Dynamic Encounter Theory**

This theory was proposed by L. Buffon explains that 4or 4.5 billion years ago a star (comet) collided with the sun, causing some parts of the sun to burst. These parts became planets in the space.

6. **Planetissimal Theory**

The Planetissimal theory is similar to the Solar Disruption Theory in that the theory agrees that the planet s are formed when the Sun and another star almost collided in space which caused the Sun to burst out some hot materials that became parts of the star passing near the Sun. As the Sun continued to spew out materials, these became the planets and other objects in space.

7. **Condensation Theory**

According to this theory the stars came from mass of hydrogen gas and atomic dust. The stars burst out into pieces that became planets.

8. **Big Bang Theory**

About 10 to 20 billion year ago, the universe was packed into one giant fireball. Then an extraordinary explosion took place and expansion of the Universe started. This extraordinary explosion is termed as the Big Bang. This cosmic explosion spread matter and energy everywhere. This mass slowly became our Universe and the astronomical objects. The Big Bang theory was first proposed by Priest, George Lamaitre of Belgium**.** Since the Big Bang, the universe is continuously expanding and the distance between galaxies is ever increasing, since the time of explosion. This movement of galaxies away from each other is called **Red shift**. In 1964 cosmic radiations were discovered. After this discovery Scientists agreed that thermal radiations produced from black bodies were same to that of the cosmic rays. The spectrum of the both types of rays was found to be same. In this way most of the scientists were convinced by the fact that Big Bang must have occurred.

Key Points

1. A widely accepted statement which have been verified experimentally is called a theory.
2. Our Earth was formed more than 4 billion years ago.
3. The belief that our earth was formed by Almighty Allah on seventh day is called Creation or Mythical theory. A ball of fire was burst its pieces were scattered and space bodies were formed.
4. Tidal theory was proposed by Sir James Jean, which states that our Sun was alone first. A wandering star came near the sun and raised tides on the surface of the sun .these tides torn away and formed planets and our earth is one of them.
5. Nebular theory tells that the sun and planets were formed from a huge cloud of dust and gas floating in the space.
6. Solar disruption or Planetissimal theories tell that the sun and other planets were formed due the collision of the sun and another star.
7. According to this theory the stars came from mass of hydrogen gas and atomic dust. The stars burst out into pieces that became planets.
8. An extraordinary explosion took place about 10 to 20 billion years ago and expansion of the Universe started. This extraordinary explosion is termed as the Big Bang. This cosmic explosion spread matter and energy everywhere which ultimately became astronomical objects.

Self Assessment Exercise 2.3

Q.1 Fill in the blanks with correct words.

i. Our earth was formed about ___________________ years ago.
ii. Our earth was formed by __________________is the belief of Chinese.
iii. The material collapsed due to gravity and became a mass. This statement is concerned with ________________________theory.

Q.2 Answer the following questions:

i. Write a note on tidal theory and Nebular theory.
ii. Which theory is liked by you the best, describe it and compare it with any other **theory?**
iii. Critically analyze the theories about the creations of the earth also give your suggestions.

Q.3 Choose the correct answers from the given options:

i. Scientists believe that our Earth was formed___________years ago.
   a. 4 trillion years ago
   b. more than 4 billion year ago
   c. Less than 4 billion years ago
   d. not known

ii. The theory proposed by Sir James jeans is.
   a. Scientific Theory
   b. Nebular theory
   c. Tidal theory
   d. Solar disruption theory

iii. Which radiations were discovered in 1964?

a. X-rays
b. Cathode rays
c. Alpha Rays
d. Cosmic rays

iv. Red Shift is

a. Movement of Galaxies towards each other.
b. Movement of Galaxies away from each other.
c. Movement of stars towards galaxies.
d. Movement of galaxies towards our solar system.

2.4 Earth and its Structure

The Earth was formed about 4.5 billion years ago. It was a big cloud of gases and dust, which gradually cooled down to the solid Earth. It took millions of years to cool down and taking the shape of present day Earth. In the beginning the molecular oxygen was not present but with the passage of time many reactions took place and many substances of atmosphere was formed. Apart from it, a series of volcanic eruptions took place releasing gases and water vapours .These gases and vapours also formed atmosphere. These water vapours accumulated in the atmosphere and condensed to form clouds and rains.

The water in the form of rains came to our Earth and was collected in hollows and deep places, and formed oceans. The surface structure of the earth continued to be changed due to the forces inside the Earth and hard crust was formed. The Crust split up into large blocks, called plates. Rocks were squeezed up to form new landmasses and mountains, when the plates pushed against each other. Plate movements continue today which sometimes causes earthquakes.

The Earth consists of three layers; viz Crust, Mantle and Core. Core is the innermost part of the earth, mostly consisted of molten iron. Surrounding the Core is a layer of molten rock called Mantle. The uppermost layer is called Earth's Crust. Every activity that we do, takes place on Earth's crust. The Crust is composed of many plates, called tectonic plates. Many persons believe that these plates float on the mantle and move and sometimes bump into each other causing shake. This shaking of plates is called Earthquakes. As we know, the Earth's surface is not all rock. The hydrosphere is the layer of water that covers 75% of the Earth's surface. And the atmosphere is the layer of the air above the surface that contains the Oxygen that supports life and also many other gases also.

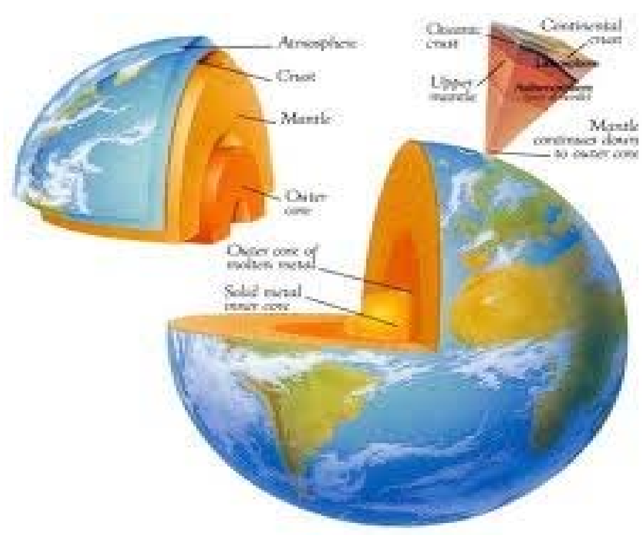

Fig.10 structure of earth

2.4.1 Motions of the Earth

The Earth is in constant motion, revolution of earth around the Sun and its rotation around its own axis. These motions result a number of consequences like occurrence of days and nights, changes in seasons and climates in different areas and regions. Movement of the Earth around its axis and around the Sun can be easily understood by mounting a globe and rotating it around its axis, and movement of the earth around the sun can be illustrated easily.

1. Rotation

If you see at the figure 11, it looks somewhat tilted. The Earth completes its rotation in the time of one day. Rotation is also called spinning .The Earth spins around its axis from West to East. Rotation of the earth cause days and nights, the rate of rotation is approximately 1,038 miles per hour, decreasing to zero at the poles. Tilting of earth causes occurrence of different seasons.

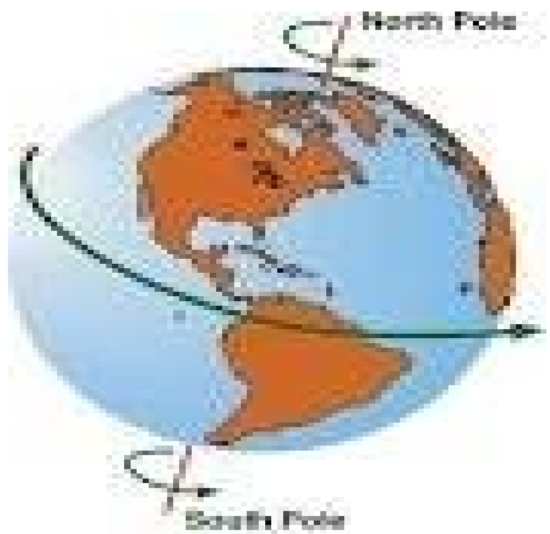

Fig.11 Rotation of Earth

2. Revolution

The motion of the Earth around the Sun is called revolution. Earth completes its revolution around the sun in the time of one year. The path on which earth revolves is called Earth's orbit. It is nearly an elliptical path. The mean distance of the Earth from the Sun is about 93million miles and the distance varies by 3 million miles, forming a slightly elliptical path.

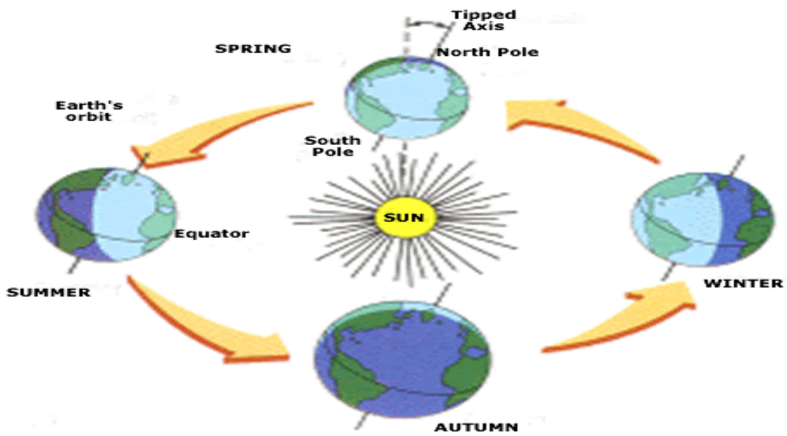

Fig.11. Revolving earth

The revolution of the Earth around the Sun travels a distance of 595 million miles in 365 days, 6 hours, 9 minutes and 9.5 seconds. This means that average speed of the earth is 18 miles a second.

3. Influence of the Sun and the Moon on Earth

The sun influences the earth in many ways. The Sunlight, warmth, and the chronology are the influences of the Sun, whereas moon has its own influences on the earth .They are gravity and its motion.

The moon orbits the earth due to the gravity of the earth. The moon also have gravitational power but moon's gravity is 1.6 where as the gravity of the earth is $10m/s^2$. By the way gravity pulls the Earth and Moon toward each other. Tides are caused (high tide and low tide) due to the gravity of the moon. The sun also has some influence here. The sun brings light and is also responsible for the warming up of the earth.

Activity 2

Prepare a model of Earth showing its different layers.

2.4.2 The Lithosphere

The uppermost layer of the earth where we live is a part of the Lithosphere. Lithosphere is composed of the earth's crust and upper mantle. It is called rock sphere. It extends up to the depth of 100 km.

The mass of lithosphere is composed of 11 elements. They are oxygen, silicon, Aluminium, iron, calcium, sodium, potassium, magnesium, titanium, hydrogen and phosphorous. Some elements occur in the form of minerals.

Lithosphere can easily move on the molten mass of mantle. This molten mass resembles to that of the plastic. This movement affects the earth's crust .It affects heat transport through the Earth. Under the lithosphere there is the Astheno-sphere, the weaker, hotter and deeper part of the upper mantle.

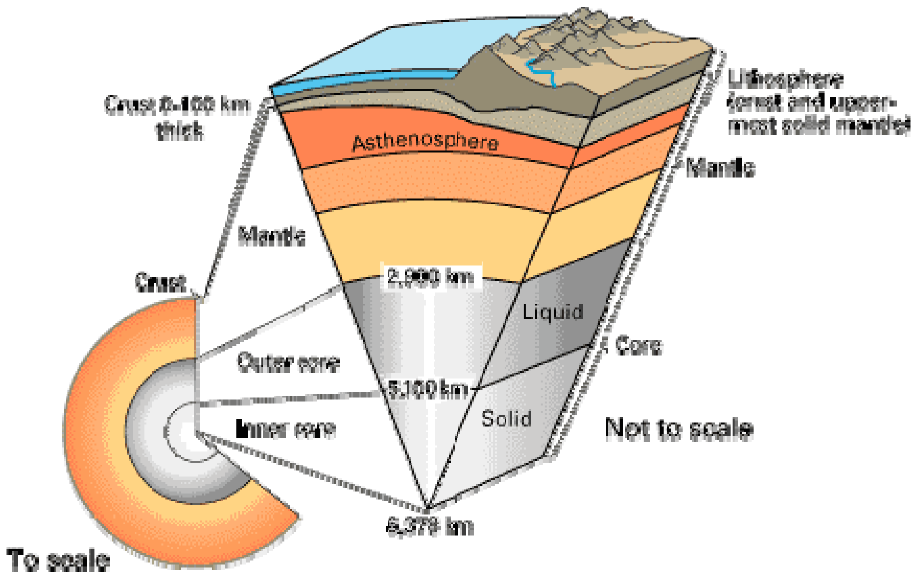

Fig.12. The Lithosphere of earth

1. Types of Lithosphere

What do you see generally when you take a glance at the surface of the earth. At most of the places there are oceans and at some places there is land portion called continental part.

1. Oceanic lithosphere, which is associated with Oceans and exists in the ocean basins Oceanic lithosphere is 50-100 kilometers thick.
2. Continental lithosphere, which is associated with Continental crust. It is 40-200 kilometers thick

The **continental crust** is the layer of igneous, sedimentary, and metamorphic rocks which form the continents and the areas of shallow sea bed close to their shores, known as continental shelves. This layer is sometimes called *sial* because there is more granite rocks, and *sima* because of the basalt rock.

Consisting mostly of granitic rock, continental crust has a density of about 2.7 g/cm^3 and is less dense than the material of the Earth's mantle, which consists of mafic rock. Continental crust is also less dense than oceanic crust (density of about 3.3 g/cm^3), though it is considerably thicker; mostly 25 to 70 km versus the average oceanic thickness of around 7–10 km. About 40% of the Earth's surface is now underlain by continental crust. Continental crust makes up about 70% of the volume of Earth's crust.

Fracis Bacon a famous English geologist first of all presented a model of world map and said that all continents were concentrated at one place. Wegner called this part of as Pangaea, which means the all earth. This theory is called Continental Drift Theory. After that this big continent was broken down into two parts. The Northern part was named an Laurasia having northern America, Europe and Asia while Southern part was named as Gondwana having south America north Africa.

Indian pacific Australia and Intarctica. A strongest argument which was given by Wegner to support continental Drift was that if all continents are put together they fit together as it were a single one. But still the actual reason of Continental Drift have never been found. In 1980 geologists have divided the tectonic plates into seven plates. These seven plates are given the names of seven Continents. These continental plates are in motion, and their motion can be divided into three types which are as under; Convergent or collision, Divergent or spreading and transform movements of plates.

2.4.3 Hydrosphere

A **hydrosphere** is a Greek word; *hydro means* "water" and - *sphaira* means "sphere". Hydrosphere is the total mass of water found on, under, and over the surface of a planet. The hydrosphere includes all water bodies, mainly oceans, rivers, streams, lakes, polar ice caps, glaciers and ground water. Oceans contain 97% of earth's water. The polar ice caps and glaciers consist of 2% of the earth's total water supply. The total mass of the Earth's hydrosphere is about 1.4×10^{18} tons, which is about 0.023% of the Earth's total mass. Only 1% of the total water resources are available as fresh water.

2.4.4 Hydrological Cycle

Water is not found only in oceans, lakes, rivers and underground water. But most of the water is found in ice and vapours form. Have you ever think how rains occur and how clouds are formed. As you have read in chemistry that evaporation is caused due to Sun light and heat, from all reservoirs water resources including oceans, rivers, lakes, soil and the leaves of plants. **Evaporation is a process of conversion of liquid (water) into vapour (gases) form**. Water vapour is further released as transpiration from plants and humans and other animals. Also the evaporation helps the plants receive water (H2O) from the soil. **The movement of water around, over, and through the Earth is called the water cycle. Water cycle is a key process of the hydrosphere.**

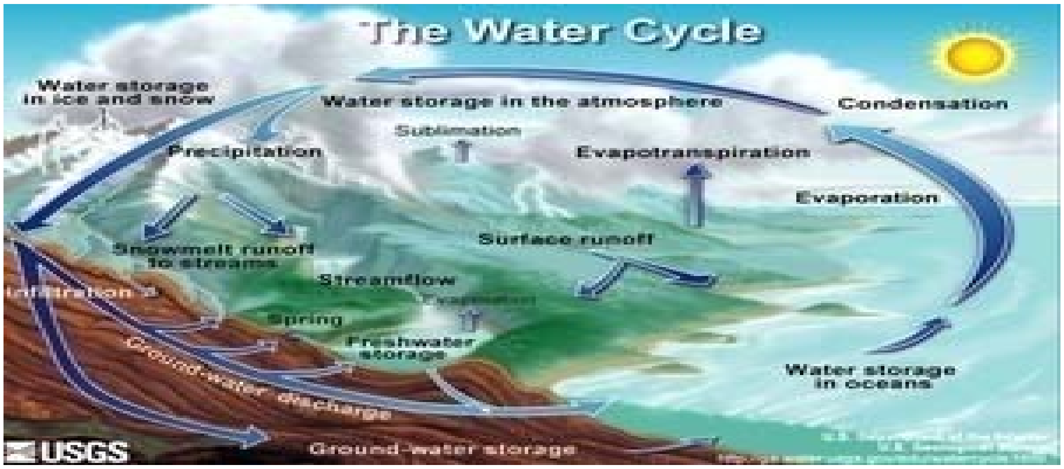

Fig.13 Hydrological Cycle

Water -cycle is of much importance because water- cycle makes our atmosphere clean from pollutants (harmful materials that enter in air due to human activities). Secondly water cycle is a good source of clean water. It is obvious that most of the water of hydrosphere is salty and is unfit for drinking purposes. Water cycle causes rain which is ultimately beneficial for the growth of crops.

2.4.5 The Earth's Atmosphere, Availability of Oxygen and the Ozone layer

1. The Atmosphere

The place all around our earth where we breathe is called atmosphere. This layer around the earth is a colourless, odourless, tasteless 'sea' of gases, water and fine dust. The earth is surrounded by gases. Without atmosphere life on earth is not possible. The atmosphere gives us air, water, warmth and is protecting us against harmful rays of the sun and against meteorites. The Troposphere is the layer where the weather happens; above this layer is the Stratosphere. Within the Stratosphere is the Ozone layer that absorbs the Sun's harmful ultraviolet rays. Above the Stratosphere is the Mesosphere, the Thermosphere - in which the Ionosphere - and the Exosphere. The atmosphere is about 500 miles (800 km) thick.

Fig.14 the Atmosphere

The atmosphere becomes thinner and thinner with increasing altitude, with no definite boundary between the atmosphere and the outer space. Air is the name given to atmosphere used in breathing and photosynthesis. Dry air contains roughly (by volume) 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapor, on average around 1%. While air content and atmospheric pressure varies at different layers, air suitable for the survival of terrestrial plants and terrestrial animals is currently only known to be found in Earth's troposphere and artificial atmospheres.

2. Composition of Earth's Atmosphere

The major part of the atmosphere is occupied by air. Nitrogen, oxygen, and argon, which together constitute the major gases of the atmosphere. The remaining gases are often referred to as trace gases, among which are the greenhouse gases such as water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Many substances like dust, pollen and spores, spray, and volcanic ash are also found in air. Various industrial pollutants such as chlorine, fluorine compounds, elemental mercury, and sulfur compounds such as sulfur dioxide (SO2) are also a part of atmosphere.

3. Composition of dry atmosphere, by volume

Composition of different gases in air is given in the table as under.

Gas	Volume	Gas	Volume
Nitrogen (N_2)	78%	Nitrous oxide	0.00003%
Oxygen (O_2)	20.946%	Carbon monoxide	0.00001%
Argon (Ar)	0.9340%	Xenon (Xe)	0.000009%
Carbon dioxide (CO_2)	0.039%	Ozone (O_3)	0 to 7×10^{-6}%)
Neon (Ne)	0.001818%	Iodine (I_2)	0.000001%
Helium (He)	0.000524%	Nitrogen dioxide	0.000002%
Methane (CH_4)	0.000179%	Ammonia (NH_3)	Trace
Krypton (Kr)	0.000114%	Not included in above dry atmosphere:	
Hydrogen (H_2)	0.000055%	Water vapor (H_2O)	0.40% over full atmosphere, typically 1%-4% at surface

4. Ozone Layer

The **ozone layer** is mainly composed of tri molecular oxygen (O_3) .This layer absorbs 97–99% ultraviolet rays of the light, which are harmful for human and other forms of life. It is mainly located in the lower portion of the stratosphere from approximately 20 to 30 kilometers above Earth. The thickness of ozone layer is different at different places.

The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson.

Ozone - Oxygen Cycle in the Ozone Layer

The photochemical mechanisms that give rise to the ozone layer were discovered by the British physicist Sidney Chapman in 1930. Ultraviolet rays break the oxygen molecule into atomic oxygen (O). This atomic oxygen is most reactive and combine with O_2 to give O_3.O_3 is ozone molecule. Again ozone is also unstable and breaks up into O_2 and (O). In this way ozone-oxygen cycle continues.

About 90% of the ozone in our atmosphere is present in the stratosphere. Ozone concentrations are greatest between 20 and 40 kilometers. If all of the ozone were compressed to the pressure of the air at sea level, it would be only 3 millimeters thick.

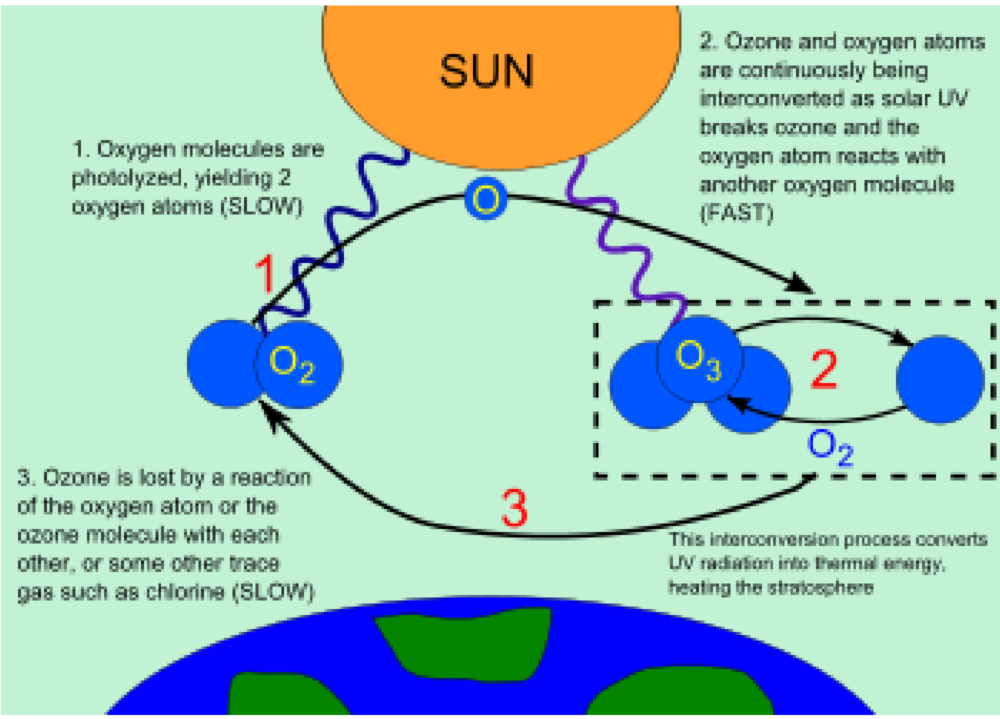

Fig.15 Ozone Oxygen Layer

Ozone Depletion a Big Issue or Problem

The chlorofluouro carbons released by manmade appliances and reach stratosphere where chlorine and Bromine ions are released due to the action of ultraviolet rays. These radical are so dangerous that it can breakdown 100,000 ozone molecules. The broken molecules of ozone are unable to absorb the ultraviolet radiations.

Ultimately unabsorbed and dangerous ultraviolet-B radiation is able to reach the Earth's surface. Ozone levels over the northern hemisphere have been dropping by 4% per decade.

Over approximately 5% of the Earth's surface, around the north and south poles, much larger seasonal declines have been seen, and are described as ozone holes. In 2009, nitrous oxide (N_2O) was the largest ozone-depleting substance emitted through human activities.

Regulation

In 1978, the United States, Canada and Norway banned on CFC-containing aerosol sprays that are thought to damage the ozone layer. In the U.S., chlorofluorocarbons continued to be used in other applications, such as refrigeration and industrial cleaning, until after the discovery of the Antarctic ozone hole in 1985. The CFC production was limited in 1987. On August 2, 2003 scientists told that ozone depletion has been reduced due to ban on CFC.. Three satellites and three ground stations confirmed that the upper atmosphere ozone depletion rate has slowed down significantly during the past decade. The study was organized by the American Geophysical Union.

CFCs have very long atmospheric lifetimes, ranging from 50 to over 100 years, so the final recovery of the ozone layer is expected to require several lifetimes.

Compounds containing C–H bonds (such as hydro chloro-fluorocarbons, or HCFCs) have been designed to replace the function of CFCs.

These HCFCs are being replaced by CFCs because HCFCs are less damaging than CFCs.

Impacts of Atmosphere on the Earth

Atmosphere has many direct and indirect impacts on the life. Some of them are described as under.

Favourable Temperature

Our atmosphere has capacity to absorb, emit and scatter the radiations, and hence keep the temperature constant. This constant temperature is very essential for sustenance of life.

Earth's Guard

Atmosphere is the guard of our earth in a sense that it keeps our earth safe from harmful effects of ultraviolet radiations and x-rays coming from the Sun. Second it meteorites burns before reaching our earth, otherwise it can cause craters and many kinds of disturbances in life activities.

Basis for Different Cycles

Atmosphere interacts with hydrosphere and lithosphere and exchange of materials take place among them. Cycles of gases and water are are going on the atmosphere which are necessary for life. In this way a biological ecosystem is maintained on the earth.

Basis for Different Phenomenon

Dispersion of sound is due to atmosphere, as sound does not travel in vacuum. Sky looks blue twinkling of stars, brightening of the moon are seen from the earth, are due to the Earth's atmosphere.

Radio Links and Broadcasting

In Stratosphere another sub layer is found which is called D-layer at the height of 80 to 85 kilometers .This layer reflects the Radio-waves on the earth which causes radio-links and broadcasting at far of places of the earth at one time.

Activity 3

List down some steps that you will take if you are asked for a campaign for protection of our atmosphere.

Key Points

1. Lithosphere is composed of the earth's crust and the upper mantle, having depth about 100 km.
2. Lithosphere is composed of eleven elements, which are oxygen, silicon, Aluminum, iron, calcium, sodium, magnesium, titanium, hydrogen, and phosphorous.
3. Below the litho-sphere is a plastic like molten mass on which Litho-sphere floats.
4. There are two types of Lithosphere. One is Oceanic and the other is continental Lithosphere.
5. Lithosphere is divided into seven tectonic plates, which are named as seven continents.
6. Hydrosphere is the total mass of water on/in the earth.
7. Oceans contain a big part of water, which is 97% of the total water of the earth.
8. Glaciers contain 2% of the total water of the hydrosphere.
9. Only 1% of the total hydrosphere is available as fresh water which is used for drinking and crop production.
10. The movement of water from one place and this form to another place and this form is called water cycle.
11. Conversion of water from liquid form to vapour form at ordinary temperature is called evaporation.
12. Evaporation cause cooling and also form clouds which may cause rain.
13. Rain is one of the processes of purification of water.
14. A layer all around Our Earth which mainly consist of air, dust particles and water vapours.
15. Air consists of many gases like Oxygen, nitrogen, Carbondioxide, Argon and many other trace gases.
16. Atmosphere consists of four layers namely troposphere, Stratosphere, Mesosphere and Thermosphere.
17. Ozone is a molecule consisting of three atoms of Oxygen.
18. Ozone layer is present 31 kilometers above the earth's surface. Ozone layer is a part of Stratosphere.
19. Nitrogen is 78% whereas Oxygen is 21% in the earth's atmosphere.
20. Our earth has to pass a series of changes to get the present position, like one volcanic eruptions which released gases and water vapours which ultimately formed atmosphere.
21. Earthquakes occur due to the movement of tectonic plates.
22. Our earth consists of three layers Crust, Mantle and Core.
23. Our earth is 3 parts water and one part land.
24. Our earth is a planet and moves around the sun. This movement is called revolution
25. Our earth spins around its axis. This movement is called rotation.
26. Rotation cause days and nights, whereas revolution causes seasons and climatic changes.
27. Our earth attracts other bodies with a force. This force is called gravity of the earth.

Self Assessment Exercise 2.4

Q.1 Fill in the blanks with correct words.

i. The earth's___________ consists of many plates called tectonic plates.
ii. The earth completes its rotation in ________________hours time.
iii. Days and nights are caused by _____________of the earth.
iv. Our earth has ______________ layers.
v. Average speed of earth is _______________miles per second.

Q.2 Choose the correct answer.

i. Shaking of plates causes.
   a. Storm. B. Earthquake. C. Hurricane d. Revolution.

ii. The earth spins around its axis from.
   a. East to West. b. West to East. c. North to South.
   d. South to North.

iii. Which of the following factors explain why Earth can support lives?
   1. It has air. 2. It has water 3. It has a large surface.
   4. It has a suitable temperature.

Choose your answer from the following options.

a. 1 and 3 B. 1, 3 and 4 c. 2 and 4. D. All 1,2,3 and 4.

iv. The ______ crust is a layer made up of igneous, sedimentary and metamorphic rocks.
   a. Oceanic b. Continental. c. Mafnic. d. Core.

v. Once our earth was a single mass, which broke into two pieces . This is supported by a theory.
   a. Planetissimal. b. Continental Drift. c. Oceanic slip.
   d. Creational.

vi. Lithosphere can be up to ______ kilometers thick.
   a. 5. b. 35 c. 65. D. 100

vii. Atmosphere is made up of.
   a. Mixture of gases. b. Gases, solids and liquid particles.
   c. Only water vapours. d. Molecular Nitrogen and Oxygen.

viii. The region of atmosphere immediately above the surface of the earth is.
   a. Lithosphere. b. Troposphere. c. Stratosphere.
   d. Biosphere.

ix. We can see clouds in the region of atmosphere.

a. Troposphere b. Stratosphere. c. Thermosphere.
d. Mesosphere.

x. Ozone layer occurs in the layer.
a. Troposphere. b. Stratosphere. c. Mesosphere.
d. Thermosphere

xi. Earth is protected from UV radiations by means of.
a. Nitrogen b. Ozone layer. c. Carbon-dioxide.
d. Stratosphere.

xii. Which gas holds the UV rays?
a. O_2 b. N_2 c. O_2 d. CO_2

xiii. Which one is the most abundant gas in the atmosphere?
a. Oxygen. b. Hydrogen. c. Nitrogen. d. Water vapors.

Q.3 Answer the following questions:

What do you know about the rotation and revolution of the earth?

i. Write series of changes which took place on earth to give it present shape.
ii. What is difference between the gravity of earth and the Gravity of the Moon?
iii. Define Lithosphere?
iv. Explain the types of Lithosphere.
v. How lithosphere is important for us?
vi. Define hydrosphere?
vii. Hydrosphere is the big part of our earth Elaborate.
viii. Draw water cycle. Also write its importance.
ix. Define Atmosphere? Also write composition of Earth's atmosphere.
x. What is Ozone and why is it important?
xi. Explain Ozone-Oxygen Cycle in the Stratosphere.
xii. Explain the importance of oxygen and ozone layer for life activities. What would happen if there was no ozone layer?

2.5 The Galaxies

A galaxy is a group of Stars and solar systems. A galaxy is so vast that it contains millions of stars. There is a number of galaxies present in our universe. A galaxy has a distinct shape, and shape depend upon the arrangement of the stars. There is one hundred thousand galaxies known to us.

Galaxies come in four main types: Ellipticals, Spirals, Barred and Irregular. Galaxies are grouped together to form Clusters

2.5.1 Elliptical Galaxies

Elliptical Galaxies are the largest known galaxies. They are circular (Ellipsoidal), long, narrow or cigar shaped. They have relatively little inter-stellar matter. Elliptical galaxies are often made up of upto 1 trillion older stars. The formation of new stars is very rare due to less amount of dust and gases. This galaxy looks red due to red coloured stars. Most stars remain close to each other due to forces of gravitation. They do not have black holes.

Fig. 16 Elliptical galaxies

2.5.2 Spiral Galaxies

The name spiral is given due to the long thin elongations (arms) extending from the centre. Spiral galaxies consist of a rotating disk of, and a central bulge of generally older stars. Extending outward from the bulge are relatively bright arms. These galaxies are rich in dust and gas. In spiral arms stars are formed actively. Spiral galaxies are composed of millions of older stars in the center while arms have new stars. They also have black holes.

Fig.17 Spiral Galaxies

Like the stars, the spiral arms rotate around the center, but they rotate with constant angular velocity. The spiral arms contain high density matter. As stars move through an arm, the velocity of each stellar system is changed by the gravitational force of the higher density.

The arms are visible because of star formation, and have many bright and young stars.

Fig.18 Formation of Spiral galaxies

A majority of spiral galaxies have a linear, bar-shaped band of stars that extends outward to either side of the core, then merges into the spiral arm structure.

Bars are temporary structures formed from density wave of the core.

The galaxy of which our solar system is a part of is large disk-shaped barred spiral galaxy. It has two hundred billion stars. Its total mass is six hundred billion times greater than the mass of the sun.

2.5.3 Irregular Galaxies

These Galaxies has no definite shape. The Stars in an irregular galaxy do not appear to be grouped in any set shape. These Galaxies have many shapes and sizes. The clouds of Magellan, is an irregular Galaxy. It is very small Galaxy near the Milky Way. These Galaxies are not very common.

Fig.19 Irregular Galaxies

2.5.6 The Milky Way Galaxy

On a dark night have you ever seen a band of lights stretched on the sky? This is called a milky way. The milky-way is composed of faint stars. The proof of the Milky Way consisting of many stars came in 1610 when Galileo used a telescope to study the Milky Way and discovered that it is composed of a huge number of faint stars.

Fig.20 Milky way Galaxy

Our solar system is considered to be present at the center of the milky-way galaxy. The first attempt to describe the shape of the Milky Way and the position of the Sun in it was carried out by William Herschel in 1785 by carefully counting the number of stars in different regions of the sky.

He produced a diagram of the shape of the galaxy with the solar system close to the center.

Key Points

1. A Galaxy is a group of Solar systems which contain millions of stars.
2. There are four main types of galaxies, Elliptical, Spiral, Barred and Irregular.
3. Elliptical galaxy is the largest known galaxy which contains one trillion older stars. New stars are formed very rare. It looks red and stars remain close to each other.
4. In these Galaxy long thin arms extends from the center. These consist of a rotating disc which contains older stars in the center and new stars in the arms.
5. Irregular galaxies has no regular shape. They are not very common.
6. Milky way Galaxies are well known as our solar system is present in the center of milky way. A milky way contain a huge number of faint stars.
7. Elliptical galaxies do not have black holes whereas Spiral galaxies have black holes.
8. A Black Hole is black because nothing can escape it as it has very strong density.

Self Assessment Exercise 2.5

Q.1 Pick the correct answers.

i. The milky way galaxy is
   a. considered a small cluster of stars.
   b. A spiral galaxy is similar to the Andromeda galaxy
   c. Composed of between 100 million and 200 million stars
   d. The largest galaxy in the universe.

ii. The center of our Milky Way Galaxy
   a. Contains a very large Sun.
   b. Is believed to contain a massive black hole.
   c. Contains hundreds of stars similar to our sun.
   d. Is a large empty hole.

iii. The age of the Milky Way galaxy is
   a. The same as the age of our sun
   b. About 5 billion years old.
   c. About 13.5 billion years old.
   d. About 25 billion years old.

iv. What is believed will be the final stage of our Sun's life?
   a. red giant. b. white dwarf.
   c. neutron dwarf. d. pulsar

v. Which type of galaxy have a clearly defined disk component.
   a. ellipitical b. irregular
   c. Spirals only d. Spirals and lenticulars.

Q.2 Answer the following questions:

i. Define a Galaxy, also write its main types.
ii. Define a milky way. Discuss different types of Milky ways.

2.6 The Black Holes

1. What is a black hole?

Dear students, you might have seen the working of a vacuum cleaner. When you do, watch closely because you will see the dirt and crumbs start to move towards the vacuum cleaner. A black hole is similar to a vacuum cleaner, cleaning up debris left behind in outer space.

However, it is not suction power that makes things fall into a black hole. Suction would not be strong enough. Instead, a black hole uses the power of gravity to pull things towards it.

A black hole is defined by the escape velocity that would have to be attained to escape from the gravitational pull exerted upon an object. For example, the escape velocity of earth is equal to 11 km/s. Anything that wants to escape earth's gravitational pull must go at least 11 km/s, no matter what the thing is — a rocket ship or a baseball. The escape velocity of an object depends on how compact it is; that is, the ratio of its mass to radius. A black hole is an object so compact that, within a certain distance of it, even the speed of light is not fast enough to escape.

2. How is a stellar black hole created?

Now question arises: How do black holes form? The answer is as follows:
When a large star runs out of fuel it can no longer support its heavy weight. The pressure from the star's massive layers of hydrogen press down forcing the star to get smaller and smaller and smaller. Eventually the star will get even smaller than an atom. Imagine that for a moment, an entire star squashed up into less space than a tiny atom.

This is a common type of black hole which is produced by some dying stars. A star with a mass greater than 20 times the mass of our Sun may produce a black hole at the end of its life. In the normal life of a star there is a constant tug of war between gravity pulling in and pressure pushing out. Nuclear reactions in the core of the star produce enough energy to push outward. For most of a star's life, gravity and pressure balance each other exactly, and so the star is stable. However, when a star runs out of nuclear fuel, gravity gets the upper hand and the material in the core is compressed even further. The more massive the core of the star, the greater the force of gravity that compresses the material, collapsing it under its own weight. For small stars, when the nuclear fuel is exhausted and there are no more nuclear reactions to fight gravity, the repulsive forces among electrons within the star eventually create enough pressure to halt further gravitational collapse. The star then cools and dies peacefully. This type of star is called the "white dwarf." When a very massive star exhausts its nuclear fuel it explodes as a supernova. The outer parts of the star are expelled violently into space, while the core completely collapses under its own weight.

3. How can something get smaller but retain the same amount of mass, or stuff?

It is really quite simple. If you take a sponge the size of a soda can, you can easily squish it in your hands until it is completely covered. But here is the interesting part. If you make something smaller by squishing it, its gravity becomes much stronger. Imagine then, if you squish a star into the size of an atom how powerful its gravity would become.

A black hole's gravity becomes so powerful that anything, including light that gets too close, gets pulled in. That's right, not even light can escape the grasp of a black hole.

4. Since light has no mass how can it be trapped by the gravitational pull of a black hole?

Newton thought that only objects with mass could produce a gravitational force on each other. Applying Newton's theory of gravity, one would conclude that since light has no mass, the force of gravity couldn't affect it. Einstein discovered that the situation is a bit more complicated than that. First he discovered that gravity is produced by a curved space-time. Then Einstein theorized that the mass and radius of an object (its compactness) actually curves space-time. Mass is linked to space in a way that physicists today still do not completely understand. However, we know that the stronger the gravitational field of an object, the more the space around the object is curved. In other words, straight lines are no longer straight if exposed to a strong gravitational field; instead, they are curved. Since light ordinarily travels on a straight-line path, light follows a curved path if it passes through a strong gravitational field. This is what is meant by "curved space," and this is why light becomes trapped in a black hole. In the 1920's Sir Arthur Eddington proved Einstein's theory when he observed starlight curve when it traveled close to the Sun. This was the first successful prediction of Einstein's General Theory of Relativity.

One way to picture this effect of gravity is to imagine a piece of rubber sheeting stretched out. Imagine that you put a heavy ball in the center of the sheet. The weight of the ball will bend the surface of the sheet close to it. This is a two-dimensional picture of what gravity does to space in three dimensions. Now take a little marble and send it rolling from one side of the rubber sheet to the other. Instead of the marble taking a straight path to the other side of the sheet, it will follow the contour of the sheet that is curved by the weight of the ball in the center. This is similar to how the gravitation field created by an object (the ball) affects light (the marble).

5. Anatomy of a Black Hole

Black holes are made up of 3 main parts. The very outer layer of a black hole is called the *Outer Event Horizon*. Within the Outer Event Horizon you would still be able to escape from a black hole's gravity because the gravity is not as strong here.

The middle layer of a black hole is called the *Inner Event Horizon*. If you didn't escape the black hole's gravity before you entered the Inner Event Horizon, then you have missed your chance to escape. The gravity in this layer is much stronger and does not let go of objects it captures. At this point you would begin to fall towards the center of the black hole. The center of a black hole is called the *Singularity*. This is simply a big word that means squashed up star. The Singularity is where the black hole's gravity is the strongest.

6. What does a Black Hole look like?

A black hole itself is invisible because no light can escape from it. In fact, when black holes were first hypothesized they were called "invisible stars." If black holes are invisible, how do we know they exist? This is exactly why it is so difficult to find a black hole in space! However, a black hole can be found indirectly by observing its effect on the stars and gas close to it. For example, consider a double-star system in which the stars are very close. If one of the stars explodes as a supernova and creates a black hole, gas and dust from the companion star might be pulled toward the black hole if the companion wanders too close. In that case, the gas and dust are pulled toward the black hole and begin to orbit around the event horizon and then orbit the black hole. The gas becomes heavily compressed and the friction that develops among the atoms converts the kinetic energy of the gas and dust into heat, and x-rays are emitted. Using the radiation coming from the orbiting material, scientists can measure its heat and speed. From the motion and heat of the circulating matter, we can infer the presence of a black hole. The hot matter swirling near the event horizon of a black hole is called an accretion disk.

7. Do all stars become Black Holes?

Only stars with very large masses can become black holes. Our Sun, for example, is not massive enough to become a black hole. Four billion years from now when the Sun runs out of the available nuclear fuel in its core, our Sun will die a quiet death. Stars of this type end their history as white dwarf stars. More massive stars, such as those with masses of over 20 times our Sun's mass, may eventually create a black hole. When a massive star runs out of nuclear fuel it can no longer sustain its own weight and begins to collapse. When this occurs the star heats up and some fraction of its outer layer, which often still contains some fresh nuclear fuel, activates the nuclear reaction again and explodes in what is called a supernova. The remaining innermost fraction of the star, the core, continues to collapse. Depending on how massive the core is, it may become either a neutron star and stop the collapse or it may continue to collapse into a black hole. The dividing mass of the core, which determines its fate, is about 2.5 solar masses. It is thought that to produce a core of 2.5 solar masses the ancestral star should begin with over 20 solar masses. A black hole formed from a star is called a stellar black hole.

8. How many types of black holes are there?

According to theory, there might be three types of black holes: stellar, supermassive, and miniature black holes — depending on their size. These black holes have also formed in different ways. Stellar black holes are described in Question 6. Supermassive black holes likely exist in the centers of most galaxies, including our own galaxy, the Milky Way. They can have a mass equivalent to billions of suns. In the outer parts of galaxies (where our solar system is located within the Milky Way) there are vast distances between stars. However, in the central region of galaxies, stars are packed very closely together. Because everything in the central region is tightly packed to start with, a black hole in the center of a galaxy can become more and more massive as stars orbiting the event horizon can ultimately be captured by gravitational attraction and add their mass to the black hole. By measuring the velocity of stars orbiting close to the center of a galaxy, we can infer the presence of a supermassive black hole and calculate its mass. Perpendicular to the accretion disk of a supermassive black hole, there are sometimes two jets of hot gas. These jets can be millions of light years in length. They are probably caused by the interaction of gas particles with strong, rotating magnetic fields surrounding the black hole. Observations with the Hubble Space Telescope have provided the best evidence to date that supermassive black holes exist.

The exact mechanisms that result in what are known as miniature black holes have not been precisely identified, but a number of hypotheses have been proposed. The basic idea is that miniature black holes might have been formed shortly after the "Big Bang," which is thought to have started the Universe about 15 billion years ago. Very early in the life of the Universe the rapid expansion of some matter might have compressed slower-moving matter enough to contract into black holes. Some scientists hypothesize that black holes can theoretically "evaporate" and explode. The time required for the "evaporation" would depend upon the mass of the black hole. Very massive black holes would need a time that is longer than the current accepted age of the universe. Only miniature black holes are thought to be capable of evaporation within the existing time of our universe. For a black hole formed at the time of the "Big Bang" to evaporate today its mass must be about 10^{15}g (i.e., about 2 trillion pounds), a little more than twice the mass of the current *Homo sapien* population on planet Earth. During the final phase of the "evaporation," such a black hole would explode with a force of several trillion times that of our most powerful nuclear weapon. So far, however, there is no observational evidence for miniature black holes.

9. When were black holes first theorized?

Using Newton's Laws in the late 1790s, John Michell of England and Pierre LaPlace of France independently suggested the existence of an "invisible star." Michell and LaPlace calculated the mass and size — which is now called the "event horizon" — that an object needs in order to have an escape velocity greater than the speed of light. In 1967 John Wheeler, an American theoretical physicist, applied the term "black hole" to these collapsed objects.

10. What evidence do we have for the existence of black holes?

Astronomers have found convincing evidence for a super massive black hole in the center of the giant elliptical galaxy M87, as well as in several other galaxies. The discovery is based on velocity measurements of a whirlpool of hot gas orbiting the black hole. In 1994, Hubble Space Telescope data produced an unprecedented measurement of the mass of an unseen object at the center of M87. Based on the kinetic energy of the material whirling about the center (as in Wheeler's dance, see Question 4 above), the object is about 3 billion times the mass of our Sun and appears to be concentrated into a space smaller than our solar system.

For many years x-ray emission from the double-star system Cygnus X-1 convinced many astronomers that the system contains a black hole. With more precise measurements available recently, the evidence for a black hole in Cygnus X-1 is very strong.

11. How does the Hubble Space Telescope search for black holes?

A black hole cannot be viewed directly because light cannot escape it. Effects on the matter that surrounds it infer its presence. Matter spinning around a black hole heats up and emits radiation that can be detected. Around a stellar black hole this matter is composed of gas and dust. Around a super massive black hole in the center of a galaxy the swirling disk is made of not only gas but also stars. An instrument aboard the Hubble Space Telescope, called the Space Telescope Imaging Spectrograph (STIS), was installed in February 1997. STIS is the space telescope's main "black hole hunter." A spectrograph uses prisms or diffraction gratings to split the incoming light into its rainbow pattern. The position and strength of the line in a spectrum gives scientists valuable information. STIS spans ultraviolet, visible, and near-infrared wavelengths. This instrument can take a spectrum of many places at once across the center of a galaxy. Each spectrum tells scientists how fast the stars and gas are swirling at that location. With that information, the central mass that the stars are orbiting can be calculated. The faster the stars go, the more massive the central object must be.

STIS found the signature of a super massive black hole in the center of the galaxy M84. The spectra showed a rotation velocity of 400 km/s, equivalent to 1.4 million km every hour! The Earth orbits our Sun at 30 km/s. If Earth moved as fast as 400 km/s our year would be only 27 days long!

Key Points

1. A black hole is an object so compact that, within a certain distance of it, even the speed of light is not fast enough to escape.
2. Elliptical galaxies do not have black holes whereas Spiral galaxies have black holes.
3. A Black Hole is black, has very strong density.
4. A star with a mass greater than 20 times the mass of our Sun may produce a black hole at the end of its life
5. There might be three types of black holes: stellar, super massive, and miniature black holes — depending on their size.
6. A black hole cannot be viewed directly because light cannot escape it.

Self Assessment Exercise 2.6

Q.1 Fill in the blanks.

i. A black hole uses the power of ___________to pull things towards it.
   - a. energy
   - b. gravity
   - c. hole
   - d. motion

ii. How Stellar black hole is produced?
   - a. new stars
   - b. older stars
   - c. dying stars
   - d. big stars.

iii. General theory of relativity was presented by…
   - a. Armstrong
   - b. Newton
   - c. Einstein
   - d. Arther Addington

iv. STIS stands for
   - a. Scientist for technical assistance of space
   - b. Space Telescope information system
   - c. Space Telescope Imaging Spectrograph
   - d. Space technological information system

Q.2 Answer the following questions:

i. What are Black Holes? Why is it important to study it?
ii. Describe the anatomy of the Black Holes?
iii. Do Black Holes emerge from Stars? Discuss.
iv. Discuss the efficiency of Hubble Telescope for searching of black holes?

2.7 The Space

The region beyond the Earth's atmosphere occurring among the solar bodies of the universe. The density of the space is almost negligible, although cosmic rays, meteorites, gas clouds, etc, can occur. The space can be divided into cis-lunar space (between the earth and moon), inter-planetary space, inter-stellar space, and inter-galactic space

2.7.1 Cis - Lunar Space

The region between Earth's atmosphere and the Moon is sometimes referred to as **cis-lunar space**. The Moon passes through geo-space roughly four days each month, during which time the surface is shielded from the solar wind.

Geo-space is mainly composed of electrically charged particles. These charged particles have very low densities and their motion is controlled by earth's magnetic field. Geo-space and ionosphere are disturbed by geomagnetic storms. These storms increase fluxes of energetic electrons that can damage satellite electronics, disrupting telecommunications and GPS technologies.

2.7.2 Inter-planetary Space

Inter-planetary space, the space around the Sun and planets of the Solar System. The volume of interplanetary space is a nearly total vacuum, with a mean free path of about one astronomical unit at the orbital distance of the Earth. However, this space is not completely empty, and is partially filled with cosmic rays, which include ionized atomic nuclei and various subatomic particles. There is also gas, plasma ,dust, small meteors, and several types of organic molecules.

Interplanetary space contains the magnetic field of the Sun. There are also magnetospheres generated by planets such as Jupiter, Saturn, Mercury and the Earth that have their own magnetic fields. These magnetic fields can trap particles from the solar wind and other sources, creating belts of magnetic particles such as the Van Allen Belts. Planets without magnetic fields, such as Mars, have their atmospheres gradually eroded by the solar wind, except mercury.

2.7.3 Inter-stellar Space

Interstellar space is the physical space within a galaxy not occupied by stars or their planetary systems. The average density of matter in this region is about 10^6 particles per cm^3, but this varies from a low of about 10^4–10^5 in regions of sparse matter up to about 10^8–10^{10} in dark nebula. Regions of star formation may reach 10^{12}–10^{14} particles per cm^3. Nearly 70% of this mass consists of alone hydrogen atoms. This also have helium atoms and other trace amounts of heavier atoms formed through stellar nucleo-synthesis. A number of molecules can also form in inter-stellar space like tiny dust particles.

2.7.4 Inter-galactic Space

Inter-galactic space is the physical space between galaxies. The huge spaces between galaxy clusters are called the **voids**. The density of the Universe, is clearly not uniform; it ranges from relatively high density in galaxies (including very high density in structures within galaxies, such as planets, stars, and black holes) and lower density than the universe's average.

Surrounding and between galaxies, there is plasma that is thought to possess a cosmic rays, and that is slightly denser than the average density in the universe. This material is called the intergalactic medium and is mostly ionized hydrogen; i.e. a plasma consisting of equal numbers of electrons and protons.

Key Points

1. The region beyond the earth's atmosphere occurring among the solar bodies of the universe is called space.
2. The region between the moon and the earth's atmosphere is called cis-lunar Space.
3. The space around the sun and planets of the solar system is called interplanetary space.
4. Physical space within a galaxy not occupied by stars or their planetary system is called inter-stellar space.
5. The physical space between galaxies is called inter- galactic space.

Self Assessment Exercise 2.7

Q.1 Choose the correct answer from the answers given below.

i. The density of space is
   - a. Higher than air
   - b. Almost negligible
   - c. Equal to plasma
   - d. Greater than water

ii. The space, __________ is mostly composed of electrically charged particles.
   - a. Geo-space
   - b. Inter-planetary space.
   - c. Inte-rstellar space
   - d. The surface of the m

iii. The huge space between Galaxy clusters is called _____________.
   - a. Null
   - b. Voids
   - c. Nimble
   - d. Clusteral space

Q.2 Answer the following questions:

i. Define space and enlist its different divisions.
ii. Which space is concerned with our Solar System? Discuss.
iii. Describe the type of space whose mass is 70% hydrogen atoms.

Answers to Self Assessment Exercises

Self Assessment Exercise 2.1

Q.1

i.	Star.	ii.	Meteoroid.	iii.	Astronauts.

Q.2 Consult 2.1 to answer this question

Q.3 i. c ii. c iii. a

Self Assessment Exercise 2.2

Q.1

i.	Revolve or orbit	ii.	Triton	iii.	84 years
iv.	Jupiter	v.	Iron oxide		

Q.2

i.	a	ii.	D	iii.	a

Q.3 Read section 2.2 to answer these questions.

Self Assessment Exercise 2.3

Q.1

i.	4or 4.5 billion	ii.	Pan Kau	iii.	Nebular.

Q.2 Consult section 2.3 to answer the questions.

Self Assessment Exercise 2.4

Q.1

i.	crust	ii.	24	iii.	Rotation
iv.	Three	v.	30.		

Q.2

i.	b	ii.	b	iii.	d.
iv.	b	v.	b	vi.	d
vii.	b	viii.	d	ix.	b
x.	b	xi.	b	xii.	c
xiii.	c				

Q.3 i. a ii. d iii. a

Q.3 Consult section 2.4 to answer the questions.

Self Assessment Exercise 2.5

Q.1

i.	c	ii.	a	iii.	c
iv.	b	v.	c		

Q.2 Consult section 2.5 to answer the questions.

Self Assessment Exercise 2.6

Q.1

i.	b	ii	c	iii.	c
iv.	c				

Q.2 Consult section 2.6 to answer the questions.

Self Assessment Exercise 2.7

Q.1

i.	b	ii.	a	iii.	b

Q.2 Consult section 2.7 to answer the questions.

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Unit–3

MATTER

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CONTENTS

Introduction

This unit is about matter and its properties. The understanding of this content will give you some insight about chemistry. Before discussing the chemical principles, it is very essential that you get to know the basic chemical concepts. Every discipline has its own language and specific skills to deal with. Similarly, chemistry requires a specific language and certain skills to deal with. Without knowing the fundamentals of chemistry, one cannot acquire a firm understanding of chemistry.

Allah has created a vast variety of materials in this universe. You have seen many materials in your daily life e.g wood, iron, water etc. Since several materials are present in nature, therefore they are classified into groups by scientists in order to make their understanding and study easy.

Everything is made up of matter. It is the property of matter that it has certain mass and occupies certain volume. All matter is made up of several atoms either of the same kind or of different kinds and hence it can be different from each other. For example, gold is composed of one type of gold atoms, whereas “water” is made up of two different types of atoms i-e hydrogen and oxygen atoms.

In this unit, you will get to know the difference between elements, compounds and mixtures. You will also study how chemical reactions happen. You will also learn how chemical equations are balanced.

Objectives

At the end of this Unit, you will be able to:

- differentiate between different states of matter.
- describe molecular theory of matter.
- discuss structure of an atom
- differentiate elements, compound and mixtures
- write different chemical formulae
- design different chemical reactions
- identify metals from nonmetals
- distinguish acids, bases, and neutralizations
- balance the chemical equations

3.1 Matter and its States

Anything that has mass and occupies some space is matter. All kind of objects are composed of matter. Matter is everywhere around us in any form. Water, bricks, chairs, tables, books are all made up of matter. We can directly sense the matter. Matter is made up of atoms of elements. Around eighty years before, scientists believed that "atom" was the smallest constituent of matter. That was the time, when atom was considered to be the "building block of matter"

Ernest Rutherford's (1911) discovery revealed that an atom is made up of a positively charged central part called "nucleus" and negatively charged particles called electrons are revolving around it.

In 1932, scientists discovered that the nucleus of an atom is made up of smaller particles called protons and neutrons. Moreover they discovered that there is positive charge on protons, negative charge on electrons while neutrons have no charge. The protons and neutrons are called nucleons as they are found in the nucleus. By that time, they were considered as the smallest constituent of matter.

Scientists discovered the fact that like charges repel each other and unlike charges attract each other. This fact made them wonder that how protons are confined within nucleus and do not fly part. In 1947 they discovered other particles called "mesons". After the discovery of "mesons", they got answer of their question. According to them mesons hold the protons and neutrons together to form the nucleus.

Scientists continued their experiments to explore more about atom. In 1968 they discovered something astonishing and amusing about protons and neutrons. They also discovered that protons and neutrons are made up of smaller particles called "quarks". They discovered six different kinds of quarks: Up, down, strange, charm, top and bottom.

Protons have two up and one down quark. Whereas neutrons have two down and one up quarks. The quarks are held together by particles called gluons.

According to some scientists, quark is the smallest piece of matter. But some are still in search of other particles.

Properties of matter

There are various quantitative, measurable properties of matter. For example mass, volume weight, color, density as well as qualitative properties e.g taste and smell.

Examples

In this universe all physical objects are made of matter: air, water, stars, galaxies, planets, rocks, etc. Living organisms such as human beings, animals and plants are also composed of matter.

Composition

In order to understand the structure and composition of matter, scientists made many efforts e.g cutting or breaking matter into smaller and smaller pieces. Living organisms are made up of cells, which are composed of molecules; these molecules are sets of atoms bounded together. Each atom, in turn, is a grouping of elementary particles.

States of matter

Scientists have classified matter into certain broad categories, known as “states” with reasonably different properties.

i. Solids

Solid is the state of matter in which atoms and molecules are so strongly bonded together that they retain their shape up to a certain temperature and pressure.
Examples: rocks, table, knife, mirror etc.

ii. Liquids

Liquid is the state of matter in which molecules and atoms are weakly bonded together. Liquids do not have a proper shape.
Examples: water, glycerin, petrol, diesel etc

iii. Gases

The state of matter in which there is weak or loose bonding among atoms or molecules of the elements is called gases. In gases molecules or atoms can move independently from each other. Gases do not exhibit a proper volume, they tend to expand and occupy the whole volume available.
Examples: air, water vapour, helium.

iv. Plasma

According to Wikipedia, Plasma is identified as the fourth state of matter. Plasma is made by heating a gas until its atoms and molecules break up (called ionized) into negatively charged electrons and positively charged ions. Differing from other states of matter, the charged particles in a plasma will react strongly to electric and magnetic fields (i-e electromagnetic fields). The formed ions will re-unite into a gas if plasma gets cold.

On the earth the lightning and aurora (colorful lights on the sky in the countries situated on poles) make plasma. Artificial (man-made) uses of plasma include fluorescent tubes, neon signs, and plasma displays used for television or computer screens. Scientists are experimenting with plasma to make a new kind of nuclear power, called fusion, which would be much better and safer than ordinary nuclear power, and would produce much less radioactive waste.

Key Points

1. Anything that carries mass, occupies space and can be felt is called matter.
2. The smallest particle of matter is an "atom".
3. Protons and Neutron are found in neucleous, hence known as "Nucleons".
4. Rutherford proposed the structure of an atom, according to him an atom consists of a central heavier part called nucleus having positive charge and negatively charged particles (electrons) are revolving around the Nucleus.
5. A Matter is found in four states viz. solid, liquid, gas and plasma.
6. Any kind of matter is ultimately composed of smaller molecules, atoms or ions, these molecules, atoms or ions are basic elements like (hydrogen, oxygen, iron, sodium and potassium etc.)
7. In solids molecules or atoms are so closely packed that they have definite shape, and fixed volume. e.g Salts, table, knife, book and brick .
8. Liquid is the state of matter in which molecules and atoms are weakly bonded together. They do not have a proper shape. Whereas they have a fixed volume. Examples: water, glycerin, petrol, diesel
9. Gases do not have a proper volume, they tend to expand and occupy the whole volume available. They also have no shape. Examples: air, water vapour, helium.
10. The fourth state of matter is "Plasma". It is prepared by heating a gas until its atoms and molecules break up (called ionized) into negatively charged electrons and positively charged ions. Plasma is used in fluorescent tubes, plasma displays, neon signs, and television or computer screens.

Self Assessment Exercise 01

Q.1 Fill in the Blanks with correct Options.

i. Anything which has mass or weight and __________________ is called matter.

ii. The charge on proton is _____________whereas there is ______________charge on neutron.

iii. ____________has _____________quarks.

Q.2 Pick correct answer from the given options.

i. there is _____________charge on neutron.

a. positive b. negative

c. no charge d. no known charge

ii. Matter exist in __________________forms

a. 2 b. 3

c. 4 d. 5

iii. A state of matter which has no definite shape nor fixed volume is called_______________

a. Plasma b. solid
c. Gas d. liquid

iv. Mostly ______________form of matter is found on starts and sun.
a. Molecule b. Plasma
c. Gas d. quark

v. There are _________different type of quarks:
a. two b. six
b. three c. four

Q.3 Answer the following questions:

i. Describe different states of matter in detail.
ii. Differentiate solids, liquids and gases on the bases of shape, volume and arrangement of molecules.
iii. What is plasma? Describe its applications in our daily life.

3.2 Molecular Theory of Matter

Scientists developed the kinetic molecular theory of matter during nineteenth century to explain the behaviour of atoms and molecules that make up the matter.

To begin with, we will consider matter as composed of small particles. This theory assumes that these particles are constantly in motion. These atoms and molecules change their velocity and direction constantly. That is the reason; the molecular theory of matter is also known as kinetic molecular theory. This theory is very useful in explaining the properties of the states of matter in terms of energy of particles and forces that act between them.

The following are the postulates of the molecular theory

1. **All kind of matter is made of tiny particles.**
2. **These particles are in constant motion.**
3. **The amount of motion is proportional to temperature. An increase in temperature results in increase in motion.**
4. **The rate of motion of the particles of solids, liquids and gases is different. The rate at which these particles interacts is also different.**

Now we will discuss molecular theory in three states of matter.

i. The movement of molecules in Solids
ii. The movement of molecules in Liquids
iii. The movement of molecules in Gases

The movement of molecules in Solids

We know that the matter in any state, is made from the smallest particle called atom. In solids the particles are closely packed together in very orderly arranged planes. In fact, there is some empty space between them. These Molecules are not at rest but move continuously. In solids the movement of molecules is vibratory. Because of their constant motion, they are not quite orderly as this image represents. Molecules vibrate about a central point, but do not change their positions. Despite these continual changes, the strong attractions between particles trap them in the same small volume with the same particles surrounding it. This is the reason solids maintain their shape and volume.

The distance between the molecules is very small so that force of attraction is very strong.

Effect of temperature on the structure of solid

The increased temperature leads to increase velocity of the particles. As the particles move faster, they collide with the particles around them with more force, pushing them slightly farther apart and leading to a small increase in volume of the solid. If a solid is heated enough, the motion of the particles becomes sufficiently increased to push the other particles around them completely; it can push neighbouring particles out of the way completely and move to a new position. For those neighbouring particles to make way, however, they must push other particles around them aside. In this way the systematized structure of solids collapses, and solid becomes liquid.

The movement of molecules in Liquids

In liquids the distance between molecules is large as compared to the solids so that the molecules move from one place to other easily. Their mutual attraction is very much less because of this reason liquid has no specific shape. The movement of molecule is not as fast that the molecules escape from the liquid. If molecules escape from the liquids this process is called vapourization.

The particles in a liquid are moving fast enough to break attractions, push other particles out of the way, and move throughout the liquid. Because particles are moving throughout the liquid, some of them eventually come to the liquid's surface. A particle's direction of movement may carry it beyond the surface into the space above the liquid, but the attraction of other particles break the attractions pulling it back .the liquids are converted into gases by this process. This conversion of liquid state to gaseous state is called vapourization or evaporation.

The particles moving up and away from the surface are usually pulled back by attractions to other particles still in the liquid, but sometimes they are moving fast enough to escape and join the other gas particles above the liquid.

The movement of molecules in Gases

In gases the mutual distance between molecules is very large. The force of attraction is very weak. That is the reason; gases have no specific shape and volume. In gases, density of molecules is very low. In gases, the molecules collide with each other and change their direction. When gases are compressed, the volume of the gases decreases.

In gases, the separation of the particles is much more than in a solid or liquid. For example, in the air, the average distance between particles is around ten times the diameter of each particle. This leads to the gas particles themselves taking up only about 0.1% of the total volume. The other 99.9% of the total volume is empty space.

Each particle in a gas moves freely in a straight line path until it collides with another gas particle or with particles of a liquid or solid. The particles are usually moving fast enough to break any attraction that might form between them, so after two particles collide, they bounce off each other and continue on their way alone.

Key Points

1. Kinetic molecular theory describes the behaviour of atoms and molecules of matter.
2. This theory is very useful in explaining the properties of the states of matter in terms of energy of particles and forces that act between them.
3. Matter is made of tiny particles which are in constant motion.
4. The movement of molecules in solids is vibratory; the molecules do not change their position.
5. According to Kinetic Molecular Theory molecules are in constant motion.
6. Increase in temperature increases the motion of the molecules and at a certain temperature solid changes into liquid.
7. Due to less attraction and more space between molecules of liquids, liquids have no definite (fixed) shape.
8. When high energy molecules come at the surface of the liquid they leave the surface of the liquid thus causing coolness.
9. Loss of liquid (water) at normal temperature is called evapouration.
10. Gases can be compressed easily, whereas liquids and solids cannot be compressed easily.
11. The molecules of gas are very farther apart from each other, the distance between molecules of gas is almost ten times the diameter of the molecule.
12. The attractive force between the particles of matter is inversely proportional to the distance between the individual particles of the matter.

Self Assessment Exercise 2

Q.1: Fill in the blanks with suitable words or phrases.

i. The particles of gas change their ____________ and ___________ constantly.

ii. Kinetic Molecular Theory is very useful in explaining the __________ of the states of matter in terms of energy of particles and forces that act between them.

iii. In gases the mutual distance between molecules is very large hence ____________ is very weak.

iv. The___________ between the molecules determine the strength between the molecules.

Q.2: Choose the correct option.

i. Which one of the following statements is not consistent with the kinetic-molecular theory of gases?

(a) Individual gas molecules are relatively far apart.

(b) The actual volume of the gas molecules themselves is very small compared to the volume occupied by the gas at ordinary temperatures and pressures.

(c) The average kinetic energies of different gases are different at the same temperature.

(d) There is no net gain or loss of the total kinetic (translational) energy in collisions between gas molecules.
(e) The theory explains most of the observed behavior of gases at ordinary temperatures and pressures

ii. **Which statement is false?**
(a) The density of a gas is constant as long as its temperature remains constant.
(b) Gases can be expanded without limit.
(c) Gases diffuse into each other and mix almost immediately when put into the same container.
(d) The molecular weight of a gaseous compound is a non-variable quantity.
(e) Pressure must be exerted on a sample of a gas in order to confine it.

iii. **Which of the following statements is not a part of kinetic molecular theory?**
(a) Matter is composed of particles that are in constant motion.
(b) Particle velocity increases as the temperature increases.
(c) Particles in a system cannot transfer energy to each other.
(d) Particle interactions involve electrostatic attractions and repulsions.

iv. **In which of the following groupings of terms are the three terms closely related?**
(a) Kinetic energy, energy of motion, cohesive forces
(b) Potential energy, energy of attraction, disruptive forces.
(c) Kinetic energy, electrostatic interactions, disruptive forces
(d) Potential energy, electrostatic interactions, cohesive forces

v. **In the liquid state, disruptive forces are**
(a) Roughly of the same magnitude as cohesive forces.
(b) Very weak compared to cohesive forces.
(c) Dominant over cohesive forces.
(d) Unimportant.

vi. **The phrases "particles close together and held in fixed positions" and "completely fills the container" apply, respectively, to**
(a) Liquids and solids.
(b) Solids and gases.
(c) Gases and liquids.
(d) Liquids and gases.

Q.3: Answer the following questions:

i. How Kinetic Molecular theory is helpful to determine the properties of matter?
ii. Compare and contrast movement of molecules in solids, liquids and Gases?

3.3 Structure of Atom

"The atom is a basic unit of matter consisting of a dense, central nucleus surrounded by a cloud of negatively charged electrons".

The electron is an elementary particle. The nucleus may consist of a proton or a combination of protons and neutrons. Both proton and neutron have same mass equal to $1.67x10^{-27}$ Kg. A proton is made of two up quarks and one down quark. A neutron is made of one up quark and two down quarks. The combination of quarks to form hadrons is mediated by elementary particles called gluons. It means that whole mass is concentrated in the centre of atom.

The smallest particle of matter that has specific structure and the same structure is repeated throughout the material is called an atom.

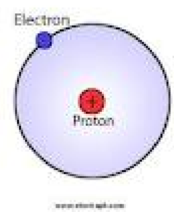
An atom cannot be divided further without modifying the characteristics of the material. Atom is the basic unit of matter like a brick in the building. For example, if you have 1 kg, 1 g or 1 atom of fresh air, all of these systems have the same qualities. If we divide an atom of fresh air into ingredients, atom loses its material qualities. For example, if you have 50 crystals of sugar but you taste only one crystal, all the remaining crystals will have the same qualities.

The main subatomic particles of an atom are electrons, protons and neutrons. These subatomic particles have different qualities. The mass of electrons is than proton and neutron. Electrons are negatively charged. Protons are much bigger and bulky than electrons and have positive charge. Neutrons are massive and heavy like protons; however there is no charge on neutrons. Every atom is composed of a variety of these subatomic particles. Let's examine one form of atom i-e hydrogen atom.

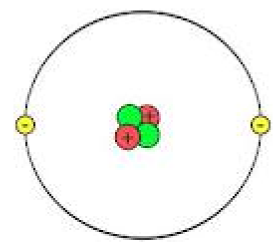
A Hydrogen Atom

The figure shows that the hydrogen atom is composed of one proton and one electron. The subatomic particles in an atom are not motionless. The electron is regularly rotating around the center of the atom i-e nucleus. The centrifugal force of the rotating electron keeps the two subatomic particles from touching each other much as the global spinning keeps it from crashing into the sun. Keeping this into account, an atom of any element would seem to be like this:

Atom is incredibly small. The diameter of one hydrogen atom, for example, is approximately $5x10^{-11}$ m. Electron spins very far from the nucleus. In an electronically neutral atom, the positively charged protons are balanced by equal number of electrons. As you have observed that hydrogen is the simplest element with only one proton and one electron. Helium is the second simplest atom in which there are two protons and two electrons revolving around the nucleus. To keep the nucleus from pushing apart, helium has two neutrons in its nucleus. As neutrons have no charge, so atom as a whole is electrically neutral. Neutrons operate like nuclear glue, holding protons, and thus nucleus, together.



Atom of an hydrogen element



Atom of Helium element

A Helium Atom

From the above picture, you can observe that helium is bigger than hydrogen. Addition of electrons, protons and neutrons in an atom increases its size. There are two ways of measuring the size of an atom:

We can evaluate the dimensions of an atom in two ways:

i. using the atomic number (Z) or
ii. using the mass number (A).

3.3.1 Atomic Number (Z) and Mass Number (A)

The Number of protons in an atom is called its atomic number. The arrangement of elements in the modern periodic table is in order of increasing atomic number. In a neutral atom, the number of electrons equal to its atomic number.

The combined number of protons and of neutrons in a particular atom is known its mass number.

With the increase in atomic number, atomic mass always increases. The sequence of elements suggested by Mendeleev was almost exactly the same as the one used today. Although there are a couple of peculiar exceptions. In general, it is acceptable to consider that atoms of elements getting heavier as you go down a column or to the right across a row in the periodic table.

Example

For hydrogen, atomic number (Z) = 1. As the number of electron in an atom is equal to the number of protons therefore hydrogen atom has one electron. Similarly the atomic number (A) of hydrogen atom is 1.

For helium, atomic number (Z) = 2. It shows that there are two electrons in the outer orbits of helium atom. The mass number (A) of helium = 4. It means that there are two protons and two neutrons in helium atom. The atomic number and the mass number of an element (X) can be denoted as follows:

$$^{A}_{Z}\mathbf{X}$$

Thus, helium can be represented as:

$$^{4}_{2}\mathbf{He}$$

3.3.2 Distribution of Electrons in Shell

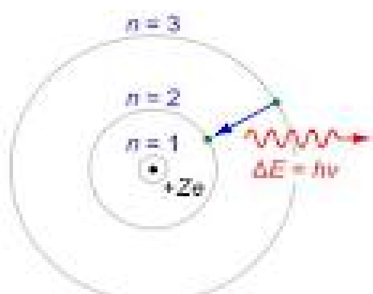
Before you get to know about the distribution of electrons in different shells, you should be familiar with atomic model. Scientists have presented several atomic models but here one of the most famous atomic model is being described.

Bohr's Model of Atom

In 1913, Niels Bohr presented a model. According to atomic model of Bohr, an electron revolves around the nucleus in a well defined circular path. He presented following two main postulates to explain the stability of atom mainly hydrogen atom

(i) An electron can have only a definite circular path around the nucleus with specific energy values. He named **orbit** or **energy level** to this circular path

(ii) Electron may go to next higher energy level (orbit) when given a definite amount of energy. In other words, an electron absorbs energy when it goes to higher energy level from a lower energy level.



On the other side, an electron will emit out a definite amount of energy when it comes from a higher energy level to lower energy level. If E2 is energy of an electron in higher energy level and E1 is energy of electron in lower energy level, then energy released ΔE will be expressed as,

$$\Delta E = E2 - E1$$
$$\Delta E = hv$$

If the electron remains in the same orbit, the energy would neither be released nor absorbed. These orbits, therefore, were called **stationary orbits** or **stationary states**. Although Bohr model could explain a number of aspects related to hydrogen atom but it could not explain stability of atoms having more than one electron. After the nature of electron was studied in detail, it was found that an electron cannot remain in a fixed circular orbit as envisaged by Bohr. Bohr model was rejected on this ground. Based on the nature of electron, concept of circular orbit was modified and a three dimensional shell with definite energy came into existence.

Shells

The shells are similar to circular path/energy levels. These shells are represented by letters *K, L, M, N* etc. Each shell is associated with a definite energy. The energies of these shells go on increasing as we move away from the nucleus. The maximum number of electrons which can be accommodated in each shell is given by $2n^2$, where n can take values 1, 2, 3….etc.

Thus, the first shell can have two electrons whereas the second shell can have 8 electrons. Similarly the maximum number of electrons present in third and fourth shells would be 18 and 32, respectively. Each shell could be further sub-divided into various sublevels of energy called **sub-shells.** These sub-shells are denoted by letters *s, p, d, f,* etc .

Sub Shells

Each shell is consisting of one or more sub shells. Each sub shell is further consists of orbitals. For example, the first (K) shell has one sub shell, known as "1s"; the second (L) shell has two sub shells, known as "2s" and "2p"; the third shell has "3s", "3p", and "3d"; and so on. The various possible sub shells are given in the following table:

Sub Shell Label	ℓ	Maximum Number of Electrons	Shells Containing it	Historical Name
s	0	2	Every shell	Sharp
p	1	6	Second shell & higher	Principal
d	2	10	3rd shell and higher	Diffuse
f	3	14	4th shell and higher	Fundamental
g	4	18	5th shell and higher	(next in alphabet after f)

Number of electrons in each Sub Shell: The shells are filled by electrons according to the following theoretical constraints:

- Each **s** sub shell holds at most 2 electrons
- Each **p** sub shell holds at most 6 electrons
- Each **d** sub shell holds at most 10 electrons
- Each **f** sub shell holds at most 14 electrons
- Each **g** sub shell holds at most 18 electrons

Therefore, the "K" shell, which contains only an "**s**" sub shell, can carry up to 2 electrons; the **"L"** shell, which contains an "**s**" and a "**p**", can carry up to 2+6=8 electrons; and so forth. The general formula for the calculation of electrons in any shell is $2n^2$. The number of electrons in sub shells is according to Aufbau principle.

Electronic configuration of elements

From the above discussions, you are aware that shells of different energies exist in an atom. The electrons occupy these shells according to the increasing order of their energy. You also know that the first shell can have two electrons whereas the second shell can accommodate eight electrons. Keeping these points in mind, let us now study the filling of electrons in various shells of atoms of different elements.

Hydrogen atom has only one electron. Thus electronic configuration of hydrogen can be represented as 1. The next element helium (He) has two electrons in its atom. Since the first shell can accommodate two electrons; hence, this second electron can also be placed in first shell.

The electronic configuration of helium can be represented as 2. The third element, Lithium (Li) has three electrons. Now the two electrons occupy the first shell whereas the third electron goes to the next shell of higher energy level, i.e. second shell. Thus, the electronic configuration of Li is 2, 1. Similarly, the electronic configurations of beryllium (Be) and boron (B) having four and five electrons respectively can be written as follows:

Be - 4 electrons Electronic configuration - 2, 2.
B - 5 electrons Electronic configuration - 2, 3.

The next element carbon (C) has 6 electrons. Now the sixth electron also goes to the second shell which can accommodate eight electrons. Hence, the electronic configuration of carbon can be represented as 2, 4. Similarly, the next element nitrogen having 7 electrons has the electronic configuration 2, 5.

The following table shows the description of different elements.

Element/ Symbol	**No of Electrons**	**Arrangement Electrons in Shell**	**Electron Distribution in Shells & Sub Shells**		**Valences**
Hydrogen, H	1	1 in first shell	1	$1s^1$	1
Helium, He	2	2 in first shell	2	$1S^2$	0
Lithium, Li	3	2 in first shell, + 1 in second shell	2,1	$1S^2$, $2S^1$	1
Beryllium, Be	4	2 in first shell, + 2 in second shell	2,2	$1S^2$, $2S^2$	2
Boron, B	5	2 in first shell + 3	2,3	$1S^2$, $2S^2$,$2P^1$	3

Table: Electronic distribution in shells of first five elements

3.3.3 Valence and Valences

We have just discussed the electronic configuration of six elements. We can see from the above table that electrons are located in different shells around the nucleus. The electrons in the last shell (popularly known as valence shell) determine the chemical properties of the atoms. These electrons are known as valence electrons. Valency or combining capacity of an atom of an element depends on the number of these electrons. You have also seen the valences of different elements along with their electronic configuration in the above table. These electronic configurations are helpful in studying the nature of bonding between various elements.

3.3.4 Isotopes

So far we have only discussed electronically neutral atoms i.e. atoms with no net positive or negative charge on them. Atoms, however, can have positive or negative charge on them by losing or gaining of electrons. Such atoms having positive or negative charge are called ions. Ions may be of two types:

i. **Cation**
   If an atom loses one or more electrons, eventually gets positive charge and is called cation.

ii. **Anion**
   If an atom gains one or more electrons, it attains negative charge and is called the anion.

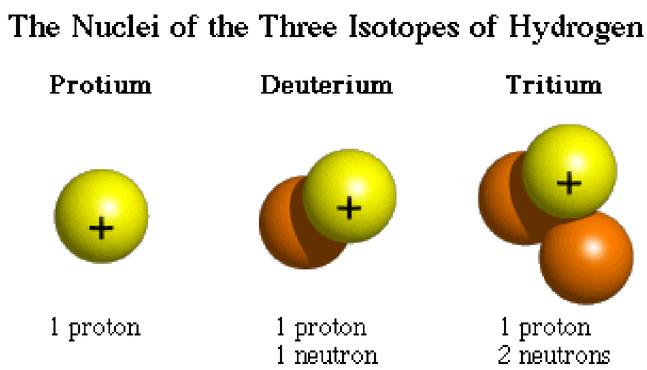
As an example we describe hydrogen atom.

Isotopes are those atoms of an element which have the same atomic numbers but different atomic masses or mass numbers.

For example, an isotope of hydrogen (commonly known as deuterium) contains 1 neutron. Since the atomic number is the number of protons plus neutrons, two isotopes of an element will have different atomic mass but same atomic number, i.e. same number of protons but different number of neutrons as shown in the following figure:

Three Isotopes of Hydrogen

Hydrogen (Protium)	Deuterium	Tritium
Atomic Mass = 1	Atomic Mass = 2	Atomic Mass = 3
Atomic Number = 1	Atomic Number = 1	Atomic No = 1



Atoms of a particular element having different number of neutrons are called isotopes. By definition, the atoms of a particular element must contain the same number of protons but may have a distinct number of neutrons which differs from atom to atom, without changing the designation of the atom as a particular element. The number of nucleons (protons and neutrons) in the nucleus, known as the mass number, is not the same for two isotopes of any element. For example, carbon-12, carbon-13 and carbon-14 are three isotopes of the element carbon with mass numbers 12, 13 and 14 respectively. The atomic number of carbon is 6 (every carbon atom has 6 protons); therefore the neutron numbers in these isotopes are 6, 7 and 8 respectively.

A nuclide is an atom with a specific number of protons and neutrons in the nucleus, for example carbon-13 with 6 protons and 7 neutrons. The nuclide concept (referring to individual nuclear species) emphasizes nuclear properties over chemical properties, while the isotope concept (grouping all atoms of each element) emphasizes chemical over nuclear.

The neutron number has drastic effects on nuclear properties, but its effect on chemical properties is negligible in most elements, and still quite small in the case of the very lightest elements, although it does matter in some circumstances (for hydrogen, the lightest of all elements, the isotope effect is large enough to strongly affect biology). Since isotope is the older term, it is better known than nuclide, and is still sometimes used in contexts where nuclide might be more appropriate, such as nuclear technology and nuclear medicine.

An isotope and/or nuclide is specified by the name of the particular element (this indicates the atomic number implicitly) followed by a hyphen and the mass number (e.g. helium-3, helium-4, carbon-12, carbon-14, uranium-235 and uranium-239).

When a chemical symbol is used, e.g., "C" for carbon, standard notation is to indicate the number of nucleons with a superscript at the upper left of the chemical symbol and to indicate the atomic number with a subscript at the lower left (e.g. ${}_2He^3$,${}_2He^4$, ${}_6C^{12}$, ${}_6C^{14}$, ${}_{92}U^{235}$, ${}_{92}U^{239}$ respectively). Since the atomic number is implied by the element symbol, it is common to state only the mass number in the superscript and leave out the atomic number subscript (e.g. He^3, He^4, C^{12}, C^{14}, U^{235}, and U^{239}respectively).

Some isotopes are radioactive and are therefore described as radioisotopes or radionuclides, while others have never been observed to undergo radioactive decay and are described as stable isotopes. For example, C^{14} is a radioactive form of carbon while C^{12} and C^{13} are stable isotopes.

Key Points

1. The smallest particle of matter that has specific structure and the same structure is repeated throughout the material is called an atom. Electrons and protons are present in all the atoms. The number of electrons and protons in any neutral atom is always same.
2. Thomson proposed the plum-pudding model of the structure of atom.
3. Rutherford's model of the structure of atom suggested that most of the mass and all of positive charge of an atom is concentrated in its nucleus and the electrons revolve around it.
4. An electron can have only a definite circular path around the nucleus with specific energy values. This circular path is called **orbit** or **energy level.**
5. The neutrons are neutral particles present in the nucleus.
6. Atomic number is the number of protons present in the nucleus of an atom.
7. Mass number gives the number of protons and neutrons present in an atom
8. Isotopes have same atomic number but different mass numbers.
9. Atoms of a particular element having different number of neutrons are called isotopes.
10. Bohr's model gave the idea of definite orbits or stationary states.
11. The electrons occupy various shells in an atom in the increasing order of their energy.
12. The maximum number of electrons which can be accommodated in a shell can be found by formula $2n^2$.
13. There are five sub-shells.

Self Assessment Exercise 3

Q.1 Fill in the blanks.

i. The nucleus consists of ———————and ——— as subatomic particles.
ii. The model which resembled the solar system was proposed by——
iii. Anode rays travel towards——————————— pole.
iv. An electron has ——————— charge.
v. The number of electrons in _______________ of an atom refers to its valence number

Q.2 Classify the following statements as true or false.

i. The plum pudding model was proposed by Rutherford.
ii. Cathode is the negatively charged electrode.
iii. Neutrons are constituents of atoms of all elements.
iv. The number of electrons present in a neutral atom is always equal to the number of protons.

Q.3 Multiple choice questions.

i. **An alpha particle has**
- (a) 2 protons only.
- (b) 2 neutrons only
- (c) 2 protons and 2 neutrons
- (d) 2 neutrons

ii. **Isotopes have**
- (a) Same mass number
- (b) Same atomic number
- (c) Different atomic number
- (d) Same mass as well as atomic number

iii. **The mass of a neutron**
- (a) Is less than that of a proton?
- (b) Is greater than that of a proton.
- (c) Is equal to that of a proton.
- (d) Zero

iv. **The filling of second shell starts with**
- (a) He
- (b) Li
- (c) C
- (d) N

v. **The electronic configuration of Cl is**
- (a) 2, 8
- (b) 2, 8, 4
- (c) 2, 8, 6
- (d) 2, 8, 7

vi. **Which of the following elements has completely filled shell?**
- (a) H
- (b) O
- (c) Ne
- (d) Mg

viii. **Which type of orbital looks like a figure-8 when drawn?**
- a) s-orbital
- b) p-orbital
- c) d-orbital
- d) f-orbital

Q.4 Answer the following questions.

1. How can you say that electrons are present in all types of matter?
2. Define an orbit.
3. Calculate the number of neutrons present in $^{19}_{9}F$
4. The mass number of iron is 56. If 30 neutrons present in its atom, what is its atomic number?
5. Which of the following are isotopes?

a. $^{12}_{6}C$

b. $^{14}_{6}C$

c. $^{14}_{7}N$

6. What are stationary states?
7. What will happen to the energy of electron when it goes from an orbit of higher energy to that of a lower energy?
8. What is a shell?
9. How many electrons can be present in a *L*-shell?
10. How many shells are present in the nitrogen atom?
11. Name any two elements which have the completely filled first shell.
12. Write the electronic configuration of an element having atomic number11.

3.4 Elements, Composed & Mixtures

Elements

An element is a pure substance that is made up of only one kind of atoms and cannot be further broken down or subdivided into simpler substances by any physical or chemical means. For example, all atoms of Oxygen are same whereas all the atoms of copper are also alike but they are different from Oxygen in size and other properties. The smallest part of an element retains its properties as it is. Elements are different from one another. An element can be represented by using a symbol. The elements can be distinguished from one another due to their properties. In the world, everything is made up of combination of elements. Up till now, overall 112 elements have been discovered. Out of these 112 elements, ninety (92) elements are found in natural form.

All elements are made up of atoms. The atom is the smallest part of an element that can take part in any chemical change.

Examples of Elements

The symbols C, Ca, Ag, and Na represent the elements carbon, calcium, silver and sodium respectively.

Compounds

A compound is defined as a pure substance made up of two or more types of elements (atoms) chemically combined in a fixed proportion, and it can be further subdivided into simpler substances only by chemical means but not by physical means e.g. if salt and other compounds are dissolved in water and electricity is passed through it, then it can be subdivided into Na and Cl. Compounds have properties that are different from its component elements, and always contains the same ratio of its component atoms.

A molecule is the smallest part of a compound, whose properties are the same as those of the compound. A compound can be represented by a chemical formula.

Characteristic Properties of Compounds:

- Elements in a compound are present in a definite proportion
  Example- 2 atoms of hydrogen + 1 atom of oxygen become 1 molecule of compound-water.
- Compounds have a definite set of properties
  Elements making a compound do not retain their original properties. Example: hydrogen (element, which is combustible and non-supporter of combustion) + oxygen (element, which is non-combustible and supporter of combustion) becomes water (compound, which is non-combustible and non-supporter of combustion)

Examples of Compounds

The chemical formulae H_2O and FeS represent the compounds of water and Ferrous sulfide (Iron sulfide) respectively.

Mixtures

A mixture is defined as an impure substance made up of two or more types of elements (atoms) or compounds or both mechanically mixed in any proportion, and it can be further subdivided into simpler substances by physical (mechanical) means.

The constituents of a mixture retain their original properties. The constituents of a homogenous mixture are uniformly mixed throughout the mixture. The properties and composition of a homogenous mixture are the same throughout the mixture.

The constituents of a heterogeneous mixture are not uniformly mixed throughout the mixture. The properties and composition of a heterogeneous mixture are not the same throughout the mixture. Homogeneous mixture is also known as a solution.

Examples of Mixtures

Stainless steel is a mixture (alloy) of iron, carbon, chromium, and nickel. Carbon gives hardness to the mixture. Chromium and nickel give a silvery look to the mixture. Potassium sulfide solution is a homogenous mixture. A mixture of water and oil is heterogeneous in nature.

Compounds Compared to Mixtures

The physical and chemical properties of compounds are different from those of their constituent elements. This is one of the main criteria for distinguishing a compound from a mixture of elements or other substances because a mixture's properties are generally closely related to and dependent on the properties of its constituents.

Another criterion for distinguishing a compound from a mixture is that the constituents of a mixture can usually be separated by simple, mechanical means such as filtering, evaporation, or use of a magnetic force, but the components of a compound can only be separated by a chemical reaction. Conversely, mixtures can be created by mechanical means alone, but a compound can only be created (either from elements or from other compounds or a combination of the two) by a chemical reaction.

Some mixtures are so intimately combined that they have some properties similar to compounds and may easily be mistaken for compounds. One example is alloys. Alloys are made mechanically, most commonly by heating the constituent metals to a liquid state, mixing them thoroughly, and then cooling the mixture quickly so that the constituents are trapped in the base metal. Other examples of compound-like mixtures include inter-metallic compounds and solutions of alkali metals in a liquid form of ammonia.

Key Points

1. An element is a pure substance that is made up of only one kind of atoms and cannot be further broken down or subdivided into simpler substances by any physical or chemical means.
2. An abbreviation used to write the name of an element is called symbol.
3. The symbols C, O, Fe, S, and Al represent Carbon, Oxygen, Iron, Sulphur and Aluminum.
4. A compound is defined as a pure substance made up of two or more types of elements (atoms) chemically combined in a fixed proportion.
5. When two elements combine in a fixed proportion they lose their identities in a compound.
6. A mixture is defined as an impure substance made up of two or more types of elements (atoms) or compounds or both mechanically mixed in any proportion.
7. The constituents of a mixture retain their original properties.
8. The constituents of a homogenous mixture are uniformly mixed throughout the mixture. The properties and composition of a homogenous mixture are the same throughout the mixture.

Self Assessment Exercise 4

Q.1 Do as directed.

i. Can an element be broken down into a simpler substance?
   a. True
   b. False

ii. What is a compound?
   a. A compound is a substance made up of one kind of mixture.
   b. A compound is a substance made up of one kind of element.
   c. A compound is a substance made up of two or more elements.

iii. What is a mixture?
   a. A mixture is two or more substances combined.
   b. A mixture is two or more elements combined.
   c. A mixture is two or more atoms combined.

iv. Mixtures can be separated. Which of the following represents a way a mixture cannot be separated?
   a. Filtration
   b. Distillation
   c. Heating

v. Which of the following is a compound?
   a. Gold

b. Alcohol
c. Helium.

vi. Are there more compounds or more elements?
a. There are more compounds
b. There are more elements
c. The number of compounds is equal to number of elements

vii. Can compounds be separated?
a. Yes
b. No

viii. Which of the following sets contains only compounds?
a. carbon, gold, water
b. alcohol, salt, sugar
c. hydrogen, oxygen, sulphur
d. coal gas, cooking oil, nitrogen

ix. Which of the following contains only mixtures?
a. seawater, salt, copper
b. blood, air, soil
c. brass, glucose, water
d. household bleach, distilled water, orange juice

x. Which of the following observations about mixtures and compounds is true?
a) Both mixtures and compounds always contain a fixed proportion of elements by mass.
b) Unlike compounds, very little or no exchange of energy occurs during the formation of mixtures.
c) A mixture cannot be easily separated into its constituents while constituents of a compound can be easily separated.
d) Compounds and mixtures can be separated into its constituents by chemical methods.

Q.2 Classify the following substances into elements, compounds and mixtures.
glucose , bronze ,neon, alcohol, calcium, milk, hydrogen, magnesium chloride, potassium nitrate, platinum, sea water, tin, zinc, water, vapour, and bromine

3.5 Chemical Formula

In the previous sections, we have already discussed that compounds are made up of elements. As Symbol is used to represent an element similarly in order to represent a compound, a formula is used. A formula gives us information about the number and kind of atoms in a molecule.

The understanding about structure of an atom and valence shell is necessary for understanding chemical formula. You have read in the previous sections about valence shell. As you know that the outer most shell of an atom is called valence shell. If the number of electrons in a valence shell is 2,8, or 18 (as in case of He, Ne, and Kr),such atoms neither can take nor can give away electrons. In other cases where there is no such situation then atoms try to complete their outer most shells such as 2,8,18 and so on. Atoms try to complete their outermost shells in the following ways.

i. By gaining electrons or losing electrons from their outermost shells.
ii. By sharing electrons and thus gaining noble gas configuration.

When an atom or group of atoms acquire positive or negative charge by losing or gaining electrons, these atoms or group of atoms are called radicals. Atoms having positive charge are called positive radical and atoms or group of atoms having negative charge are called negative radicals. These are the types of radicals on the basis of charges. Another classification of radicals is on the basis of number of atoms. If a radical consists of a single atom of an element, it is called a simple radical. Na^{+1}, Mg^{+2} ,Al^{+3}, C^{+4} ,N^{-3} ,O^{-2}, Cl^{-1} are examples of simple radicals .But if a radical consists of two or more than two atoms of different elements ,then it is called a compound or poly-atomic radical. CO_3^{-2}, NO_3^{-1},

NH_4^{-1}, SO_4^{-2}, HCO_3^{-1} are some of the examples of compound radicals. The positive or negative signs on the right upper corner of atoms or molecules is called the valency of these radicals. Valency is in fact combining capacity of an atom with another atom or group of atoms. An atom which has an unpaired electron and bears no electrical charge is called a free radical. For example H^0, Cl^0 are free radicals.

Definition

A chemical formula or molecular formula is a way of expressing information about the atoms that constitute a particular chemical compound. In order to describe chemical compounds, chemical formulas are used. As a symbol represents the name of an element, the formula represents the name of a chemical compound.

A formula can also be defined as a collection of symbols in a compound. For example Ammonia contains one atom of Nitrogen and three atoms of Hydrogen, so its formula will be NH_3.

Functions of a Formula

The chemical formula recognizes each element present in a compound by its chemical symbol and specifies the number of atoms of each element present in each discrete molecule of that compound.

It also tells the type and ratio of atoms of each element present in a formula.

You can predict the formula of an ionic compound based on the loss and gain of electrons, to reach a noble gas configuration. However, you really can't make that type of prediction with covalent compounds, because they can combine in many ways, and many different possible covalent compounds may result.

Most of the time, you have to know the formula of the molecule you're studying. But you may have several different types of formulas, and each gives a slightly different amount of information. There are several types of chemical formulas that you can use to represent chemical bonds. These include empirical formulas, molecular (or *true*) formulas, and structural formulas

Empirical formula: Just the elements

The *empirical formula* indicates the different types of elements in a molecule and the lowest whole-number ratio of each kind of atom in the molecule. For example, suppose that you have a compound with the empirical formula:

Three different kinds of atoms are in the compound, C, H, and O, and these are in the lowest whole-number ratio of 2 C to 6 H to 1 O. So the actual formula (called the *molecular formula* or *true formul*a) may be any of the following, or another multiple of 2:6:1.
Empirical formula of glucose ($C_6H_{12}O_6$) is CH_2O.

Molecular or True Formula: Inside the Numbers

The *molecular formula*, or *true formula*, tells you the kinds of atoms in the compound and the actual number of each atom.

You may determine, for example, that the following empirical formula is actually the molecular formula, too, meaning that there are actually two carbon atoms, six hydrogen atoms, and one oxygen atom in the compound:

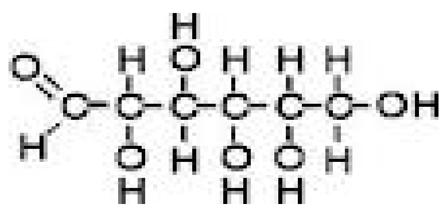
For ionic compounds, this formula is enough to fully identify the compound, but it's not enough to identify covalent formula that stands for the exact compound you have in mind, you often must write the structural formula instead of the molecular formula.
The molecular formula of glucose is $C_6H_{12}O_6$.

Molecular Formula = n x Empirical formula

$$\text{Where, } n = \frac{\text{Molecular mass of a compound}}{\text{Empirical formula mass}}$$

Structural Formula and the Bonding Pattern

The structural formula shows the elements in the compound, the exact number of each atom in the compound, and the bonding pattern for the compound.



Structural formula of Glucose.

How to write a Formula: (Criss Cross Method)

While writing a formula of any compound positive radical is written on the left hand side with its valence number on top and negative radical is written on the right side with its valence number. For example sodium chloride is formed from sodium (Na^{+1}) and chloride (Cl^{-1}).

$$Na^{+1} \quad \times \quad Cl^{-1}$$

$Na_1 Cl_1$

NaCl

Other examples of writing Formulae are as under.

Formula of Water

The steps involved in writing the chemical formula of water are as follows:

A. Write down the elements that make up the compound. The water molecule contains hydrogen and oxygen.

B. Determine the valence no .of each element .The valence no. of hydrogen is 1 and the valence no. of oxygen is 2. This means that oxygen can form two bonds with other elements and each of the hydrogen atoms can form one. Using the valencies of hydrogen and oxygen, we know that in a single water molecule, two hydrogen atoms will combine with one oxygen atom. The chemical formula for water is therefore:

$$H^{+1} \quad \times \quad O^{+2}$$

$$H_2O_1$$

$$H_2O$$

To write chemical formula for magnesium oxide. We will follow the following steps.

Write down the elements that make up the compound. For example, a molecule of magnesium oxide contains the elements magnesium and oxygen. Determine the valency of each element. The valency of magnesium is 2, while the valency of oxygen is also 2. In a molecule of magnesium oxide, one atom of magnesium will combine with one atom of oxygen.

$$Mg^{+2} \quad O^{-2}$$

$$Mg^{+2} \quad O^{-2}$$

$$Mg_2 \quad O_2$$

$$MgO$$

Activity

Make formulae of the following compounds with the help of following Radicals.(Sodium sulphate, Potassium permaganate, Calcium chloride, Ammonium bicarbonate, Magnesium phosphate**)**

Name of Positive Radicals	**Symbolic Representations**	**Name of Negative Radicals**	**Symbolic Representations**
Sodium	Na^{+1}	Oxide	O^{-2}
Potassium	K^{+1}	Sulphate	SO_4^{-2}
Calcium	Ca^{+2}	Nitrate	$NO_3^{-!}$
Aluminum	Al^{+3}	Carbonate	CO_3^{-2}
Hydrogen	H^{+1}	Phosphate	PO_4^{-3}
Ammonium	NH^{+1}	Bicarbonate	HCO_3^{-1}
Magnesium	Mg^{+2}	Permagnate	MnO_4^{-1}

Table 1: Table showing common compound radicals and their formulae

Activity 1

Calculate the valence numbers of and radicals from these formulae. (Potassium bromide, Calcium carbonate, potassium per mangnate, sodium Thiosulphate, Aluminum chloride, Sulphuric acid, Sodium hydroxide, Ferrous sulphate etc)

Key Points

1. A chemical formula is the symbolic representation of a chemical compound.
2. A chemical formula tells the number and kind of atoms of each element present in a compound.
3. There are three types of a chemical Formula; empirical formula, molecular formula and structural formula.
4. Empirical formula tells the simplest ratio between atoms of elements in a Compound.
5. Molecular formula tells the actual number of atoms of each kind in a compound.
6. Structural formula tells the arrangement of atoms and bonds in any chemical compound.
7. Valency of an atom is its combining capacity with other atoms.
8. Molecular formula can be calculated by,
9. Molecular formula = n x Empirical formula

Self Assessment Exercise 5

Q.1 Fill in the blanks with correct answers.

i. The formula of ______________________ is Na_2CO_3.

ii. The____________formula shows the simplest ratio between atoms of the elements.

iii. The atoms which have 8 electrons in outermost orbits are called __________________ elements.

iv. $MnO_4^{-1}$is an example of _____________________ radical.

Q.2 Choose the correct answer from the given options.

i. $C_6H_{12}O_6$ is the formulaof Glucose ,what is its empirical formula.

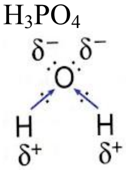
(a). $C_6H_{12}O_6$ (b) $c_2H_6O_2$

(c) CH_2O (d) C_3H_2O

ii. Correct formula of Phosphoric acid may be ;

(a). $H_3(PO_4)_2$ (b) $H_3(PO_4)_2$

(c) H_3PO_4 (d) $H_{3(}(PO_4)_3$



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iii. This structure is ___________ formula of water

(a) Molecular formula (b) Empirical formula

(c) Structural formula (d) Polimer of water

iv. Which of the following elements has three valence electrons?
   (a) Lithium   (b) Boron
   (c) Nitrogen   (d) More than one of the above

v. Cations have:
   (a) Positive charge   (b) Negative charge
   (c) No charge   (d) It is impossible to predict the charge on a cation.

vi. The chemical name for Fe_2O_3 is:
   (a) Iron oxide   (b) Iron (II) oxide
   (c) Iron (III) oxide   (d) Iron (VI) oxide

Q.3 Match the columns.

Name of Chemical compounds	Chemical Formulae
Hydrogen cyanide	$NaCO_3$
Carbon dioxide	CO_2
Sodium carbonate	Ba_2SO_4
Ammonium hydroxide	HCN
Barium sulphate	NH_4OH

Q.4 Answer the following questions:

i. Define Formula, also give examples?
ii. Compare and contrast types of chemical formulae with the help of examples?
iii. Sodium is a simple positive radical, make as many compounds taking different negative or compound radicals with sodium, and write their molecular formulae.
   (**Hint;** Sodium,+ Bromide = Sodium bromide.
   (Na^{+1} Br^{-1} = NaBr)

3.6 Chemical Reactions

Chemical changes are such changes during which:

i. Compounds loose their original identity
ii. Chemical composition of compound is changed
iii. Formation of new compound occurs
iv. There is either no reversibility or difficulty in reversibility
v. Some portion of the matter would be consumed into energy
vi. Mostly a chemical reaction is related with such changes

You have seen that if you keep iron nails in humid air, after some time there will be rust on them. What happened there? The oxygen present in the air combined with iron; as a result, a brown colored compound (iron oxide) is formed. During this process, iron has lost its original composition and formed into a new compound. In other words, iron has lost its original form. The chemical composition is changed altogether therefore it is a chemical change.

Similarly when electricity is passed into water, the water will be divided into its constituents. This is also a chemical change because water has lost its original identity. Two gases, hydrogen and oxygen are produced as a result of this. The chemical arrangement of these gases is entirely different from water. There is difficulty for the recombination of these gases.

If you light a candle, it will be converted into carbon, water and gas. This is also a chemical change because the candle will loose its identity. New compounds will be formed whose chemical composition will be different from composition of candle. It will be not possible to join these gases and carbon to remake a candle again from the products.

The chemical changes are related with chemical properties. Here are some chemical changes and there are certain chemical properties associated with them.

Chemical Change	Action	Chemical Properties
To make an oxide with the combination of	Sulpur + oxygen	Dioxide oxidation
Yeast raise decay of things	Milk sour	Fermentation
Corrosion	Rusting of iron	Rusting
Electrically passage from solution	Passage of electricity from water	Electrolysis

Therefore in chemistry, a reaction happens when two or more molecules interact and something happens. A **chemical reaction** is a process that leads to the transformation of one set of chemical substances to another. Chemical reactions can be either spontaneous, requiring no input of energy, or non-spontaneous, typically following the input of some type of energy, such as heat, light or electricity.

There are certain questions: What molecules are they? How do they interact? What happens? Those are all the possibilities in reactions. The possibilities are infinite. There are a few key points you should know about chemical reactions.

1. A chemical change must occur. You start with one compound and turn it into another. That's an example of a chemical change. A steel garbage can rusting is a chemical reaction. That rusting happens because the iron (Fe) in the metal combines with oxygen (O_2) in the atmosphere. When a refrigerator or air conditioner cools the air, there is no reaction. That change in temperature is a physical change. Nevertheless, a chemical reaction can happen inside of the air conditioner.
2. A reaction could include ions, molecules, or pure atoms. We said molecules in the previous paragraph, but a reaction can happen with anything, just as long as a chemical change occurs (not a physical one). If you put pure hydrogen gas (H_2) and pure oxygen gas in a room, they can be involved in a reaction. The slow rate of reaction will have the atoms bonding to form water very slowly. If you were to add a spark, those gases would create a reaction that would result in a huge explosion. Chemists would call that spark a catalyst.
3. Single reactions often happen as part of a larger series of reactions. Take something as simple as moving your arm. The contraction of that muscle requires sugar for energy. Those sugars need to be metabolized. You'll find that proteins need to move in a certain way to make the muscle contract. A whole series (hundreds actually) of different reactions are needed to make that simple movement happen.

All chemical reactions can be placed into one of six categories. Here they are, in no particular order:

1) Combustion: A combustion reaction is when oxygen combines with another compound to form water and carbon dioxide. These reactions are exothermic, meaning they produce heat. An example of this kind of reaction is the burning of naphthalene:

$$\mathbf{C_{10}H_8 + 12\ O_2 \dashrightarrow 10\ CO_2 + 4\ H_2O}$$

2) Synthesis: A synthesis reaction is when two or more simple compounds combine to form a more complicated one. These reactions come in the general form of:

A + B ---> AB

One example of a synthesis reaction is the combination of iron and sulfur to form iron (II) sulfide:

$$\mathbf{8\ Fe + S_8 \dashrightarrow 8\ FeS}$$

3) Decomposition: A decomposition reaction is the opposite of a synthesis reaction - a complex molecule breaks down to make simpler ones. These reactions come in the general form:

AB ---> A + B

One example of a decomposition reaction is the electrolysis of water to make oxygen and hydrogen gas:

$$2\ H_2O \text{ ---> } 2\ H_2 + O_2$$

4) **Single displacement:** This is when one element trades places with another element in a compound. These reactions come in the general form of:

A + BC ---> AC + B

One example of a single displacement reaction is when magnesium replaces hydrogen in water to make magnesium hydroxide and hydrogen gas:

$$Mg + 2\ H_2O \text{ --->} Mg(OH)_2 + H_2$$

5) **Double displacement:** This is when the anions and cations of two different molecules switch places, forming two entirely different compounds. These reactions are in the general form:

AB + CD ---> AD + CB

One example of a double displacement reaction is the reaction of lead (II) nitrate with potassium iodide to form lead (II) iodide and potassium nitrate:

$$Pb(NO_3)_2 + 2\ KI \text{ ---> } PbI_2 + 2\ KNO_3$$

6) **Acid-base:** This is a special kind of double displacement reaction that takes place when an acid and base react with each other. The H^+ ion in the acid reacts with the OH^- ion in the base, causing the formation of water. Generally, the product of this reaction is some ionic salt and water:

$$HA + BOH \text{ ---> } H_2O + BA$$

One example of an acid-base reaction is the reaction of hydrobromic acid (HBr) with sodium hydroxide:

$$HBr + NaOH \text{ --->} NaBr + H_2O$$

Key Points

1. When two or more molecules interact and something happens. A **chemical reaction** is a process that leads to the transformation of one set of chemical substances to another.
2. When oxygen combines with another compound to form water and carbon dioxide. This reaction is called combustion.
3. When two atoms or compounds combine to form a single compound, this is called a synthesis reaction.
4. When a single compound is broken down to give two or more than two substances, this type of reaction is known as decomposition.
5. When a more electronegative element or atom displaces less electronegative atom from a compound, this type of reaction is called single displacement reaction.
6. When ions of two compounds are exchanged giving entirely different compounds. This is called double displacement reaction.
7. When an acid react with base, water and salt is formed. This type of reaction is called neutralization reaction.
8. When a reaction is taking place and heat is evolved during this reaction, this reaction is called exothermic reaction.
9. When heat is absorbed during any reaction .this is called endothermic reaction.

Self Assessment Exercise 6

Q.1 Answer the following questions:

i. Define a chemical reaction and write the names of types of reactions.

Q.2 How displacement and double displacement reactions are different .Explain your answer with the help of reactions equations.

Q.3 What type of reactions photosynthesis and respiration are? Give their types and write their chemical equations.

Q.4 Choose the correct answer from the given options.

i. $HCl + NaOH \text{--->} NaCl + H_2O$ is a reaction of type.

a. Combustion. b. Displacement.
c. Double displacement d. Synthesis.

ii. In exothermic reaction heat energy is

a. Absorbed. b. Evolved.
c. Remains constant. d. No answer

iii. A chemical reaction is certainly

a. Chemical change. b. Physical change.
c. No change d. Simple mixing of molecules.

iv. Reactions mostly and very often require heat.

a) Decomposition reactions b) Neutralization
c) Exothermic reactions. d) Combustion reactions.

v. In combustion reactions one of the elements is

a) Nitrogen b) Oxygen
c) Hydrogen d) Sulpher

vi. The equation $C_6 H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$ which type of reaction

a) Decomposition reaction b) Oxidation /Combustion
c) Displacement d) Synthesis reaction.

vii. The equation $CaO + H_2O \longrightarrow Ca(OH)_2$ is a type of reaction.

a) Exothermic b) Endothermic
c) Reduction d) Oxidation

3.7 Acid, Base and Neutralizations

ACID

The word acid is derived from Latinacidus / acēre which means sour. Acids are sour in taste. Acids react with some metals to produce H_2. Acids carbonate salts releasing CO_2.

It is a substance which reacts with a base. Usually, acids can be known as tasting sour, reacting with bases like sodium carbonate and metals like calcium. Aqueous acids have less than 7 pH, where an acid of lower pH is typically stronger, and it turns blue litmus paper into red. Such substances or chemicals containing the property of an acid are called to be acidic.

Examples:

i. Tartaric acid which is used in baking,
ii. Sulphuric acid which is used in car batteries,
iii. Acetic acid present in vinegar.

These three examples illustrate that acids can be solutions, liquids, or solids. In addition to it, gases like hydrogen chloride can be acids too. Strong acids and some concentrated weak acids are corrosive, but there are exceptions such as carboranes and boric acid.

There are three common definitions for acids:

i. The Arrhenius definition: it states that acids are substances which increase the concentration of hydronium ions ($H_3O^{\pm}$) in solution.
ii. The Brønsted-Lowry definition: His definition is an expansion: an acid is a substance which can act as a proton donor. By the Brønsted-Lowry definition, any compound which can easily be deprotonated can be considered an acid. Examples include alcohols and amines which contain O-H or N-H fragments.
iii. And the Lewis definition. An acid is a substance which can accept a pair of electrons.

The majority of acids we encounter in our everyday lives is aqueous solutions, or can be dissolved in water, and these two definitions are most relevant. The reason why pHs of acids are less than 7 is that the concentration of hydronium ions is greater than 10^{-7} moles per liter. Since pH is defined as the negative logarithm of the concentration of hydronium ions, acids thus have pHs of less than 7.

Strong Acids (strong electrolytes)

HCl hydrochloric acid
HNO_3 nitric acid
$HClO_4$ perchloric acid
H_2SO_4 sulfuric acid

Weak Acids (weak electrolytes)

CH_3COOH acetic acid
H_2CO_3 carbonic

Bases

In chemistry, a base is a substance that can accept hydrogen ions (protons) or more generally, donate electron pairs. Bases are bitter in taste. These turn red litmus into blue. These are slippery to the touch.

A soluble base is considered as an alkali if it contains and releases hydroxide ions (OH^-) quantitatively.

According to Brønsted-Lowry theory, bases are proton (hydrogen ion) acceptors, while the more general Lewis theory defines bases as electron pair donors, allowing other Lewis acids than protons to be included.

According to oldest Arrhenius theory, bases are hydroxide anions, which is strictly applicable only to alkali. In water, by altering the auto-ionization equilibrium, bases give solutions with a hydrogen ion activity lower than that of pure water, i.e. a pH higher than 7.0 at standard conditions. Examples of common bases are sodium hydroxide and ammonia. Metal oxides, hydroxides and especially alkoxides are basic, and counter anions of weak acids are weak bases.

Strong Bases (strong electrolytes)

$NaOH$	sodium hydroxide
KOH	potassium hydroxide
$Ca(OH)_2$	calcium hydroxide

Weak Base (weak electrolyte)

NH_3 (ammonia)

Neutrilization

Bases can be considered as the chemically opposite of acids. Neutralization is a process between acid and base. Acids are considered as opposites because the effect of an acid is to increase the hydronium ion (H_3O^+) concentration in water. Whereas bases reduce this concentration.

Bases and acids are typically present in aqueous solution forms. Aqueous solutions of bases react with aqueous solutions of acids to produce water and salts in aqueous solutions in which the salts separate into their component ions. If the aqueous solution is a saturated solution with respect to a given salt solute any additional such salt present in the solution will result in formation of a precipitate of the salt.

Neutralization Reactions

Acid + Base → Salt + Water

When an acid like HClis combined with a base like NaOH, following reaction occurs:

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

When an acid and a base are combined, water and salt are the products.

Salts are ionic compounds having a positive ion other than H^+ and a negative ion other than the hydroxide ion, OH^-

Double displacement reactions of this type are called “neutralization reactions”.

When a strong acid and a strong base are combined inproper amounts, where $[H^+]$ equals $[OH^-]$, a neutral solution results in which ph=7.

The acid and base neutralize each other, and the acidic and basic properties are no more present.

Key Points

1. Acids are Sour in taste. Acids react with some metals to produce H_2. Acids carbonate salts releasing CO_2.
2. Aqueous acids have less than 7 pH, where an acid of lower pH is typically stronger, and it turns blue litmus paper into red.
3. Arrhenius defines acid as a species which gives hydrogen ion in aquous solution and increase the concentration of hrdronium ions in solution.
4. Brønsted-Lowry defines an acid as a substance which can act as a proton donor. By the Brønsted-Lowry definition, any compound which can easily be deprotonated can be considered an acid
5. According to Lewis an acid is a substance which can accept a pair of electrons.
6. Strong acids are also strong electrolytes, whereas weak acids are weak electrolytes.
7. HCl (hydrochloric acid), HNO_3 (nitric acid), $HClO_4$ (perchloric acid) and H_2SO_4 (sulphuric acid) are examples of strong acids.
8. CH_3COOH (acetic acid), H_2CO_3 (carbonic acid) are examples of weak acids.
9. Base are those substances which are bitter in taste, turns red litmus into blue, and are slippery when touched.
10. All soluble bases are called alkalies, but all bases are not alkalies.
11. According to Brønsted-Lowry theory, bases are proton (hydrogen ion) acceptors, while the more general Lewis theory defines bases as electron pair donors.
12. Strong bases in alkali form are strong electrolytes whereas weak alkalies are weak electrolytes.
13. Sodium hydroxide, potassium hydroxide and calcium hydroxide are examples of strong bases, while ammonia and soap are examples of weak bases.
14. Acids neutralize the effects of bases.
15. When acids react with bases, salt and water is formed .This process is called neutralization.

Self Assessment Exercise 7

Q.1 Choose the best answer:

i. Which of the following is not an acid?

a) HNO_3 b) CH_3COOH
c) H_2SO_4 d) NaoH

ii. If a solution conducts electricity, it is probably:

a) An acid b) A base
c) Neutral d) Both a and b

iii. If a compound has a pH of 6.5, it has a POH of:

a) 6.5 b) 7.5
c) 3.16×10^{-7} d) 3.16×10^{-8}

iv. Water contains more H^+ ions than OH^- ions. In this case, water is
   a) Neutral
   b) Basic
   c) Acidic
   d) Cannot say

v. When an acid reacts with a base what compounds are formed?
   a) Water only
   b) Metal oxides only
   c) A salt only
   d) A salt and water

Q.2 Answer the following questions

i. Write examples of strong acids and strong bases.
ii. Predict what will happen when an acid combines with a base.
iii. Define acids and bases according to Arrhenius and Lewis.
iv. Elaborate application of acids and bases in our daily life.

3.8 Balancing the Chemical Equation

When elements or compounds are combined, a chemical reaction takes place. In order to represent this reaction in simpler form, a chemical equation is used. Achemical equation describes what happens in a chemical reaction.

The equation identifies the reactants (starting materials) and products (resulting substance), the formulas of the participants, the phases of the participants (solid, liquid, gas), and the amount of each substance.

While writing a chemical equation normally reactants are placed on the left side and product is place at the right side. There is an arrow between them which shows the direction of reaction e.g. The chemical equation of the chemical reaction of silver nitrate and sodium chloride is as follows:

$$Nacl + AgNO_3 \rightarrow AgCl + NaNO_3$$

- Chemical equations are used to graphically illustrate chemical reactions. These consist of chemical or structural formulas of the reactants on the left side of the arrow and those of the products on the right side. They are separated by an arrow (→) which indicates the direction and type of the reaction. The tip of the arrow points in the direction in which the reaction proceeds. There are certain reactions in which products react again and they make reactants again. Such reactants are known as reversible reactions. The two half arrows $\rightleftharpoons$ in opposite directions are used for such reactions. Whereas a double arrow ($\longleftrightarrow$) pointing in opposite directions is used for equilibrium reactions.

Equations should be balanced according to the stoichiometry, the number of atoms of each species should be the same on both sides of the equation.

1. Chemical Reactions

Chemical reactions are like a 'dance'. The people starting the dance are called **reactants.** The number of people on the dance floor remains the same. During the dance people change partners and form new groups called **products.** This is what happens in a chemical reaction. Atoms swap with one another and produce new chemicals.

Old chemicals (reactants) rearrange to produce new chemicals (products)
Reactants → Products
The arrow means 'produces'

In a chemical reaction atoms are rearranged as old chemical bonds are broken and new chemical bonds are formed. The 'law of conservation of mass' is supported as the weight doesn't change between the mass of the reactants and the mass of the products.

Balancing the Equation of Chemical Reaction

Balancing a chemical equation refers to establishing the mathematical relationship between the quantity of reactants and products. The quantities are expressed as grams or moles. It takes practice to be able to write balanced equations. There are essentially three steps to the process:

1. **Write the unbalanced equation.**
   - Chemical formulas of reactants are listed on the left-hand side of the equation.
   - Products are listed on the right-hand side of the equation.
   - Reactants and products are separated by putting an arrow between them to show the direction of the reaction. Reactions at equilibrium will have arrows facing both directions.

2. **Balance the equation.**
   - Apply the Law of Conservation of Mass to get the same number of atoms of every element on each side of the equation. Tip: Start by balancing an element that appears in only *one* reactant and product.
   - Once one element is balanced, proceed to balance another, and another, until all elements are balanced.
   - Balance chemical formulas by placing coefficients in front of them. Do not add subscripts, because this will change the formulas.

3. **Indicate the states of matter of the reactants and products.**
   - Use (g) for gaseous substances.
   - Use (s) for solids.
   - Use (l) for liquids.
   - Use (aq) for species in solution in water.
   - Write the state of matter immediately following the formula of the substance it describes.

Worked Example Problem

Tin oxide is heated with hydrogen gas to form tin metal and water vapour. Write the balanced equation that describes this reaction.

1. **Write the unbalanced equation.**

   $SnO_2 + H_2 \rightarrow Sn + H_2O$

2. **Balance the equation.**

   Look at the equation and see which elements are not balanced. In this case, there are two oxygen atoms on the left-hand side of the equation and only one on the right-hand side. Correct this by putting a coefficient of 2 in front of water:

   $SnO_2 + H_2 \rightarrow Sn + 2\ H_2O$

This puts the hydrogen atoms out of balance. Now there are two hydrogen atoms on the left and four hydrogen atoms on the right. To get four hydrogen atoms on the right, add a coefficient of2 for the hydrogen gas. Remember, coefficients are multipliers, so if we write 2 H_2O it denotes;

2x2=4 hydrogen atoms and 2x1=2 oxygen atoms.
$SnO_2 + 2\ H_2 \rightarrow Sn + 2\ H_2O$

The equation is now balanced. Be sure to double-check your math. Each side of the equation has 1 atom of Sn, 2 atoms of O, and 4 atoms of H.

3. Indicate the physical states of the reactants and products.

To do this, you need to be familiar with the properties of various compounds or you need to be told what the phases are for the chemicals in the reaction. Oxides are solids, hydrogen forms adiatomic gas, tin is a solid, and the term 'water vapour' indicates that water is in the gas phase:
$SnO_2(s) + 2\ H_2\,(g) \rightarrow Sn(s) + 2\ H_2O(g)$
This is the balanced equation for the reaction.

Key Points

1. Chemical equations are used to graphically illustrate chemical reactions.
2. The compounds or elements which react with each other are called reactants.
3. The reactants are often written on left side of the arrow.
4. The compounds or atoms which are formed as a result of reaction are called products.
5. A double arrow ($\longleftrightarrow$ pointing in opposite directions is used for equilibrium reactions.
6. During a chemical reaction, older bonds are broken down and new bonds are formed.
7. A balanced chemical equation tells the type and number of elements taking part in a reaction.
8. There are two common methods of balancing the chemical equation, a). Hit and trial method and b). ion exchange method.

Self Assessment Exercise 8

Q.1 Answer the following questions:

i. Define a chemical equation.
ii. How a chemical equation is balanced, explain your answer with the help of an example?
iii. Write steps of balancing equation by Oxidation number method.

Q.2 Balance the following equations.

i. $NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$
ii. $KClO_3KCl + O_2 \longrightarrow$
iii. $N_2 + H_2 \longrightarrow NH_3$
iv. $NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + NH_3 + H_2O$
v. $C_8H_{18} + O_2 \longrightarrow CO_2 + H_2O$
vi. $N_2H_4 + N_2O_4 \longrightarrow N_2 + H_2O$
vii. $Al + S \longrightarrow Al_2S_3$
viii. $FeS_2 + O_2 \longrightarrow Fe_2O_3 + SO_2$
ix. $CO + H_2 \longrightarrow CH_3OH$
x. $Fe + H_2O \longrightarrow Fe_3O_4 + H_2$
xi. $NH_3 + CO_2 \longrightarrow CO(NH_2)_2 + H_2O$
xii. $KNO_3 + H_2SO_4 \longrightarrow HNO_3 + K_2SO_4$
xiii. $HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$
xiv. $HCl + Zn \longrightarrow ZnCl_2 + H_2$
xv. $Cu_2S + O_2 \longrightarrow Cu_2O + SO_2$
xvi. Zn + O2 →
xvii. Ca + HNO3 →
xviii. SrCl2 (aq) + AgNO3(aq) →
xix. C3H6O + O2 (g) →

3.9 Metals and Non Metals

Metals

Metals are those substances which are electropositive in nature i.e., they have a tendency to lose electrons. Generally there are 1, 2, or 3 electrons in their outmost shell. On the periodic table, a zig-zag line separates metals from nonmetals.

Physical Properties of metals

Physical state: Generally these are solids except mercury which is a liquid at room temperature.
lustrous: metals have shiny luster which is known as "metallic luster"
Sonorous: while striking on hard surface, they generally produce a sound.
Malleability: Some metals can be flattened into thin sheets. Gold and silver are most malleable.
Ductility: it is the ability of metals to be drawn into thin wires. Gold is the most ductile metal
Electrical conductivity: metals are good conductors of electricity. Silver and copper are the best conductors.
Thermal conductivity: metals are good conductors of heat. Silver and copper are the best conductors whereas lead and mercury are poor conductors.
Hardness: generally these are hard. Alkali metals like sodium, potassium are exceptions.
Melting point: Generally metals have high melting points. The exceptions are gallium, alkali metals like sodium, potassium. If you will put Gallium and caesium on your palm, these will melt.
Densities: Generally metals have less densities

Chemical Properties of metals

- The number of electrons in the outmost shell ranges 1-3.
- Metals can be easily corroded.
- Metals easily lose electrons.
- Metals form oxides that are basic.
- Metals have lower electro negativities.
- Metals are good reducing agents.

Non-metals

These substances are electronegative in nature, i.e. they have a tendency to gain electrons. Generally, there are 4 to 8 electrons in their outmost shell.

Physical Properties of non metals

Physical state: Generally these are either solids or gases except Bromine which is liquid.
Lustrous: Non-metals do not have shiny luster except iodine and graphite.
Sonorous: non-metals are non sonorous.
Malleability: these are not malleable.

Ductility: these are not ductile.
Electrical conductivity: Generally these are not good conductors of electricity except Graphite.
Thermal conductivity: non-metals are poor conductors of heat.
Ha**rdness:** Generally these are soft except diamond which is known as the hardest substance.
Melting point: Generally non-metals have low melting points.
D**ensities:** Generally non metals have low densities

Chemical Properties of Non-metals

- Generally there are 4-8 electrons in the out most shell of non-metals.
- Non-metals willingly gain or share their valence electrons
- Non-metals form oxides that are acidic
- Non-metals have higher electro negativities
- Non-metals are good oxidizing agents

Metalloids

There are 92 elements which occur naturally. Out of these 70 elements are metals while 22 are non-metals. There are certain elements which have intermediate properties of both metals and non metals. Such elements are called metalloids.

Occurrence of metals and nonmetals

Only a few metals are present in the Free State e.g like silver, gold, platinum etc. The majority of metals are found in the collective states as sulphides, silicates, oxides, carbonates, etc.

A few non-metals are present in the free State like neon, helium, argon etc. While some are present in free and combined states like phosphorus, sulphur etc.

Metallurgy

It is science of drawing out of metals from their ores and their refinement.

Ore

It is a mineral from which one or more metals can be taken out profitably.

Minerals

These are naturally occurring substances having one or more elements or their compounds.

Metallurgical processes

This process consists of three major steps. These are as follows:

i. Concentration of the ore
ii. Reduction
iii. Refining

The detail of these steps is as follows:

i. Concentration of the ore is the elimination of impurities from the ore.
ii. Reduction is the process of getting the metal from its compound.
iii. Refining is the process of purifying the impure metals in order to obtain the pure metal.

Chemical Reactions of Metals and Non-metals

a) Reaction with oxygen

When metals react with oxygen these are formed into metallic oxides. The oxides formed are basic oxides because they react with water to form bases.

Example: When Sulphur burns in air ,it is formed into Sulphur-di-oxide. Sulphur-di-oxide reacts with water to form sulphurous acid.

$$S + O_2 \rightarrow SO_2$$
$$SO_2 + H_2O \rightarrow H_2 SO_3$$

Magnesium burns in air to form magnesium oxide and magnesium reacts with water to form magnesium hydroxide.

$$2 Mg + O_2 \rightarrow 2 MgO$$
$$MgO + H_2O \rightarrow Mg (OH)^2$$

When non-metals react with oxygen these are formed into non-metallic oxides. The oxides formed are acidic oxides because they react with water to form acids.

b) Metals Replace Metals

When a more reactive metal react it replaces a less reactive metal from its salt solution.
Example: Iron replaces copper from copper sulphate solution to form iron sulphate and copper

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

Magnesium replaces copper from copper sulphate solution to form magnesium sulphate and copper.

$$Mg + CuSO_4 \rightarrow MgSO_4 + Cu$$

Zinc replaces copper from copper sulphate solution to for zinc sulphate and copper.

$$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$$

Based on the reactivity of metals, they can be arranged in the decreasing order of their activity.

c) Reaction with Water

When metals react with water these form metal hydroxides and hydrogen.
Example: When Magnesium reacts with water it is formed into magnesium hydroxide and hydrogen.

$$Mg + H_2O \rightarrow Mg (OH)^2 + H^2$$

When Sodium reacts with water it is formed into sodium hydroxide and hydrogen.

$$2\ Na + 2\ H_2O \rightarrow 2Na\ OH + H_2$$

Non metals do not react with water.

d) Reaction with Acids

When metals react with acids these are formed into metallic salts and hydrogen.

Example: When Zinc reacts with dilute hydrochloric acid it is formed into zinc chloride and hydrogen.

$$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$$

Most of the non metals do not react with acids.

A few non metals like sulphur reacts when reacts with concentrated nitric acid, it is formed into sulphur dioxide, nitrogen dioxide and water.

$$S + 4\ HNO_3 \rightarrow SO_2 + 4\ NO_2 + 2\ H_2O$$

e) Noble Metals

The metals which retain their luster because they do not react with water, air, or acids are called noble metals e.g. silver, gold, platinum etc. gold dissolves in aqua regia. Aqua regia is a mixture of concentrated nitric acid and concentrated hydrochloric acid in 1:3 ratios.

Pure gold is 24 carat. It is very soft and cannot be used for ornaments making, therefore it is combined with some silver or copper to make it hard.

f) Uses of Metals

There are many uses of metals. A few are discussed below:

Aluminum: It is used for making parts of aircrafts, utensils, furniture, wires, vehicles, machines, for packing medicines and food etc.

Iron: It is used for making pins, nuts, bolts, nails, tools, construction of buildings, machines, bridges etc.

Copper: It is used for making vessels, gadgets, wires, electric etc.

Platinum: It is used for making jewellery, electric gadgets, and plugs in vehicles etc.
Gold: It is used for making coins medals, jewellery, etc
Sodium: It is used as compounds e.g. common salt, chemicals etc.
Calcium: It is used as compounds for making cement, glass etc.
Silver: It is used for making jewellery, Coins, medals etc.

g) Uses of Non-metals

Oxygen: It is used for burning of fuels and used by respiration by living things, etc.
Sulphur: It is used for making sulphuric acid, salts of metals etc.

Nitrogen: It is used for making ammonia which is used for making fertilizers.
Chlorine: It is used to kill germs in water.
Hydrogen: It is used for making ammonia which is used for making fertilizers, as fuel in rockets, for welding etc.
Iodine: It is used as tincture iodine which is an antiseptic

h) Corrosion

It is a process in which the surface of some metals get corroded when are exposed to moist air.

i) Prevention from Corrosion of Metals:

Metals can be prevented from corrosion by:

i) Applying paint
ii) Applying oil or grease.
iii) Alloying (when iron is alloyed with chromium and nickel, it forms stainless steel which is resistant to corrosion)
iv) Galvanization (it is the process of coating the metals with non corrosive metals like zinc)
v) Electroplating (it is process in which metals are coated with non corrosive metals like chromium tin by passing electricity)

Key Points

1. Metals are those substances which are electropositive in nature\
2. Nonmetals substances are electronegative in nature.
3. The metals which retain their luster because they do not react with water, air, or acids are called noble metals.
4. Metallurgy is science of drawing out of metals from their ores and their refinement.
5. Ore is a mineral from which one or more metals can be taken out profitably.
6. Minerals are naturally occurring substances having one or more elements or their compounds.
7. Corrosion is processes in which the surface of some metals gets corroded when are exposed to moist air.
8. Galvanization is the process of coating the metals with non corrosive metals like zinc.
9. Electroplating is process in which metals are coated with non corrosive metals like chromium tin by passing electricity.

Self Assessment Exercise 9

Q.1 Choose the best

i. Of these, the most ductile metal is ___________.
   1. Al
   2. Au
   3. Cu
   4. Ag

ii. Of these, the least dense metal is ___________.
   1. Hg
   2. Au
   3. Cu
   4. Na

iii. Of these, the most reactive metal is ___________.
   1. Fe
   2. Zn
   3. Al
   4. K

iv. Which of the following is displaced by 'Cu'?
   1. Fe^{2+}
   2. Ag^{+}
   3. Zn^{2+}
   4. Al^{3+}

v. Which of the following metals does not displace H_2 gas from dilute HCI or dilute H_2So_4?
1. Mg
2. Cu
3. Zn
4. Al

vi. The metal reacting readily with cold water is ____________.
1. Au
2. Ag
3. Na
4. Mg

vii. Of these, which metal will lose electrons most readily and form cations?
1. K
2. Zn
3. Cu
4. Au

viii. Of these, which ion will get reduced most readily?
1. K^+
2. Zn^{2+}
3. Cu^{2+}
4. Ag^+

ix. Of these, the metal which occurs in a free state is ____________.
1. Na
2. Mg
3. Zn
4. Pt

x. Which of the following metals is extracted only by electrolysis?
1. Zn
2. Al
3. Fe
4. Cu

xi. Which oxide of a metal gets reduced only by coke and not by H_2 gas or CO gas?
1. Fe_2O_3
2. PbO
3. ZnO
4. Cuo

Answers to Self Assessment Questions

Answers of SAQ .1

Q.1:	i.	Occupies space	ii.	Positive, No
	iii.	Two up and one down.		
Q.2:	i.	c.	ii.	d.
	iii.	b.	iv.	d.
	v.	d.	vi.	a.

Q.3 Please consult topic 3.1 for Q.3; I, ii. Iii.

Answers of SAQ.2:

Q.1:	i.	Velocity and motion.	ii.	Behaviour.
	iii.	Attractive forces.	iv.	The forces of attraction.
Q.2:	i.	d.	ii.	a.
	iii.	c.	iv.	a.
	v.	b.	vi.	b.

Q.3: Consult topic 3.2 for part I and ii.

Answers of SAQ.3:

Q.1:	i.	Protons, Neutrons	ii.	Neil Bohr.
	iii.	Negative Pole	iv.	Negative
	v.	Outer most shell		
Q.2:	i	True	ii.	True
	iii.	False.	iv.	True.
Q.3.	i.	c.	ii.	b.
	iii.	b.	iv.	b.
	v.	d.	vi.	c.
	vii.	b.	viii.	b.

Q.4 Consult topic 3.3 for q:4.

Answers of SAQ.4:

Q.1	i.	False	ii.	c.
	iii.	a.	iv.	a.
	v.	b.	vi.	a.
	vii.	No,	viii.	b.
	ix.	b.	x.	b.

Q.2 c, m, e, c, e, m, e, c, c, e, m, e, e, c, c, e..

Answers of SAQ.5:

Q.1	i.	Washing soda,	ii.	Empirical formula
	iii.	Noble gas elements	iv.	Molecular radical.
Q.2	i.	c.	ii.	c.
	iii.	c.	iv.	b.
	v.	a.	vi.	c.

Q.3. (Hydrogen Cyanide= HCN)
(Carbon dioxide = CO_2)
(SodiumCarbonate = Na_2CO_3),
(Ammonium Hydrooxide= NH_4OH)
(Barium Sulphate = Ba_2SO_4)..

Q.4. Consult topic 3.5 for questions i to iii.

Answers of SAQ.6:

Q.1.
i. c.
ii. b.
iii. a.
iv. a.
v. b.
vi. b.
vii. d.

Q.2. Consult Topic 3.6

Answers of SAQ.7:

Q.1
i. d.
ii. d.
iii. b.
iv. c.
v. d.

For question 2, consult the relevant section.

Answers of SAQ.8:

For question 1 and 2, see the relevant section

Answer of SAQ.9:

i. 2
ii. 4
iii. 4
iv. 2
v. 2
vi. 3
vii. 1
viii. 4
ix. 4
x. 2
xi. 3

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Unit–4

MECHANICS

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CONTENTS

Introduction

In our daily life we observe different motions of objects and the different causes of motion. The queries about the motion of objects were first given by Sir Isaac Newton more than 300 years ago. He explained the way in which forces pushes and pulls, influence the motion. Newton summed up his explanations in three summarizing laws. These laws explain what and how much is needed to make an object move.

After introducing Newton's law of motion, we will discuss about the gravitational force. The Earth's gravity is understood in universal law of Gravity. We will also learn how pressure, force and area are used in our daily life and their applications in science. Weight of a body on the earth is gravitational force exerted on it by the earth. Like all forces, weight is a vector quantity. The quantity of matter enclosed with in an object or a body is called mass. Kilogram is the unit of mass.

For thousands of years, doing work has been of vital concern for the human life. However, the forces the human body can exert are limited by physical strength and body design. Human beings have developed machines that increase the amount of force the human body can produce. We will learn about simple machines like lever, pulley inclined plane, screw and gears.

Objective

After reading the unit, you will be able to:

- recognize the basic ideas of physics
- describe Newton's first law of motion
- explain the significance of Newton's second law and use it to solve the problems of motion.
- describe the Newton's third law and describe the role of pairs of forces which are equal in magnitude and opposite in direction.
- describe inertia in detail and explain its role in our lives.
- identify that all objects in nature have the force of attraction between them, which is called the force of gravitation; especially the case of the attraction of the objects near the vicinity of Earth and Earth itself.
- relate force to work and explain how simple machines make easier by changing forces.

4.1 Force

When we think of a force, we usually imagine push or pull exerted on some object. For instance, you exert a force on a ball when you throw it or kick it. What happen to an object when it is acted by a force? Force is commonly defined as a push or a pull. We can apply the forces through contractions or extensions of our muscles. When you open a door, you pull it. By the contractions of your muscles we can exert a force. A **push** force moves something away from you and the **pull** force moves something closer. You can push hard or gently, left or right so the force has the magnitude as well as direction. Force is a vector quantity. The symbol F is used to represent the vector force. If you pull a spring or kick a ball, they change their positions due to the application of force. When you throw a ball in air it comes back due to the force of gravity of the earth.

Fig 4.1 a boy pushes a cart

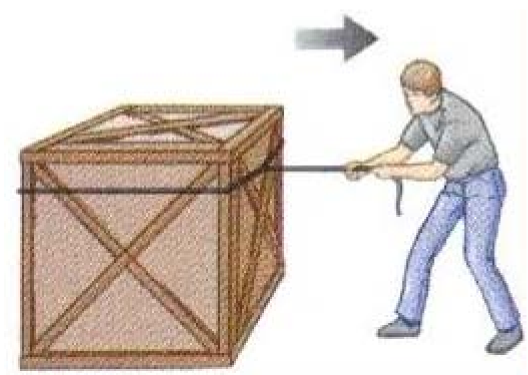

Fig 4.2 a man is pulling a heavy box.

Forces can be categorized into two types, one is the contact force and the other is the non-contact force. In fact when the objects are in contact directly with the forces are called contact forces. Examples from our daily life are normal push and pull force, surface tension of the liquids, air resistance carried by air planes and frictional forces (the cause of motion). The second types of forces are those which reason to attract and repel without get in touch with an object are called non-contact forces. Examples of the Non-contact forces are electric force, gravitational forces and magnetic force. These forces act due to the presence of their respective field's i.e. magnetic field created by the magnetic materials, similarly the gravitational force is the result of the gravitational field created by the Earth itself.

? **How many common push and pull forces do you apply in daily routine?**

An object that experience a push and pull has a force exerted on it. Notice that it is the object that is considered to be the **system**. The world around the object that exerts the force on object is called the **environment**. Each force has a specific, identifiable cause which is called **agent**. You should be able to name the agent of each force, for example when you push a book by your hand then the agent of pushing a book is your hand.

The first step in solving such problems is to create a pictorial model. To represent force acting on ball hanging by a rope, sketch the situation. Circle the system and identify where the system touches the environment. Next replace the object by a dot and each force is representing by arrows that points the direction of the force. Finally label each force acting on the system. Given below is the figure in which a ball is hanging by a rope. The gravitational force of Earth is acting downward and as result of this force a tension in the rope is present. The hanging ball with rope is the system. The gravitational force acting downward is the main agent. The system (ball) is represented by a dot in the pictorial model, where as the forces are represented by the arrows giving the directions of the forces.

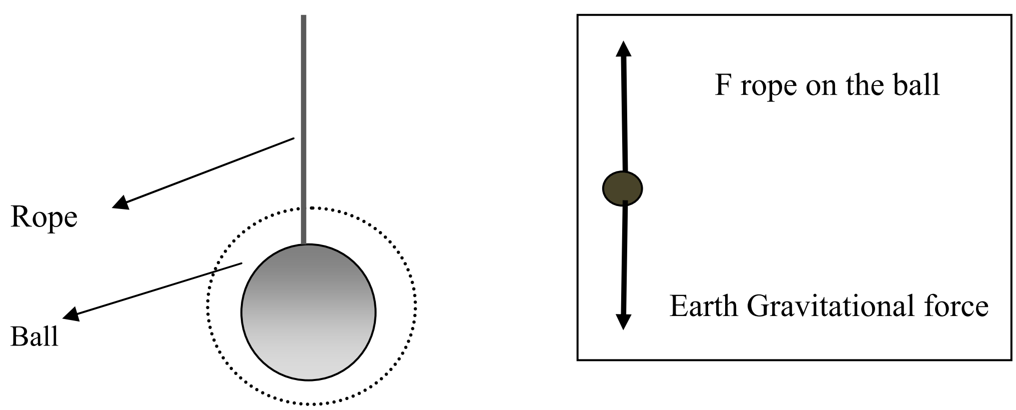

Fig 4.3 A pictorial model of ball hanging by a rope

You can push or pull hard or gently, left or right, so force has both magnitude and the direction. Force is a vector quantity. Here are some forces listed with their definitions and symbols.

Sr. No.	**Force**	**Symbol**	**Definition**	**Direction**
1.	Friction	F_f	The force of friction is the contact force that acts to go up against the sliding motion between the two surfaces.	Parallel to the surface at which the sliding occurs and opposite the direction of the sliding.
2.	Normal	F_N	The normal force is the contact force exerted by a surface on an object.	Perpendicular to and away from the surface
3.	Tension	F_T	The tension force is the pull exerted by a string, rope or cable when attached to a body and pulled out	Away from the object and parallel to the string, rope or cable at the point of attachment
4.	Weight	F_g	Weight is a non-contact force which produces the gravitational attraction between two objects, generally between the Earth and an object.	Straight down toward the center of the earth.

Table 4.1 Different forces, their symbols, definitions and directions

4.1.1 Newton's First Law of Motion:

? Is there any motion of an object when there is no force acting upon it?
Think of a ball rolling on a surface, how long will the ball continue to roll?

The motion of an object depends upon the force and also the quality of the surface. If you roll it on a thick carpet or sand, it will quickly come to rest. If you roll it on a marble floor, the ball rolls it for a long time. You could imagine that if all friction eliminated, the ball might roll forever. Galileo did all the above mentioned experiments and concluded that in ideal case, horizontal motion is eternal. He was the first to recognize the general principles of motion.

Newton generalized Galileo's results to motion in any direction. According to Newton:

An object that is at rest will remain at rest or an object that is moving will continue to move a straight line with constant speed, and if the net external force acting on that object is zero.

By external force we mean any force that results from the interaction between the object and its environment. In simpler terms, Newton's First Law states that when the net external force on an object is zero, its acceleration is zero. When

$$\Sigma F=0 \quad \text{then} \quad a=0$$

ΣF=0 means that the quantity of the applied force is equal the quantity of resistive force which is experienced by the object. Quantity is the same but the directions are opposite, in this way ΣF=0 is said to be zero.

Imagine a cricket ball and a tennis ball is placed side by side on the ground. First Law tells us that both remain at rest as long as no net external force is applied on them. Now imagine applying a force on each ball with a tennis ball, both balls resist to attempt to change their state of motion. But you know from the everyday experience that if the two balls are struck with same force, the tennis ball moves faster as compare to the cricket ball. Thus the cricket ball resists more to change their state of motion. The tendency of an object to resist change of motion is called inertia.

4.1.1.2 Balance and Unbalance Forces

We have learnt in the above section about Newton's First Law of motion. It actually predicts the behavior of objects that if the forces are balanced in the state of rest such that a man is standing on the floor. The weight is a force which is acting downward and the floor also exerting the force in the upward direction. If both the forces are balanced then the man is said to be stabled or in the equilibrium position. The force of gravity applies the force which is actually the weight of the man.

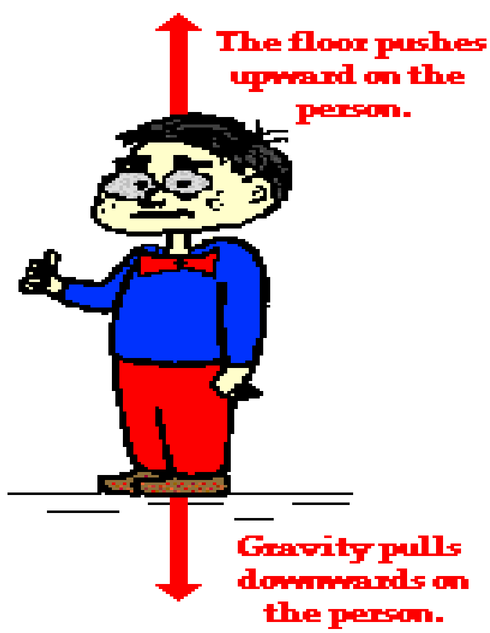

Fig 4.4 Forces shown on a person standing on the floor in a balance position

Similarly the First Law describes that the objects in constant motion will continue to move with constant velocity. The objects are in the state of balance. Newton discovered that objects will continue to do what they are doing until a net, or unbalanced force, acts on the object. A car is moving with a constant velocity on the road then the situation is said to be balanced because the car is applying a force by overcoming the friction of the road. The applying force is the power generated by the car whereas the friction of road is the reactive forces. Both forces have the same magnitude but are opposite in direction. If the car accelerates, then the condition of the balance will no more in balance but it is now in the unbalance condition. The car has applied more force and the friction it will have on less, so the applying force is more as compare to the friction of the road.

Fig 4.5 Car is accelerating, example of the un-balance force.

4.1.1.3 Inertia

The law of inertia is actually called the Newton's First Law of motion.

Inertia is the resistance of any physical object to a change in its state of motion or rest, or the tendency of an object to resist any change in its motion

If an object is at rest it will remain at rest until and unless a force is acted upon it. Whereas, if an object is moving with constant speed then it will try to move with the same speed constantly, until some force acts upon it and stops its motion.

Newton's first law of motion describes that a force is not desirable to keep an object moving because if an object is pushed by some force then it should continue to move unless some force or agent causes it to stop. As we all know that when we slide a book across a table after some time its motion stop and it comes to a rest position. The book in motion on the table comes to a rest position not because of the non-existence of a force, but due to the existence of a force. That force is the force of friction between the book and the surface of the table. It should be realized that in the absence of force of friction, the book continues to move with the same initial speed .So we can conclude that the presence of force is necessary to stop the motion of a book.

Mass is a measurement of inertia, and the SI unit of mass is Kilogram (Kg). The greater the quantity of mass in the body, the greater would be the inertia of that body. Mass is a scalar quantity. This is the nature of all objects that they refuse to accept the changes in their state of motion or the rest. All objects have this tendency, so they possess inertia. Objects having more mass have the large tendency to resist the state of rest or motion. The tendency of an object to resist changes in its state of motion varies with mass. Mass is that quantity that is solely reliant upon the inertia of an object. The more inertia an object has the more mass it possesses.

Suppose that there are two identical blocks, one is of brick and the other is of metal on the table. Apply the same force to push the two bricks or change their state of rest. The block that is made of brick, will resist less as compare to the metal brick. The reason is that the metal brick has large mass, so more inertia.
Similarly if two buckets are hanged by a stand, one is filled with sand and the other is empty, push the two buckets. The bucket which is filled with sand needs more force. Whereas the empty bucket needs only a little push.

?

1. Describe some common examples about inertia.

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2. If four books are placed on each other. The last book is pulled out, what will happen?

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Activity 1

Find Out About Inertia

<u>Material Required:</u>
One glass, one coin, a piece of paper measuring 3″ x 3″.

<u>Procedures and Observations:</u>

1. Place the 3″ x 3″ measuring piece of paper on the empty glass. Then placed the coin in the center of the paper. Do you think that the weight of paper will be more than coin weight?

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2. Apply little push on the paper by the finger in the right hand direction. The paper flew away while the coin drops in the glass, why?

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3. Repeat step 2 by applying the push in left hand direction. Describe what happens?

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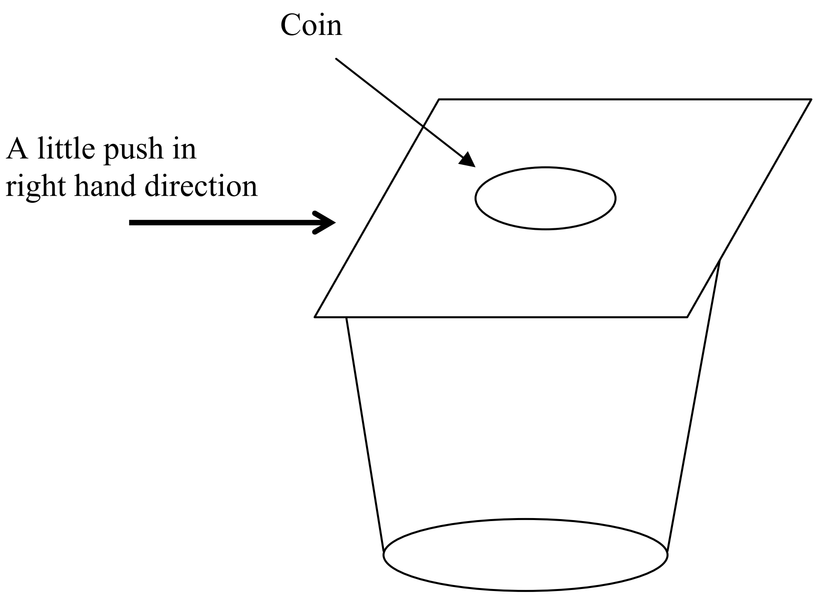

Fig 4.6 Car is accelerating, example of the un-balance force.

4.1.2 Newton's Second Law of Motion

Newton's first law describes that what happens to an object when the net force acting on it is zero, the object either remain at rest or move with constant velocity. Newton's Second Law describe what happen to an object that has a non-zero net force acting on it. Newton's Second Law explains the inter connectivity between the net force applied on an object and its acceleration. The second law discovers the root cause of a change in velocity and the resulting displacement.

By the application of force the objects moves, the rate of change of displacement is called velocity and rate of change of velocity is called acceleration.

$v = ds / dt$

Where v = velocity

ds = change of displacement (how much distance it cover) ,

dt = change in time

$a = dv/ dt$

a = acceleration,

dv = change of velocity

dt is change in time

Imagine pushing a block of ice across a frictionless horizontal surface. When you exert some force on the block, it moves in the direction of force, if you apply double force then it moves faster or we can say that by applying more force the acceleration of the body increases. So we can conclude that

Acceleration of the body is directly proportional to the applied force.

We have common experience while pushing objects, the mass of a body also affects the acceleration. Imagine that two blocks of metals are placed, one is of 10 kg and the other is of 5 kg. The force required to move the 10 kg metal block will be more as compare to 5 kg of metal block. So we can conclude form the above results that the

Acceleration of the objects in inversely proportional to the mass of the object.

These observations are summarized in the second law of motion:

The acceleration of an object is directly proportional to applied net force and inversely proportional to its mass".

In the equation form we can say that

$a \propto \Sigma F$ (acceleration is directly proportional to applied net force)

$a \propto 1/m$ (acceleration is inversely proportional to mass of object)

$$\Sigma F = ma$$

4.1.2.1 Mass and Weight

As we all know that in our daily life the mass of an object and the weight of an object are said to be the same quantity. But in reality they are not same but these are two different concepts and quantities. In general science, mass of a body refers to the quantity of "matter" an object has. Weight of a body refers to the force subjected by the Earth gravitational force on the body. So a mass of 10 kilograms will weigh 98 Newton.

We have learned in the above section that the mass is the measure of inertia, the resistance offered by the object to change of its state of rest or motion. Mass is a measure of the amount of substance in a body. The SI unit of mass is Kilogram (kg). Mass cannot be changed by the location, shape and speed of the body. Every object possesses mass, an electron has 10^{-03} kg mass, where a single pea has 10^{-3} kg and earth mass is 10^{24} kg. Mass is a scalar quantity. If a mass of 3 kg produces 4 m $/s^2$ acceleration then the same force will applied on a 6kg mass will produce 2 m $/s^2$ acceleration. The greater the mass the less acceleration it has and lower the mass greater will be the acceleration.

Fig 4.6 Electronic Balance

Mass is measured by using a balance, in which a known amount of matter is compared with an unknown amount of matter with the help of spring balance, or electronic balance.

Newton observed the fall of an apple from a tree. He began to think about the following lines: when the apple from the tree moved downward, it motion accelerated. The speed was zero as it was hanging on the tree and has the velocity when it moved toward the ground. Thus, by Newton's Second Law, he concluded that there was some force present which actually acted upon the apple in order to accelerate the apple. He called this force as the force of gravity, and the related acceleration to the acceleration due to gravity.

We all are aware that objects are attracted towards the Earth. The force exerted by the earth on an object is the gravitational force **Fg**. This force is directed approximately towards the centre of the Earth and its magnitude varies the distance from the center of earth. The magnitude of the gravitational force is called the weight of the object. While the weight of a mass is a function of the power of gravity, the mass of an object remains constant.

$$W = mg$$

W = weight of the object

M = mass of the object

g = acceleration due to the gravity.

The SI unit of weight is Newton (N), it is actually the force exerted by the Earth on an object. Bodies have less weight at high altitudes as compare to the sea level. This is the same case that astronauts feel weightlessness at the moon. Hence the weight is not the inherent property of an object. If an object has a mass of 70 kg then at the sea level, its weight will be

$$W = 70 \times 9.8 = 686 \text{ N}$$

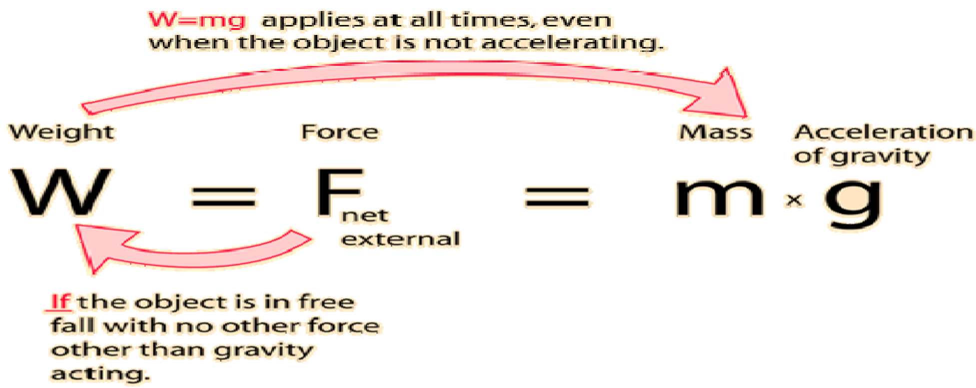

Fig 4.7 Weight is the net external force on an object due to gravity

Weight	**Mass**
pull of gravity on the body	amount of matter in the body
has both magnitude and direction	has only magnitude but no direction
measured in Newton	measured in kilograms
mass is measured by using a balance	weight is measured on a scale
comparing a known amount of matter to an unknown amount of matter	

Table 4.1 Comparison of mass and weight

?

1. What is the relation between mass and weight?

____

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2. Describe the role of "g" the acceleration due to gravity in the equation w= mg .

____

____

Activity 2

Does the air have weight?

Material Required:
Two balloons, 1/2 meter fine thread, a wooden stick, a needle.

Procedures and Observations:

1. Fill the two balloons with air until they are equal in size. Cut the thread in equal three pieces. Then attach the piece of fine thread to the each balloon. Now attach the two pieces of thread with the two balloons in such a way that the length of the thread will be the same. Then place the threaded balloons to the corner of the stick. Keep the balloons on the same distance from the end of the stick. Tie the third string to the middle of the stick and hang it from the edge of a table. Find the balance point where the stick is parallel to the floor. What is the situation of equilibrium?

   ____

   ____

2. Puncture the one balloon, what will happen?

   ____

   ____

3. Describe that the unbalance situation of the stick and give reason that the air possesses weight.

   ____

   ____

4.1.3 Newton's Third Law of Motion

Let's consider the task of driving a nail into a block of wood, to accelerate the nail and drive it into the block a net force is supplied to the nail by the hammer. However, Newton recognized that a single isolated force (such as the force on the nail by the hammer) cannot exist. Instead, a force in nature always exists in pairs. According to the Newton, the hammer exerts a force on the nail and the nail also exerts force on the hammer. There is clearly a net force on the hammer, because it rapidly slows down after coming into contact with the nail.

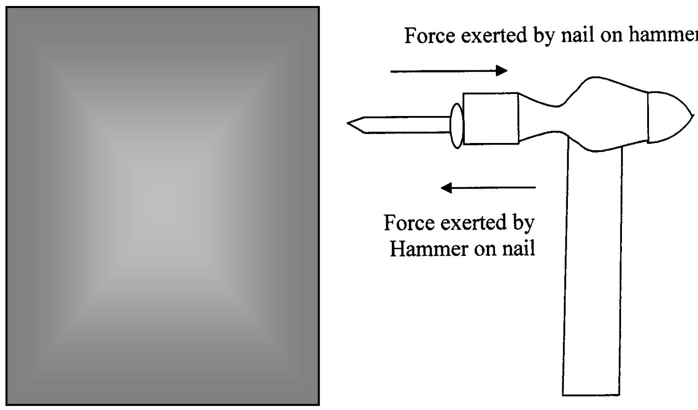
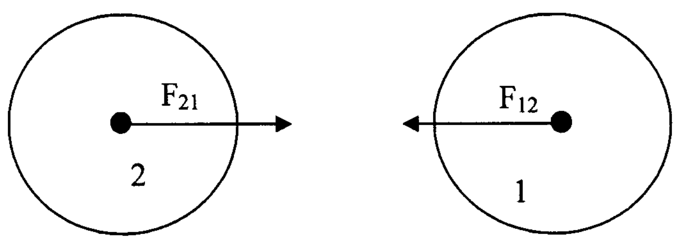


Fig 4.8 Driving a nail into a wooden block

Newton described this type of situation in terms of the third law of the motion

If two objects interact, the force exerted on the first object by the second object is equal in magnitude but opposite in direction to the force exerted on second object by the first object.

This law states that forces always exist in pairs or that a single isolated force cannot exist. The force that first body exerts on the second body is sometimes called **action force** and the force of the second body exerts on the first body is called **reaction force**. In all case the action force and the reaction force acts on different objects and must be the same type.



$$F_{12} = -F_{21}$$

Fig 4.9 the force exerted by the object 1 on object 2 is equal to and opposite the force exerted by object 2 on object 1

Let's have a look when a ball is dropped from some height, the earth is applying a force of gravity on that ball Fg and the magnitude of the ball is mg. the reaction of this force of the ball on the earth if Fg′.

$$\text{So} \quad F_g = -F_g'$$

The reaction force F_g accelerates the ball towards earth and F_g' accelerates the earth towards ball but the earth has a huge mass as compare to the ball so its acceleration due to the reaction is negligible.

As we all know that the Earth exerts a force F_g on any object. If a mass of 1 kg is placed on floor at rest, the F_g is the force the Earth is exerting on 1 kg mass and F_R is the force that 1 kg mass exerts on the earth. The mass is not accelerating or moving but it is held up by the floor. The floor exerts the reactive force in an upward direction F_R which is the normal force; it balances the mass on the floor and provides equilibrium and the reaction to the F_R is the force of the mass on the floor. Therefore we can conclude that

$$F_g = - F_R$$

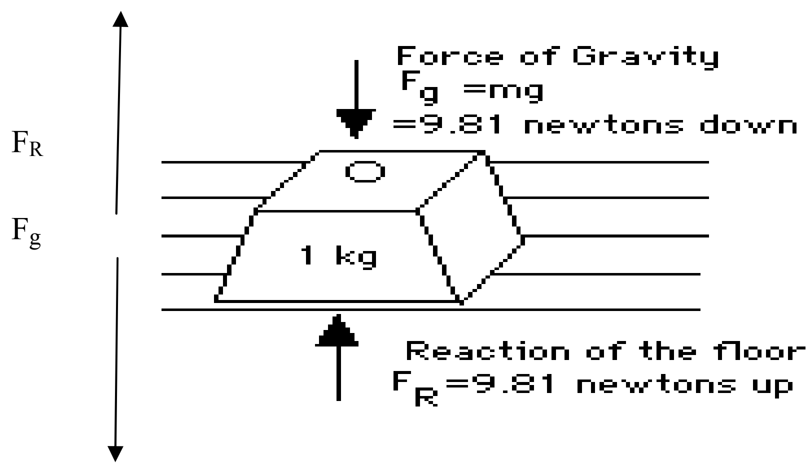


Fig 4.10 The force exerted by the mass on floor is equal to and opposite the force exerted by the floor on mass

4.1.3.1 Force of Friction

When a body is in motion either on a surface or through a fluid (air or water), there is a resistance to the motion because the body interacts with the surroundings. We can call such resistance the force of friction. Force of friction is very important in our daily lives. They allow us to walk, run and necessary for the motion of the wheeled vehicles.

Consider a block on a horizontal table. If we apply an external horizontal force F on the block, acting to the right, the block remains stationary provided the force is small. The applied force F keeps the block moving and the force which is acting in the left direction is called the force of static friction F_s. As long as the block is not moving we can say that $F_s = F$.

As F increases the F_s is also increasing, the body moves when the value of the F becomes greater than the F_s. The frictional force arises from the nature of the two surfaces because of their roughness; contact is made only at few points as shown in the magnified view given below. The frictional force is a complicated phenomenon because it involves the study of the surface of bodies at the microscopic level.

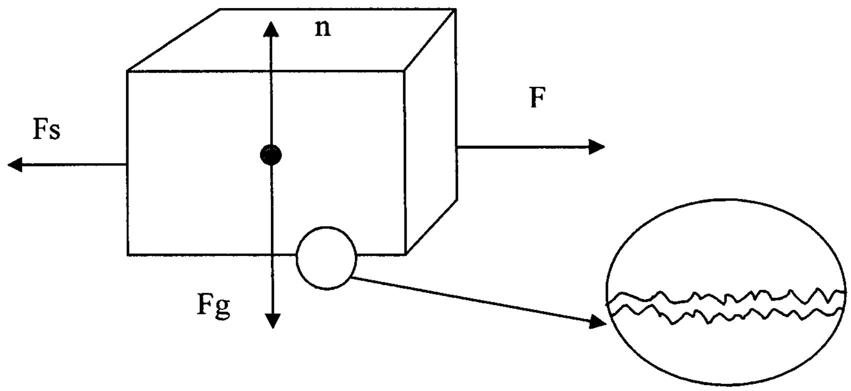


Fig 4.1 The direction of the force of friction Fs between a block and a horizontal surface is opposite the direction of the applied force

If we increase the magnitude of F, the block eventually slips, when the block is on the verge of slipping the F_s will be maximum. When F exceeds $F_{s\,max}$, the block will move to the right and accelerates .When the block is in motion, the frictional force become less than $F_{s\,max}$. We call the friction force for an object in motion the force of kinetic friction F_k. The unbalanced force in the x-direction F- F_k will produce the acceleration. If the applied force is removed then the frictional force acting to the left accelerates the block in the –x direction and eventually brings it to rest.

Some observations related to the force of friction are given below:

- The magnitude of the force of static friction between any two surfaces in contact have the values

$$F_s \leq \mu_s n$$

Where μ_s is the co-efficient of static friction
Where n is the magnitude of the normal force.

The above equation has the two states, first condition is that F_s is equal to the $\mu_s n$ when the block is at the verge of slipping and the second condition of inequality or less than means that the value of F_s is less than the value of $\mu_s n$

- The magnitude of the force of kinetic friction acting on an object is given by

$$F_k \leq \mu_k n$$

μ_k is the co-efficient of kinetic friction

- The values of μ_k is less than the values of μ_s

?

1. Does the force of friction exist when the airplane moves in the sky?

____

____

2. Describe the force of friction when a car is moving back.

____

____

Activity 3

Force of Friction

Material Required:

Two 1-meter long strings, two small carts (if not available then use any two similar baskets or cans), four 0.2 kg masses.

Procedures and Observations

1. Tie the two 1 meter strings to the back of the carts and attach 0.2 kg masses at the other end of the strings. Hang the masses over the end of a table in such a position that the masses are just above the floor. Place the two masses in the carts separately. Give the carts a little push, what will happen?

   ____

   ____

2. If no masses are present in the carts, what will be the movement?

   ____

   ____

3. If the masses in the carts will be double, will the speed of the motion reduce?

   ____

   ____

Key Points

1. A push force moves something away from you and the pull force moves something closer to you.
2. Forces can be categorized into two types, one is the contact force and the other is the non-contact force.
3. The world around the object that exerts the force on object is called the environment.
4. Each and every force has a particular, identifiable cause which is called agent.
5. According to the first law of motion "An object with no motion will keep the position of rest or an object moving with some velocity will continue to move along a straight line with constant speed, if the net external force acting on that object is zero".
6. Newton discovered that objects will continue to do what they are doing until a net, or unbalanced force, acts on the object.
7. Inertia is the tendency of an object to resist change of its rest position or the moving position. If an object is at rest it will remain at rest, if it is moving at constant velocity it tends to move at the same speed continuously.
8. The second law of motion "the acceleration of an object is directly proportional to applied net force and inversely proportional to its mass".
9. **$\Sigma F = ma$**
10. The force exerted by the earth on an object is the gravitational force Fg . The magnitude of the gravitational force is called the weight of the object.
11. The SI unit of weight is Newton (N), which is actually the force exerted by the Earth on an object.
12. Weight has both magnitude and direction and the mass has only magnitude but no direction.
13. The third law of the motion" If two objects interacts; the force exerted on the first object by the second object is equal in magnitude but opposite in direction to the force exerted on second object by the first object".
14. The force that first body exerts on the second body is sometimes called action force and the force of the second body exerts on the first body is called reaction force.
15. Force of friction is very important in our daily lives. They allow us to walk, run and necessary for the motion of the wheeled vehicles.
16. The magnitude of the force of static friction between any two surfaces in contact have the values $F_s \leq \mu_s n$
17. The magnitude of the force of kinetic friction acting on an object is given by $F_k \leq \mu_k n$.

16\. The values of μ_k is less than the values of μ_s

Self Assessment Exercise 4.1

Q.1 Fill in the blanks:

i. ----------------------- is commonly defined as a push or a pull
ii. A ------------- force moves something away from you
iii. A ------------- force moves something closer
iv. Forces can be categorized into ------------- types, one is the contact force and the other is the non-contact force.
v. Force has both ----------------- and the ------------------.

Q.2 Answer the following questions:

i. A book pushed across the desk by your hand, what are the forces acting on it?
ii. A book pulled across the table by a string, what are the forces present?

4.2 Pressure

Imagine that you are standing on the surface of road, your feet exerts force on the earth. The area under your shoe bears the force of your body. The ratio of the applied force to the area is called pressure. When you talk about a high heel, the high heel exerts more pressure on earth than the shoe, because the area is small but the force is same. For example a man is sitting on a ground; the weight is the force which is acting on the surface of Earth. The force (weight of man) acted upon the area he covers while sitting cause the pressure of the man on the Earth. But a man is standing applies the same force (weight) with different area in contact with the surface and therefore exert a different pressure.

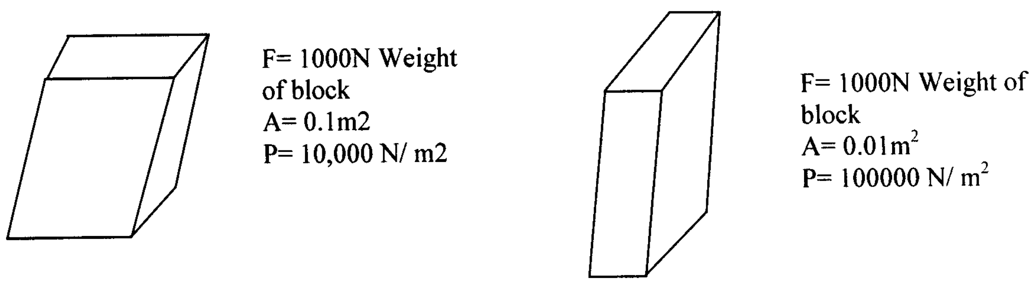


Fig 4.13 Different Area in contact will give different value of the pressure

Pressure is defined as force per unit area.

It is usually more suitable to use pressure rather than force to describe the fluid behavior. The standard unit for pressure is the Pascal, which is a Newton per square meter.

$$P = F / A$$

Where: P is the pressure,
F is the normal force,
A is the area of the surface area on contact

There are many common physical examples where pressure is the most important variable. If you peel some apple, you actually apply pressure on the apple with the help of a knife. As the knife edge is sharp you have to apply less force, because the area of contact of the apple and the knife is small.

If you visit a doctor and he advises you to get an injection. The sharp needle can pass the right pressure as compare to a dull one. The smaller area of contact involves less force for the needle to push through the skin.

As we all know that the fluids exert pressure. The individual molecules of the fluid, however, are in constant random motion. In the fluids, there are extremely huge amount of molecules and because the movement of the particular molecules is random in every direction so we do not specify the motion.

If we fill a container with some fluid (either gas or liquid), we can detect a pressure in the fluid from the molecules, which have a collision with the walls of container. We can put the gas in the container , and the force per unit area (the pressure) is the same. Similarly, pressure acts in all directions at a point inside a fluid. At the surface of a fluid, direction of the pressure acts at right angle to the surface. Pressure is the effect of a force applied to a surface. Pressure is a scalar quantity. The transmission of pressure from the fluid to the solid boundaries is always perpendicular to that surface at every point.

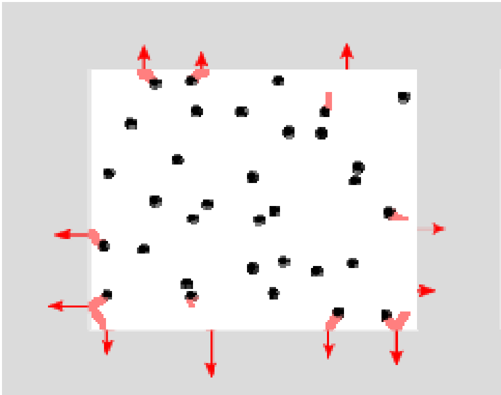


Fig 4.14 Pressure as exerted by particle collisions inside a closed container

Absolute Pressure

The absolute pressure is measured relative to the absolute zero pressure. Absolute pressure is pressure that would occur at absolute vacuum, or zero pounds per square inch (PSI). All calculations concerning the gas laws have need of pressure, and temperature in absolute units. Absolute pressure is actually referred as 'total systems pressure'. To differentiate it from gauge pressure, the term 'abs' is usually placed after the unit. The absolute pressure, Pabs is measured relative to the absolute zero pressure .It is the pressure that would occur at absolute vacuum. All calculation involving the gas laws requires pressure (and temperature) to be in absolute units.

$$P_{abs} = P_g + P_{atm}$$

Gauge Pressure

A gauge pressure is often in use to measure the difference between a system pressure and its environment (surrounding) pressure. The gauge pressure actually has shown on the dial of a gauge gives record of the pressure relative to atmospheric pressure. For example if a pressure gauge gives the reading of zero value, it does not mean that there is no pressure acted upon the fluid , actually it means that there is no pressure in addition of to the atmospheric pressure. This pressure is often called the gauge pressure and can be expressed a

$$Pg = Pabs - Patm$$

Where
Pg = gauge pressure
Ps = Absolute pressure
Patm = atmospheric pressure

Atmospheric pressure

Atmospheric pressure can be defined as the force exerted by the weight of air just above that surface per unit area applied against that surface. Think in terms of air molecules, if the quantity of the air molecules above a surface increase, so there are more number of molecules to exert a force on that surface and in this way the pressure automatically increases. The case will be opposite; when there is a reduction in the quantity of air molecules above that surface will give low pressure in result.

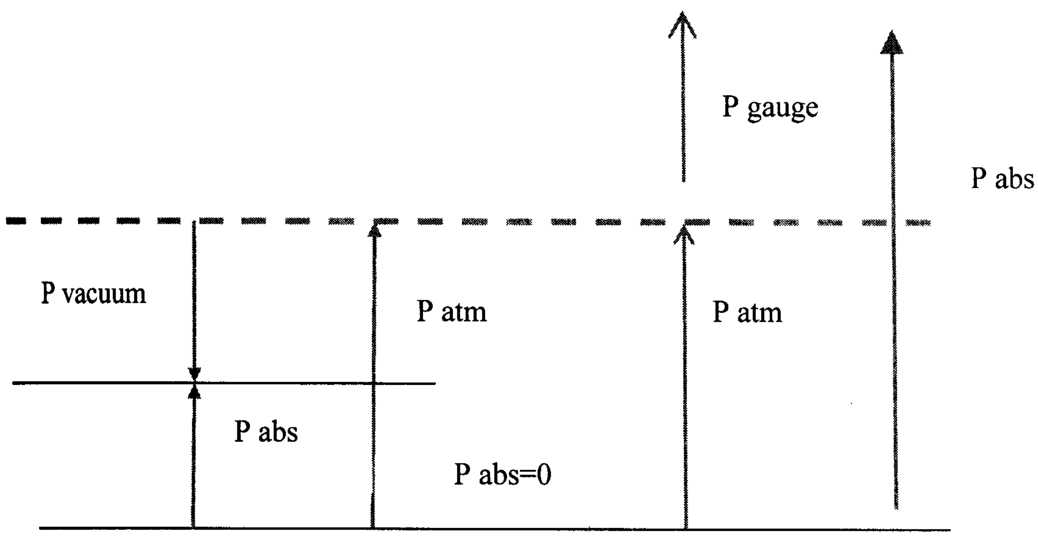


Fig 4.15 The relationship among the absolute, atmospheric and gauge pressure

Atmospheric pressure is measured with an instrument called a "barometer", that is why atmospheric pressure is also called as barometric pressure.

Units for Pressure

- The SI unit for pressure is Pascal (Pa), equal to one Newton per square meter (N/m^2 or $kg{\cdot}m^{-1}{\cdot}s^{-2}$).
- The British system measures pressure in pounds per square inch .
- The CGS unit of pressure is the barye (ba), equal to 1 $dyn{\cdot}cm^{-2}$ or 0.1 Pa. Pressure is sometimes expressed in grams-force/cm^2, or as kg/cm^2.

- The standard atmosphere is approximately equal to typical air pressure at earth mean sea level and is defined as follows:
  Standard atmosphere = 101,325 Pa = 101.325 kPa

Example Problem 01

A woman has 550 N weight and she wears the high heel shoes that come into contact with the ground over an area of 425 cm^2.

a) What will be the value of the average pressure exerted by the shoes in kPa over the floor?
b) How much pressure will be exerted by the woman if she stands up on her one foot?
c) What will be the value of the pressure if she puts all her weight on the heel of one of his shoe with the area of the high heel of 0.5 cm^2?

Known:

F = 550 N

A_{shoes} = 425 cm^2

A_{shoe1} = 212.5 cm^2

$A_{of\ high\ heel}$ = 0.5 cm^2

Unknown;

P_{shoes} =?

P_{shoe1} =?

$P_{of\ high\ heel}$ =?

Formula:

P = F/A

Calculation:

1. A_{shoes} = 425 cm^2 = 412 / $(100)^2$ = 0.0425 m^2
   So P_{shoes} = 550 / 0.0425 = 12914 N/m^2 = 12 kilo Pascal

1. A_{shoe1} = 212.5 cm^2 = 212.5 / $(100)^2$ = 0.0212 m^2
   So P_{shoe1} = 550 / 0.02212 = 24864 N/m^2 = 24.86 Kilo pascal

2. $A_{of\ high\ heel}$ = 0.5 cm^2 = 0.5 / $(100)^2$ = 0.00050 m^2
   So $P_{of\ high\ heel}$ = 550 / 0.00050 = 1100000 N/m^2 = 110 kilo pascal

Key Points

1. Pressure is defined as force per unit area. . The standard unit for pressure is the Pascal, which is a Newton per square meter.

   $$P = F / A.$$

2. Pressure is a scalar quantity.
3. Absolute pressure is pressure that would occur at absolute vacuum, or zero pounds per square inch (PSI). Absolute pressure is also referred to as 'total systems pressure'. $P_{abs} = P_g + P_{atm}$
4. The pressure actually shown on the dial of a gauge that registers pressure relative to atmospheric pressure
5. Atmospheric pressure is defined as the force per unit area exerted against a surface by the weight of the air above that surface.

Self Assessment Exercise 4.2

Q.1 Fill in the blanks:

i. The ratio of the_____________________ to the____________ is called pressure.

ii. The standard unit for pressure is the _______________, which is a Newton per square meter.

iii. Pressure is a______________ quantity.

iv. Atmospheric pressure can be defined as the force exerted by the weight of air just _______________that surface per unit area applied against that surface.

v. Atmospheric pressure is measured with an instrument called a ______________

4.3 Gravitational Force

As we all know that the fall of an apple made Newton to think on the subject of the motion of the planets. He recognized that the apple falls on the surface of Earth only because of the Earth attraction towards the apple. He was in doubt whether this force of attraction could extend beyond the tree to cloud, to moon and even beyond the moon.

He thought that the force on the apple must be directly proportional to its mass . In addition, according to his own third law of motion, the apple would also attract towards Earth. Similarly, the force of attraction is also proportional to the mass of earth and the mass of the object. Another factor involved is the distance between the apple and the Earth. He concluded that this force of attraction is inverse of the distance between them. This attractive force between objects and the Earth is called the **Gravitational force**.

Newton was so confident about his governing laws of motion on Earth, that he suggested that this force would work anywhere in the universe. He assumed that the same force of attraction would act between two masses m_A and m_B.

The law of Gravitation states

The gravitation between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them.

He proposed his law of gravitation, which is represented by the following equation:

$$F \propto m_A m_B$$

$$F \propto 1/d^2$$

Law of Universal Gravitation

$$F = \frac{G m_A m_B}{d^2}$$

In the above equation, d = distance between the centers of the two objects

G= Universal Constant

m_A, m_B = Masses of two objects

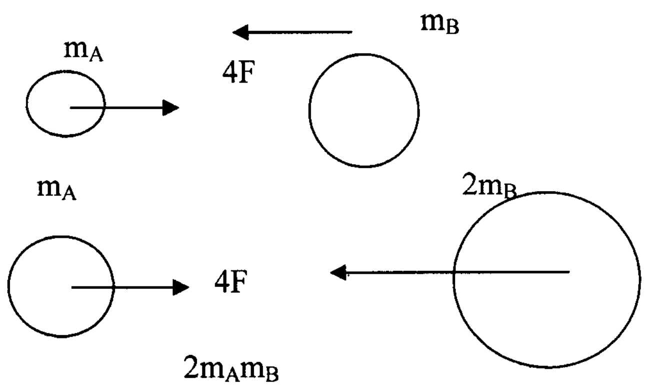


Fig 4.16 Different objects exerts the force according to their masses

How large is the constant G? As you know that the force of gravitational attraction between two objects on earth is small. You can't feel the slightest attraction even between two huge objects. It took about 100 years after the Newton's law of motion.

4.3.1 Henry Cavendish Experiment

In 1797 AD, a scientist from Britsih, Henry Cavendish had first performed experiment to measure the gravitnational force between two masses in the laboratory. He was the first to give accurate values results about the gravitational constant. He used the equipment given below in the figure 4.17. The apparatus consisted of a torsion balance made of a six-foot (1.8 m) wooden rod suspended from a wire, with a 2-inch (51 mm) diameter 1.61-pound (0.73 kg) lead sphere attached to each end. Two 12-inch (300 mm) 348-pound (158 kg) lead balls were located near the smaller balls, about 9 inches (230 mm) away, and held in place with a separate suspension system. The experiment measured the giant gravitational attraction between the small balls and the larger ones. The two large balls were positioned on alternate sides of the horizontal wooden arm of the balance. Their mutual attraction to the small balls caused the arm to rotate, twisting the wire supporting the arm.

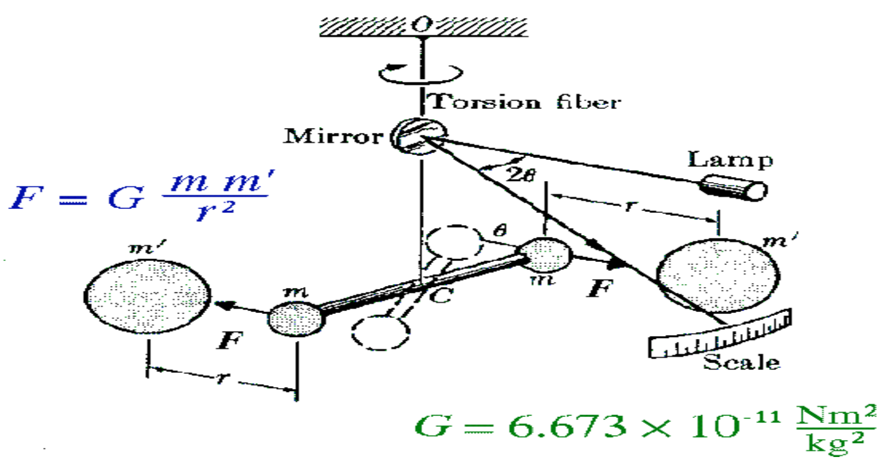


Figure 4.17 Apparatus of the Henry Cavendish Experiment

The arm was stopped rotating when it arrived at an angle where the rotating force of the wire balanced the combined gravitational force of attraction between the large and small lead spheres. By measuring , the angle of the rod, and with the known value of twisting force (torque) of the wire, Cavendish determined the force of attraction between the pairs of masses. Since the gravitational force of the Earth on the small ball could be measured directly by weighing it, the ratio of the two forces allowed the density of the earth to be calculated, using Newton's law of gravitation.

4.3.2 Weight & Weightlessness

The accelaration of objects due to earth's gravitation can be found by using Newton's law of universl gravitation and second law for a free falling object. Lets the force between the Earth nad an object paced on Earth is given by

$$F = \frac{G\, m_E\, m}{d^2} \quad ....1$$

We know F = ma ………………….2

Combining equation 1 and equation 2

$$a = \frac{G\, m_E}{d^2}$$

On the earth surface the distance between will be d= Re , so the above equation will become

$$g = \frac{G\, m_E}{Re^2}$$

As the distance is increasing then the value of the g will be reducing according to the inverse square relationship. You have seen the photos of the Astronauts that feel the condition of weightlessness of space shuttle. This situation is called "zero-g". The shuttle distance from the surface of Earth is only 400 km. At that distance the value of "g" is 8.6 m/s^2, thus the gravitational force is certainly not zero in the shuttle.

The Astronauts have the weight because the gravitational force is exerted on them, but they don't have apparent force. Remember that you sense weight when something such as floor or your chair exerts force on you. But if you, your chair and the floor are accelerating towards Earth together, then no contact forces exerted on you. Your apparent weight is zero and you are experiencing the condition of weightlessness.

Example Problem 2

There are two 5.0 kg masses, which are 2.5 meter apart from their centers. Determine the force of attraction between them?

Known

M1 = 5.0 kg

M2 = 5.0 kg

d= 2.5 meter

G= 6.67×10^{-11} N m^2 / kg^2

Unknown **Force of attraction** =?

Formula: $F = \frac{G\, m_A\, m_B}{d^2}$

Calculation:

$$F = \frac{6.67 \times 10^{-11}\ N\ m^2 / kg^2 \times 5.0\ kg \times 5.0\ kg}{(2.5)^2\ m^2}$$

F= 26.68×10^{-11} N

Two 1.0 kg masses have their centers 1.0 meter apart. What is the force of attraction between them?

Key Points

1. The law of Gravitation states "the gravitation between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them".

$$F = \frac{G\, m_A\, m_B}{d^2}$$

2. If the mass of one object is double than the force would be double.
3. Similarly if the distance between them is reduced to half, the force will be of the four times the actual force between them.
4. Henry Cavendish, a British scientist did the first experiment to measure the force of gravity between two masses in the laboratory and give the specific value of the gravitational constant.
5. Forces can be categorized into two types, one is the contact force and the other is the non-contact force.
6. The Astronauts that feel the condition of weightlessness of space shuttle. This situation is called "zero-g".

Self Assessment Exercise 4.3

Q.1 Answer the following questions:

i. If the Earth weight was as twice as massive but remained the same size, what will be the value of "g" will be?

ii. The moon and the Earth are attracted to each other by the Gravitational force. The massive Earth attracts the moon with a greater force than the moon attracts the earth, why?

4.4 Simple Machines

We do not know exactly, when and what kind of machine was first made and used by human beings. From the study of the Stone Age period, we know that they used wood, bone, stone to make tools such as axes, hammers, knives, and pins and needles. After the invention of pulley and lever, the creation of the wheel revolutionized the transportation without which our modern machinery would be impossible.

Everyone uses a number of machines every day, some are simply the tools, such as bottle opener and screwdrivers and some are complex machines such as automobile, bicycles etc. Machines, whether power-driven by engines or by the people, they make task easier. A **machine** reduces load by modifying either the quantity or the direction of the force as it transmits energy to the task. So we can say that the machines serve any of the three following purpose:-

i) They increased speed; examples are egg beater, drive wheel of a bicycle.
ii) They increase force; example car jack, screwdriver etc.
iii) They change the direction of the force; example pulley.

As you have noticed that machines you use in every day, perform the three kinds of tasks mentioned above. These machines do not produce energy but made use of the energy supplied to them.

Consider the case of bottle opener, when you use the bottle opener, you actually lift the handle, in this manner you do work on the bottle opener. The opener raises the cap by doing work on it. The work you do is called the input work Wi and the work that machines does is called the output work Wo. As you know that work is done when some force applied and as a result some displacement occurs. Another definition of the work is that the transfer of energy by the mechanical resources. You put the work on the machine and as a result it does the work. In the current example, the machine used is the bottle opener.

You give energy to the opener. In response to the energy applied by your hand, the opener does work on the bottle cap and transfer energy to cap. The source of energy is not the opener but the source is your hand. The cap is not receiving much energy that you put into an opener, but the outcome is the greater force. The machine simply helps to transfer energy from your hand to the bottle cap. In general, simple machines provide mechanical advantage.

Listed below are the four classical simple machines:

- ◊ Lever
- ◊ Pulley
- ◊ Screw
- ◊ Gear

These simple machines fall into two classes:

(i) The inclined plane, wedge, screw characterized by the vector resolution of forces and movement along a line.

(ii) The lever, pulley, wheel and axle characterized by the equilibrium of torques and movement around a pivot.

A simple machine is an elementary device that has a specific movement (often called a mechanism), which can be combined with other devices and movements to form a machine.

4.4.1 Lever

Try to displace a heavy stone with hand, can you do this easily? To do this you only need block of wood and a strong rod or a wooden plank. The wooden block is placed under the plank. The stone is placed on one end of the lever and on other side you applied the force in the downward direction. The stone will be lifted in the upward direction.

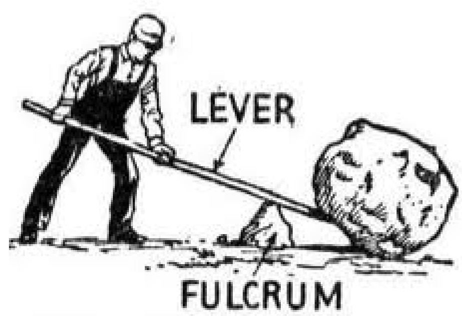


Fig 4.18 a man lifting a stone by lever

The supporting block provides the pivot point called the fulcrum of lever. The distance on the plank from the fulcrum to the end of the plank is called the force arm. Two force arms are present on the lever. One arm is towards the man who is lifting the weight and the other arm is towards the weight. The greater the force arm, the man will require less push and more load/weight will be loaded.

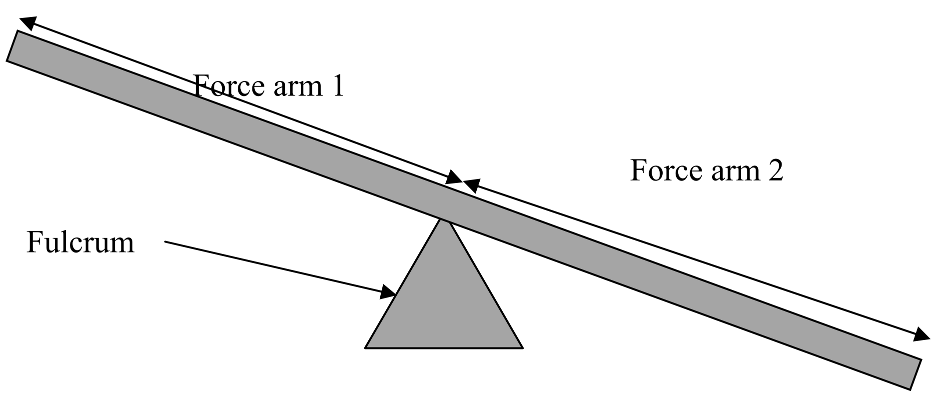


Fig 4.19 a lever parts: force arms and fulcrum

Another example of lever is the hammer. When hammer is used to pull a nail, its long handle makes it possible for the user to exert a strong pull. The hammer is a bent lever. The nail offers the resistance and the point of contact of hammer with wood is the fulcrum. The pull of the hand holding the hammer serves as the force.

Principle of lever

In all types of lever, the moment of effort is always equivalent to the moment of load provided it is in equilibrium state. Hence,

Effort x Effort arm = Load x load arm

Mechanical Advantage of Lever

A typical lever is shown in the fig. The "X" is the effort arm whereas "Y" is the load arm.

According to principle of lever

Effort x Effort arm = Load x load arm

E x X = L x Y

L / E = X / Y

As

Mechanical Advantage = load / Effort

M.A = L / E

Mechanical Advantage of lever = X / Y

Mechanical Advantage of lever = Effort Arm / Load Arm

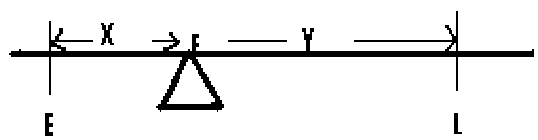


Fig. 4.20

4.4.2 Pulley

Pulley is a wheel with groove through which a string is passed. The pulley can rotate freely about its axis. What advantage we get from it? Let us perform an experiment, take a bucket full of water and lift it up. Can you lift easily? Now suspend a pulley by a string as shown in fig. 4.20. Pass long string over it. Tie bucket with one end of the string and pull the other end of the string downward. Is the load being lifted up easily? Pulley is also used to draw water from a well. Thus we see that the pulley helps to apply the effort more easily in the suitable direction. By pulling the string downward the load can easily be lifted up to sufficient height.

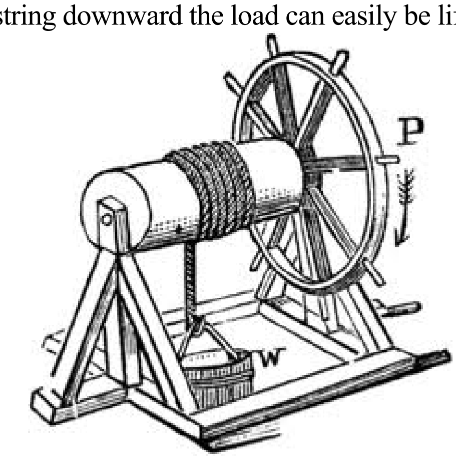


Fig. 4.21 a fixed or stationary pulley.

The fixed pulley does not increase the force but makes it more conveient to apply. The combination of pulleys, in which one or more pulleys actually moves called a compound pulley. They are used in moving heavy objects. The more pulleys are present, the less force is required to pull the weight.

Pulleys can be used in two ways:
i. Single Fixed Pulley
ii. Single Movable Pulley

i. Single Fixed Pulley

In order to lift up the load of construction material single fixed pulleys are used.
In a single fixed pulley,the block of pulley is attached with some strong support.

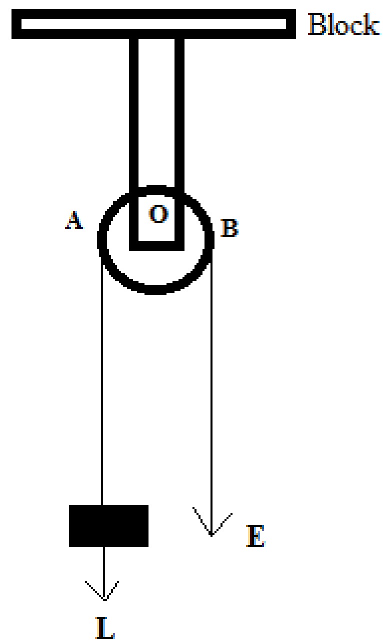


Fig. 4.22 Single Fixed Pulley

Mechanical Advantage Of Single Fixed Pulley

We know that
Effort moment arm = load moment arm
From figure L x OA = E x OA
As OA = OB
Therfore L = E

Mechanical Advantage = M.A = L / E = 1
In reality,due to friction ,the mechanical advantage of single fixed pulley is less than "1". Although in single fixed pulley,an effort is applied equivalent to load. Our work becomes easy as we have to apply effort downwards in order to lift up the weight.

ii. Single Movable Pulley

In a single movable pulley, one end of string is fixed with some strong support.the effort is applied to some other end. The load is attached to the block of pulley.

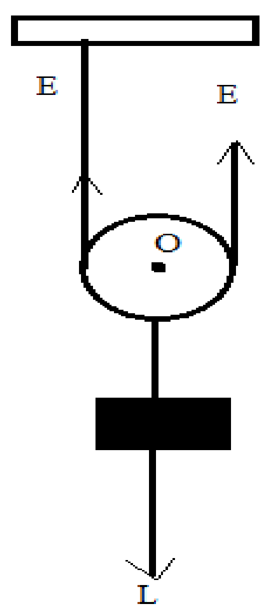


Fig. 4.23 Single Movable Pulley

Mechanical Advantage Of Single Movable Pulley

At every part of the string,effort "E" is the same. As both of the parts of the string lift up the load in upward direction. Therfore the effort acting on the load "L" is "2E". Neglecting weight and friction, then

Load = 2 x Effort

L = 2 x E

Mechanical Advantage = L / E = 2
Thus, the mechanical advantage of single movable pulley is 2. As compare to effort, the two times weight can be lifted up.By applying another single fixed pulley,the direction of effort can be changed. In this way work can be made more simple.

4.4.3 Screw Jack

Screw is a machine that changes rotational motion into linear motion. The most familiar type consists of a cylindrical shaft with helical grooves or ridges called threads around the outside. The screw passes through a hole in another object or medium, with threads on the inside of the hole that mesh with the screw's threads. When the shaft of the screw is rotated relative to the stationary threads, the screw moves along its axis relative to the medium surrounding it; for example rotating a wood screw forces it into wood.

In order to replace the punctured tyre, there is need to lift up vehicle body. And to do this, the machine which is used is called screw jack. The weight to be lifted rests on the screw head. As the screw is turned, it twists out of the base and elevates the load resting on it.

A screw jack is a kind of simple machine. It consists of two main parts:

a. Bolt which is a strong cylinder made up of metal. The outer surface of bolt contains thread.
b. Nut is the second part .the inner surface of the nut contains threads similar to the outer surface of the bolt.

Pich is the vertical distance covered by completing one cycle.

Mechanical Advantage of a Screw Jack

Assume the length of handle is “l”. On one end, effort E is applied. The handle covers a distance $2\pi l$ in one cycle. Hence,
Input = Effort x distance moved by the effort
Input= $E \times 2\pi l$
Aassume the bo;t lifts the load “L” upwardd covers a vertical distance “h” in one cycle. Now the,
Output = load x distance moved by the load
Output = $L \times h$
We are ignoring friction, then
Output = input
$L \times h = E \times 2\pi l$
$L/E = 2\pi l / h$
Mechanical Advantage = load/ Effort = L/E
$M.A = 2\pi l / h$

The mecahnical advantage of the screw jack is always greater than 1 because the lentgh of the handle l is always larger than the pitch of the bolt h.

A screw is essentially a coiled plane. In fact, the screw is the combination of the two simple machines, a wheel and the axle and an inclined plane.

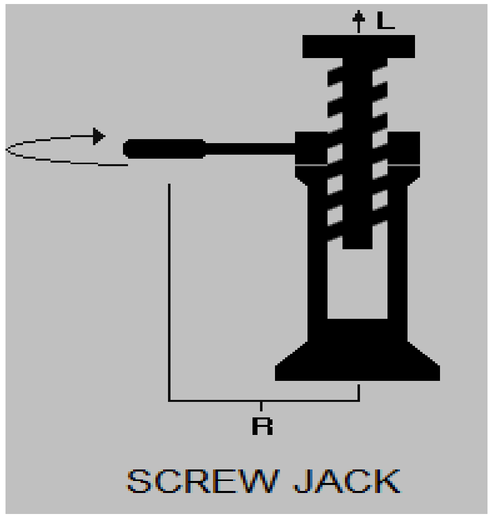


Fig. 4.24 A screw jack.

4.4.4 Gears

Power can also be transmitted from one wheel to another by equipping the wheels with

Fig. 4.25 A Gear

Intermeshing teeth's. Such wheels are called gears or gear wheels (which together with their mounting), are variants of the wheel and axle. A gear is a teethed wheel use in rotating machinery. The teeth of the one gear mesh with another toothed gear in order to pass on the torque. More than two gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. The basic purpose of gears is to change the speed, direction, and torque of a power source. Commonly in machines the situation is for a gear to engage with another gear. The purpose of the gears like other machines is to increase force, or change the direction of the force.

Key Points

a) A **machine** reduces load by modifying either the quantity or the direction of the force as it transmits energy to the task.
b) Machines do not produce energy but made use of the energy supplied to them.
c) The simple machines fall into two classes:
  (i) The inclined plane, wedge, screw characterized by the vector resolution of forces and movement along a line.
  (ii) The lever, pulley, wheel and axle characterized by the equilibrium of torques and movement around a pivot.
d) Pulley is a wheel with groove through which a string is passed. The pulley can rotate freely about its axis.
e) Screw is a machine that changes rotational motion to linear motion.
f) Power can also be transmitted from one wheel to another by equipping the wheels with intermeshing teeth's. Such wheels are called gears or gear wheels (which together with their mounting), are variants of the wheel and axle. A gear is a teethed wheel uses in rotating machinery.

Self Assessment Exercise 4.4

Q.1 Select the best answer:
  i. What do Simple Machines do?
    a) has the fulcrum between the effort and the load
    b) fixed point of a lever
    c) a twisting or turning as a result of a push or pull
    d) change size or duration of the force
  ii. Effort force
    a) force you put into a simple machine
    b) a twisting or turning as a result of a push or pull
    c) how well a machine changes force to work
    d) fixed point of a lever
  iii. Inclined Plane
    a) a large wheel attached to a smaller wheel or rod
    b) flat surface that has one end higher than the other
    c) basic machines that make up other machines
    d) twisting or turning as a result of a push or pull
  iv. Fulcrum
    a) increases effort force
    b) a large wheel attached to a smaller wheel or rod
    c) fixed point of a lever
    d) force you put into a simple machine
  v. Lever
    a) Force you put into a simple machine
    b) result of a force moving an object through distance

c) a bar that turns around a fixed point
d) how well a machine changes force to work

Answers of Self Assessment Exercises

Exercise 4.1
Q.1

i. Force
ii. Push
iii. Pull
iv. Two
v. Magnitude, Direction

Q.2

i. A book pushed across the desk by your hand, four forces are present, 1. The earth gravitational pull, 2. Reaction of the desk on the book, 3. The force exerted by you 4. Force of friction offered by the desk
ii. Same force of answer in 1 except push of hand is converted into the pull of the string.

Exercise 4.2

i. Applied force, area
ii. Pascal
iii. Scalar
iv. Above
v. Barometer

Exercise 4.3

i. If the Earth weight was as twice as massive but remained the same size, the value of "g" will be double, because double the mass of earth the force of gravitation will be double. So as the value of "g".
ii. The moon and the Earth are attracted to each other by the Gravitational force. The massive Earth attracts the moon with a greater force than the moon attracts the earth, because the greater mass produces more attraction

Exercise 4.4

i. d
ii. a
iii. b
iv. c
v. c

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Unit–5

HEAT, LIGHT & SOUND

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CONTENTS

Introduction

In everyday, the word energy is used in many different ways. A child, who runs and plays long, is said to be full of energy. The sun provides solar energy for the planet. The Companies that supply electricity to your home, natural gas and petrol are called the energy companies. Physicists use the term energy in a much more precise way. The ability to do work is called energy. In this chapter you will investigate variety of forms of energy that objects can have and the ways in which energy is transferred from one form of energy to another.

As you know it is a common observation that if you place hot objects (say a cup of coffee) or cold object (a glass of ice water) in an environment at ordinary room temperature, the object will tend towards thermal equilibrium with its environment. That is, the coffee gets colder and ice water gets warmer, the temperature of each approaches the temperature of the room. We have observed that the flow of heat is from a warm body towards a cold body.

We receive information about the world around you by means of light and sound. The most important source of light in our daily life is the sun. It is always been a blessing for mankind. God has blessed man with 5 senses. Among all senses, senses of sight is the most important, it depends upon light so light is essential for the universe. Life is not possible without light. We can see things due to light. We know that light can also pass from space. Its speed is greater than all other things. Light always travels in a straight line.

Objective

After reading this unit, you will be able to:

- describe different forms of energy i-e heat, light and sound and can distinguish between the energy and work.
- identify the way that the total energy in a closed system never changes.
- describe the natural world of thermal energy.
- differentiate temperature from the thermal energy.
- explain the role of specific heat when heat transfer occurs through the matter.
- recognize the properties of light.
- understand the fundamentals of light including its speed, wavelength range and intensity.
- establish the knowledge about sound waves and the sound properties.

5.1 Energy

The conception of energy is the most important concepts of science world. In our daily life we use the term energy as fuel used for transportation, electricity for home appliances and the food we eat gives us the source of energy. However all these cases refer to the energy we consume through different sources to accomplish different objectives of our daily routine. Above mentioned are the sources for energy that we consume daily.

Energy is the fundamental ingredient for the execution of human development. Man has reshaped different sources of nature i.e. solar, wind, water and petroleum etc to make their lives comfortable. Engineering and use of technology closely linked with the properties of energy which make it open to human civilization.

The conversion of one form of energy into another form is the main issue of the physics, and reveals the inner workings of the various forms of energy. Energy is needed to make cars run, to heat or cool our homes, to walk or run, pushing a cart and many more. Solar energy is required for crops and forests to grow. The energy stored in the food gives you the energy needed to do work. However, notice that in all the above statements the energy enables something to perform an action.

The property or the ability to produce change in itself or the environment is called the energy.

The energy of the object can have many forms i.e. kinetic energy, thermal energy etc.

5.1.1 Work

As we know that in our daily life, we come across a term whose significance in physics is dissimilar form the meaning of our routine affairs, this new term is work. It can be defined with the help of example that when an object has displacement along straight line by the application of a force F, the work is done on the object.

The work W done is defined as the product of the applied force and the displacement it covers.

The difference between the definition of work and our everyday knowledge about the work is explained by an example. Consider holding a heavy chair with arms for 10 minutes. After 10 minutes, you feel tiredness in your arms and you think that you have done a significant amount of work. But according to the description of work, no work is made on the chair; rather you have applied a force to support the chair, but did not move it. A force does no work on an object because the object does not move.

The equation for work is

W = F x D ……………………Equation (5.1)

Where, W = is the work done

F = Force applied

D = Distance it covers

When the force is making angle θ with the surface, then the above equation will be changed.

The work W done is defined as the product of the component of the force along the direction of displacement and the magnitude of the displacement.

W = F cos θ x D …………………… Equation (5.2)

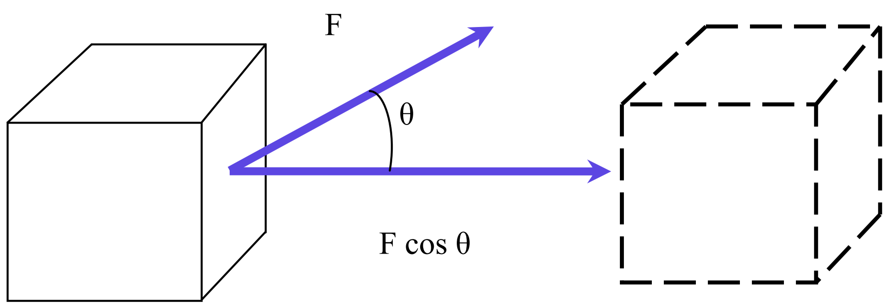

Fig: 5.1: The applied force making an angle with horizontal surface

The sign convention of the work is depending upon the direction of applied force and the distance it covers. Work will be taken a positive if both the directions are same and taken as negative when one direction is opposite to another.

Work is a scalar quantity and its units are force time length, therefore the SI unit of work is the Newton Meter (N. m), another name of the Newton Meter is the Joule (J). The unit of work in the CGS system is the dyne centimeter (dyn.cm), which is also, called the erg, and the unit in the conventional (British engineering) system is the foot-pound (ft.lb).

These are summarized in table 5.1

Sr. No	System	Unit of work
1.	SI	Newton Meter (N. m) Joule (J)
2.	CGS	Dyne Centimeter (dyne.cm)
3.	British Engineering	Foot pound (ft. lb)

Table 5.1 unit of work in three common systems of measurement

Example Problem 01

Example Problem 01:

2. A hockey player exerts 2 Newton force with 0.5 kg hockey. If the hockey player moves the hockey for a distance of 1.5 meter. How much the work is done by the hockey player?

Known data:

m = 0.5 kg
F = 2 N
d = 1.5 meter

Unknown quantities:

Work done =?

Formula to be used: W = F x d

Calculation:

i) W= F x d = 2 N x 1.5 m = 3 Joules

Result:

The work done by the player on the hockey puck is 3 Joules.

Key Points

1. The property or the ability to produce change in itself or in the environment is called energy.
2. Work is the transfer of energy by means of forces.
3. Work is the product of the force exerted on an object and the distance the object moves in the direction of the force.

Self Assessment Exercise 5.1

Q.1 Answer the following questions:

i. When a bowling ball rolls on a marble floor, does the earth gravity do any work on it?

ii. If three objects exert forces on a single object, can they all do work at the same time?

Q.2 Select the correct answer

i. What is the unit of work in SI system?
   a) Newton
   b) Joule
   c) Joule-m

ii. A worker pushes a box with a force of 60N and cover 7.0 meter distance, if the frictional force of 40N is applied in opposite to the direction of force, what net work done on the box?
   a) 250 J
   b) 215 J
   c) 140 J
   d) 7 J

iii. Do we consume energy while sleeping?
   a) Yes
   b) No
   c) Sometimes

iv. If you lift a bucket full of water vertical ($\theta = 90^\circ$), the work done will be
   a) Minimum
   b) Maximum
   c) Zero

5.2 Forms of Energy

In the universe, there is a variety of forms of energy. These different forms include mechanical energy, chemical energy, electromagnetic energy, and nuclear energy. Although energy can be changed from one form of energy to another form, the total quantity of the energy remains constant. If one form of energy in a system decreases, then by the principle of conservation of energy, another form of energy in the system has to rise. For example, if in a system, a motor is attached to the terminal of a battery then the chemical energy of the battery is converted to electrical energy to run the electrical motor, which in turn produces mechanical energy. The transformation of energy from one form into another is not only essential part of the physics, but also applicable to other science branches i.e. Chemistry, Biology, Geology and Astronomy.

5.2.1 Kinetic Energy

You will find that a variety of forms of energy that an object have. You know that change in the energy is called the work. Work transfer energy between an environment and a system .When you throw a ball, you exert a force F and it covers a distance d, in the direction of the force. So, work w= Fxd on the ball. The energy of the ball increases by an amount equal to the work done W on it. The ball gains energy of motion that is referred to as kinetic energy. The kinetic energy is defined as the energy associated whit motion.

Lets suppose an object of mass m be in motion by the application of a force F, Because the quantity force is remain same, so according to Newton's second law that the object moves with a constant acceleration "a" if the object is displaced a distance of s, the work done by F is.

$$W_{net} = F \times d = (ma) \times s \ldots\ldots\ldots\ldots \qquad \text{Equation (5.3)}$$

We all know that the following relationship holds when an object undergoes constant accelerations, the final velocity v_f of the object equal to the under root of the square of the initial velocity v_0 plus twice of the product of acceleration and distance.

$$V_f = \sqrt{v_o^2 + 2as}$$

$$V_f^2 = V_o^2 + 2as$$

$$as = \frac{V_f^2 - Vo^2}{2}$$

Put the value of as in the 5.1 equation:-

$$W_{net} = m \frac{(V^2 - V_o^2)}{2}$$

$$W_{net} = \tfrac{1}{2} mv_f^2 - \tfrac{1}{2} mv_0^2 \ldots\ldots \qquad \text{Equation (5.4)}$$

The above equation tells us that net work done on a object is the change in the kinetic energy of the object. The quantity mv/2 has a special name in physic, called Kinetic energy. Any object of mass m and speed v is defined to have a kinetic energy KE, of

$$KE = \frac{1}{2} mv^2$$

Fig: 5.2 Work done on the ball changes the kinetic energy of the ball and the kinetic energy increase.

Kinetic energy is a scalar quantity and has the same units as work for example, a 1.0 kg mass moving with a speed of 4.0m/s has a kinetic energy of 8.0 j. we can think of kinetic energy associated with the motion of an object.

$W_{net} = KE_f - KE_i$………….. Equations 5.5

According to this result, the work done by a net force acting on a object is to change the kinetic energy of the object some initial value, KE_i to some final value, KE_f. Equation 5.3 is an important result knows as the **work-kinetic energy theorem**. So, we can conclude that, the net work done on an object by net force acting on it is equal to the change in the kinetic energy of the object.

From the work kinetic energy theorem, we also discover that the speed of the object raise so the work done on this object is positive. The positive work means that the work done on the object to increase its speed so the final kinetic energy is greater than the initial kinetic energy. The object speed decreases if the work done is negative, resulting the less amount of final kinetic than the initial kinetic energy. Notice that the speed and kinetic energy of an object will change only if work is done on the object by some external force.

Consider the connection between the work done on an object and the resultant change in its kinetic energy as expressed by equation 5.3. Because of this connection, imagine a hammer is on the edge of hitting a nail. The hammer in motion has kinetic energy and be able to work on the nail. The work done on the nail is equal to F x d, where F is the applied force on the nail by the hammer and d is the distance covered by the nail driven into the wall.

5.2.2 Potential Energy

In the last section we have learned that work done by the object is actually due to kinetic energy. Now we will talk about the form of the energy associated with the position of the object. We all know that when an object is dropped from some height towards the ground, the object is under the Earth Gravitational Field. This field exerts the force on the object. According to the definition of work, an object experiences a force and travel some distance in the direction of the force has done work. So the object dropped from height covered the distance under the influence of the gravitational force and work is done by gaining the kinetic energy.

In the given below figure a brick of mass "m" is held at some height "h" from the nail in a board lying on the ground. The brick is dropped; it falls towards the ground by gaining the speed and gaining the kinetic energy. As a result of its position (at a surface higher than ground) it has the potential energy to do some work. This potential energy is converted to kinetic energy of the brick.

The brick reaches the ground and hits the nail. The work is done on the nail by driving it into the board.

"The energy that an object has a result of its position in the space near the surface of earth is called Gravitational Potential Energy".

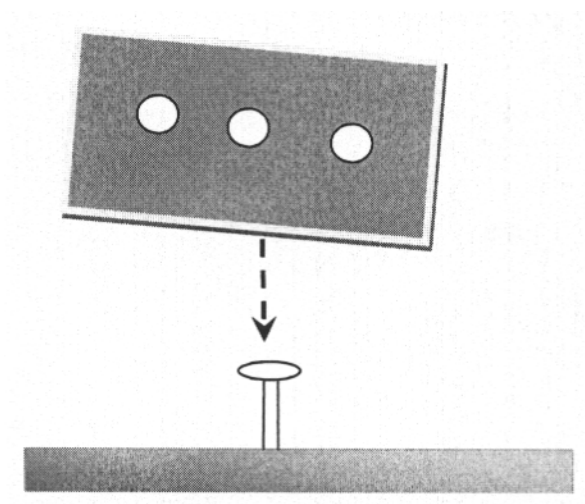

Fig: 5.3 Work done by the brick on the nail

In the above stated example, the brick has the mass "m" and placed at the position "h" from the surface. By hitting the nail into the board the work is done. The force on the brick is gravitational force due to the gravity of the earth and it covered the distance "h", so the work done will be:

$$W = F \times d$$

$$F = mg$$

$$W = (mg) \times h$$

The work done is under the distance hi to h_f, so the work done will be

$$W = (mg) \times (h_i - h_f)$$

$$W = (mgh_i) - (mgh_f)$$

$$W = P.E_i - P.E_f \ldots\ldots\ldots\ldots \qquad \text{Equation 5.6}$$

The quantity **mgh** is called the potential energy of an object, due to the position of the object above the surface of the earth when the value of "g" remains constant. The unit of the potential energy is the same as the unit of work," Joule" or foot-pound. It is a scalar quantity.

Example Problem 02

1. What will be the potential energy of a 3.0 kg book, which is placed on a 3.5 meter high from the ground?
   a) If you are 1.75 meter tall, what will be the potential energy relative to you?

Known quantities:

m = 3.0 kg

h_1 = 3.5 meter, h_2 = 1.75 meter

Unknown quantities:

$P.E_1$ =?

$P.E_2$ =?

Formula to be used: P.E = mgh

Calculation:

i) $P.E_1 = mgh = 3.0 \text{ kg} \times 9.8 \text{ m/sec}_2 \times 3.5 \text{ m} = 102.9$ Joules

ii) $P.E_2 = mg(h_i - h_f) = 3.0 \text{ kg} \times 9.8 \text{ m/sec}_2 \times (3.5-1.75) \text{ m} = 51.45$ Joules

Activity 1

What is the Potential Energy?

Material Required:

Wooden board 6" square, 1.0 kg mass, 2.0 kg mass, wooden block, stop watch, paper tape.

Procedures and Observations

Place the wooden block on the ground and place the wooden board in such away that the one end of the board is on the floor and the other will be on the wooden block, just as given in the figure below. Slip the 1.0 kg mass from the higher position of the wooden board. Note the time to reach the floor. Repeat the procedure with 0.5 kg mass.

1. If the height of the wooden board is made higher, will the mass slips quickly or not.

 ____

 ____

2. The two masses 1.0 kg and 0.5 kg tied together , the time to reach the floor of the 1.5 kg mass from 1.0 kg mass is more or not.

 ____

 ____

2. What will be thee potential and kinetic energy at the top of wooden block?

 ____

 ____

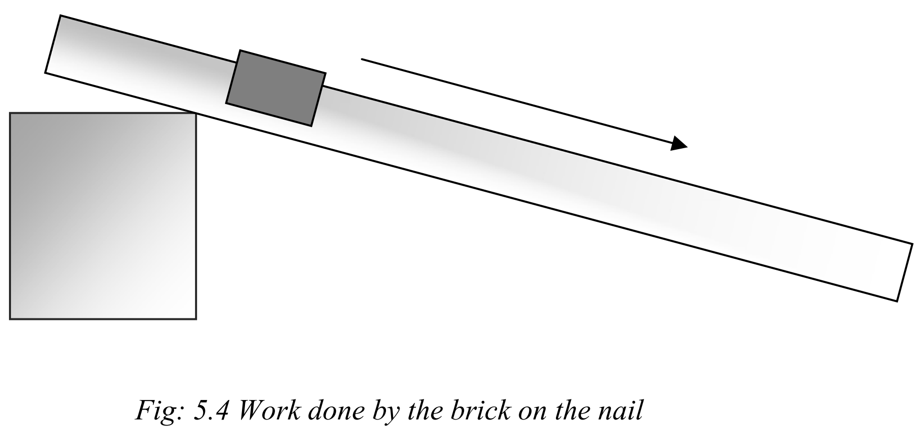

Fig: 5.4 Work done by the brick on the nail

Key Points

1. The kinetic energy of the object is directly proportional to the mass and the square of the velocity.
2. By the influence of earth, the work done by gravity is replaced by the gravitational potential energy.
3. The gravitational potential energy of an object is depended on the mass and its distance from the earth's surface.

Self Assessment Exercise 5.2

Q.1 Answer the following questions:

i. Why the heavier body falls with high speed as compare to a body with light weight?

ii. A grass cutting machine apply 50 N force with an angle of 60 ° and moves 5 meters,
What is the amount of work done by the machine?

Q.2 Select the correct answer.

i. If the velocity of the body is double what will be the kinetic energy?
   a) Double
   b) Same
   c) Tipple

ii. Due to the motion of the object , the energy produced will be
   a) Kinetic
   b) Potential
   c) Sum of kinetic and potential

iii. Two blocks of 12 kg and 20 kg are placed at 10 meter high, the potential energy of the blocks will be
   a) Similar
   b) 20 kg has more P.E than 12 kg
   c) 12 kg has P.E than the 20 kg

5.3 Law of Conservation of Energy

If you have ever observed energy in action around you, you may have notice that energy does not always seem to be conserved. The kinetic energy of a rolling football is soon gone. Even on smooth ice, a hockey puck eventually stops moving. The swings of the pendulum soon die out. Before going into detail of the law of conservation of energy, we have to examine the properties of the two categories of the forces, conservative and non conservative.

A force is conservative if the work done on an object moving between two points is independent of the path the object takes between the points.

In other words, the work done on an object by a conservative force depends only on the initial and final position of the object. The force of gravity is conservative. As we have learned that the work done by the gravitational force on an object moving between any two points near the earth's surface is

$$W = (mgh_i) - (mgh_f)$$

The work done depends only on the initial and final position and independent of the path travelled. The work done will be zero if the initial and final position are same or in a closed path.

A force is non-conservative if it leads to a dissipation of mechanical energy.

If you move an object on a plane straight surface in such away that it returns back to its initial position then no work is done on the object. The dissipated energy is transferred to the object by the force of friction between the object and the surface.

Conservation principles play a very important role in the physics. When a physical amount is conserved, this means that the quantity of the amount remains the same. Even the shape of the quantity may transform in some way, its final value is identical to its initial value. For instance, if a ball is dropped from some height, the energy of the ball changes from gravitational potential energy to kinetic energy. The energy change occurs from one form to the other form, but total amount of energy is never lost but remains the same. The sum of these two energies is referred as mechanical energy.

According to the work – energy Theorem, that the work done in a system is the change in the kinetic energy of the system. Let us assume that the only force doing work on the system is conservative.

$$W = P.E_i - P.E_f$$

According to the work energy theorem

$$P.E_i - P.E_f = \frac{1}{2} mv^2_i - \frac{1}{2} mv^2_f$$

$$P.E_i + \frac{1}{2} mv^2_i = \frac{1}{2} mv^2_f + P.E_f$$

The principle of the conservation of mechanical energy sates that:

The total mathematical energy in an isolated system remains constant, if the object interact only through conservative forces

It is important to note that no energy is added or remove from the system and no conservative force is present in the system. If the kinetic energy of the conservative system increases by some amount, the potential energy of the system must decrease by the same amount.

Let's see the example of the motion of the bob of a simple pendulum which executes the simple harmonic motion. Place the bob at point 'A', the velocity of the bob is zero at this point. So, when the velocity is zero it means that Kinetic Energy (K.E) at point of bob is zero (0). But due to the height, the bob has certain potential energy (P.E). This P.E is at the highest value.

Total Energy at point "A" = K.E. + P.E

Energy total = 0 + mgh

Total Energy at point A = mgh

If we release the bob of pendulum from point 'A', velocity of bob gradually increases, but the height of bob will decreases from point A to the point M. At point 'M' velocity will become maximum and the height of the bob will be nearly equal to zero. Thus,

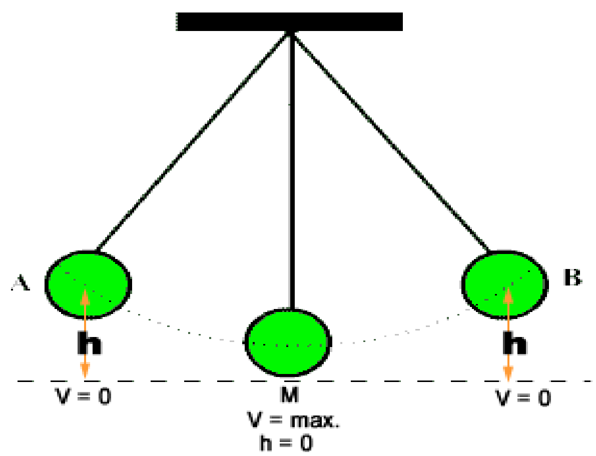

Fig: 5.5 motion of the bob of simple pendulum

K.E. = maximum = $1/2mv^2$ but P.E. = 0.

Total Energy = K.E. + P.E

Energy total = $1/2mv^2 + 0$

Energy total at point M = $1/2mv^2$

This shows that the P.E. at point is completely converted into K.E. at point 'M'.

At point M the bob of Pendulum will not stop but due to inertia, the bob will moves towards the point ‘B’. As the bob moves from ‘M’ to ‘B’, its velocity gradually decreases but the height increases. At point ‘B’ velocity of the bob will become zero.

Thus K.E. at point ‘B’ = 0 but P.E. = max.
P.E. = mgh.
Total Energy = K.E. + P.E.
Total Energy = 0 + mgh
Total Energy at point “B” = mgh

This shows that at point B total energy is again potential energy. Above analysis indicates that the total energy during the motion does not change i.e. the motion of the bob of simple pendulum is according to the law of conservation of energy.

Key Points

1. A force is conservative if the work done on an object moving between two points is independent of the path.
2. A force is non-conservative if it leads to a dissipation of mechanical energy.
3. The principle of the conservation of mechanical energy sates that the total mathematical energy in an isolated system remains constant.

Self Assessment Exercise 5.3

Q.1 Answer the following questions:

i. A team of furniture mover's whishes to load a truck using a ramp from the ground to the rear of the truck. One of the movers' claim that less work will be done if the length of the ramp is increased and reducing the angle between the ramp and ground. Is his claim valid?

ii. Consider a tug of war in which two teams pulling on a rope are eventually matched. So that no motion takes place. Is work done on the rope?

iii. In most situations the friction force reduces the kinetic energy. However, frictional force can sometime increase the kinetic energy. Describe a few situations in which friction causes an increase in kinetic energy.

Q.2 Select the Correct Answer

i. A cup full of tea placed at some height have potential energy, when it is dropped
The kinetic energy goes to
(a) Ripping of the mug apart
(b) The sound produces
(c) Heating the floor
(d) All of the above

ii. When we consume gas / petrol in the car as fuel, does all the fuel converts into heat energy and then to the mechanical energy and some part of it waste also.
a) Yes
b) No
c) Sometimes

iii. What type of energy conversion takes place in a hydroelectric power plant
a) Water to electric
b) Electric to water
c) Kinetic energy of water into the electrical energy

5.4 Heat Energy

We rub our hands on a cold day, hands feel warmer. We burn gas under the kettle of water, the kettle gets hot and the water boils. Electricity runs through the wires of a toaster and wires become red hot. The sun produces heat to the earth. Thus the heat produced in a number of different ways. The mechanical work done in the processes of rubbing your hands, the chemical energy released in burning and the electrical energy flowing through the wires. But what is actually heat? The matter is composed of extremely small separate particles called molecules. These molecules are in constant and continuous motion. When a substance is heated, its molecules move with more speed or with more energy. So, the heat in a substance is the energy of the motion of its molecules.

In the rubbing hands, the motion of the molecules transferred directly to the molecules of the skin. In the kettle on the stove, the chemical energy released by burning produces hot gases with high excited molecules. These make the steel molecules of the kettle to move more vigorously, which in turn makes the molecules of the water the case of the kettle is particularly interesting, because the agitation of the molecules transferred from the gas to the solid and then to the liquid

When we recognize heat as moving molecules, "cold" has a new meaning. It is simply the less molecular activity. As the molecules in the heated state has great motion and they expand, whereas in the cool state the molecules contract.

Heat energy can be transferred from one body or thermodynamic system to another body or thermodynamic system due to thermal connection between the systems at different temperatures. It is often described as one of the basic principles of energy transfer between two physical entities.

5.4.1 Specific Heat

The quantity of heat energy required to raise the temperature of a given mass of a substance by some amount varies from one substance to another. For example, the heat required to raise the temperature of 1 kg of water by 1°C is 4186 Joules, but the heat required to raise the temperature of 1 kg of copper by 1°C is only 387 Joules. Every substance has a unique value for the amount of heat required to change the temperature of 1 kg of it by 1°C, and this number is referred to as the specific heat of that substance.
Suppose that a quantity, Q of heat is transferred to a substance of mass , m , thereby changing its temperature by ΔT, the specific heat, C of that substance is defined as

$$C = Q / m \Delta T \qquad \text{Equation 5.7}$$

From the above equation 5.1, we can express the heat transferred between a system of mass m and its surrounding for a temperature change of ΔT will be

$$Q = m C \Delta T \qquad \text{Equation 5.8}$$

So we can say that to raise the temperature of 0.5 kg of water by 3°C is equal to 6280 Joules. When the temperature and heat is given into the system, they are taken as positive. Likewise the temperature decreases when the temperature and heat flows out from the system.

Sr. No.	Material Name	Specific Heat (J/kg°C)
1.	Aluminum	900
2.	Copper	387
3.	Glass	837
4.	Gold	129
5.	Iron	448
6.	Mercury	138
7.	Water	4186

Table 5.2: The specific heats of few substances

From the above table, it was noted that the highest value of the specific heat is of water. The fact that the specific heat of water is higher than that of land is responsible for the pattern of air flows at a beach. During the day sun transfers the heat to the sand on the beach. The sand has the low specific heat as compare to water so it becomes hot earlier and the air above the sand also heat up. The air above the water has low temperature as compare to air above the land, so this cause the flow of breeze from ocean to land during the day. The case is opposite for the night in the beach areas.

5.4.2 Phase Change & Latent Heat

All of us familiar with the word fluid, the fluid terms means gases and liquid. The solids are another state of matter. These fluid and solids matters are commonly classified as the two states of the matter. The atoms of solid object are strongly packed, vibrating about an unchanging position. Therefore they have a specific shape and a significant volume. In the case of liquid the atoms are tightly packed, but are at a distance to slide over one another. They have an imprecise shape and an exact volume. The gas atoms are away from each other and move about uncontrolled. The gases do not possess any shape and no volume.

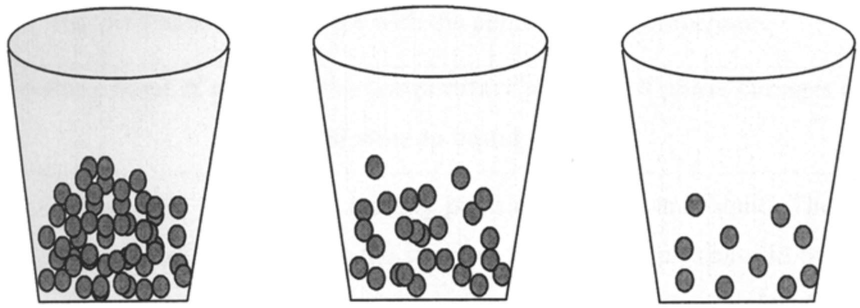

Fig: 5.6 Distribution of molecules in Solids, Liquids and Gases

These states of matters are convertible to one another by the application or removal of heat i.e. the terms melting and freezing. When some solid melts, it means that its changes its state from solid to liquid by adding heat to it. The term freeze means that some liquid looses heat and change its state of liquid to solid. The scientific view of these two processes, however, is a little more complicated than one might at first imagine.

The situation in which the flow of heat does not result in a change of temperature rather to undergo to a physical change from one form/shape to another form/ shape of the matter is referred as the phase change. Some common phase change is solids to liquid, the melting point and the liquid to gas is boiling. This phase change actually changes the crystalline structure of the solid.

The given below is the graph in which the ice at a temperature of -20 °C and at normal/atmospheric temperature. The difference of temperature cause the melting of ice , and when the temperature of ice reached to zero 0°C the ice melts and becomes water and change of phase occur from solid to liquid shape. This graph shows also that when the phase changes occur, no change in temperature at that time. This can be checked simultaneously with the help of thermometer at any time.

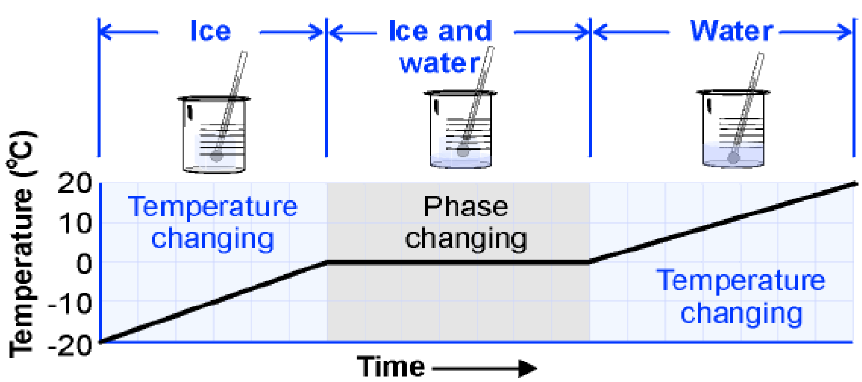

Fig: 5.7 Phase change of ice with the application of temperature

The melting point of a solid is the temperature at which it phase changes occur from solid state to liquid state.

The equilibrium state exists at the melting point of the solid and liquid. The melting point of a substance usually depends on the standard atmospheric pressure. In the melting process, the heat supplied to the body actually proceeds to overcome the bonding forces between the small particles. The change of phase occurs at constant temperature because when a substance melts the added thermal energy does not increase the kinetic energy of atoms rather it changes the bonding between the atoms.

The highest melting point among the chemical elements is of tungsten, at 3683 K (3410 °C, 6170 °F) making it outstanding to make use of as filaments in light bulbs. We all know that the melting point of water is 0 °C (32 °F). It is not easy to heat a solid beyond its melting point because the total amount of heat that goes through the solid at its melting point is consumed to change the solid into a liquid.

Once the solid has completely changed the state to liquid, no more forces are present to hold the smaller particles in the solid state. If some more energy is supplied at this stage then the addition of thermal energy results in the motion of atoms. In this way the kinetic energy is increasing. The heat is supplied continuously; some particles in the liquid obtained enough energy to break free from other particles. At a specific temperature, the addition of the thermal energy converts another change of state from liquid state to gaseous state. This point is called the boiling point.

The boiling point is the temperature at which a liquid changed its shape from liquid to vapor by the application of heat.

The boiling point of a liquid differs according to the liquid's individuality and the pressure at which the boiling occur. The boiling point of water at ambient atmospheric pressure, or at sea altitude, boils at 212 °F (100 °C), while ethanol boils at about 172 °F (78 °C). At higher height above sea level, the boiling points of the substances are lesser and foodstuff takes more time to cook rather than on the sea level. The use of pressure cookers increases the pressure and simultaneously the boiling point is increased.

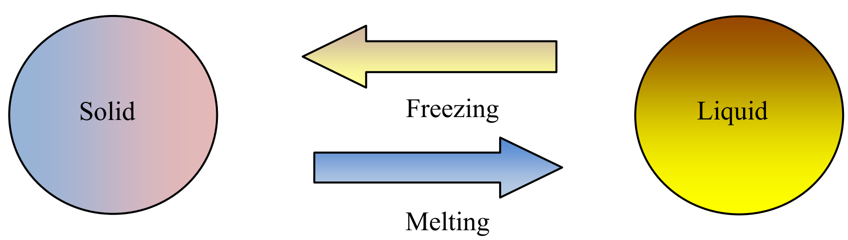

Fig: 5.8 Phase change between solid and liquid

The heat required to change the phase of a given mass, m of a pure substance is given by

$Q = m L$……………………… Equation 5.9

Q = heat required to change the phase

m = mass of the object

L = latent heat of the substances.

The latent heat is the hidden heat of the substance and depends upon the nature of the phase change as well as the properties of the substance. Latent heat is named as latent heat of fusion H_f, when some solid change its phase to liquid . The amount of energy needed to melt one kilogram of a substance is called the heat of fusion. The heat of fusion of ice is 3.34 x 10^5 J/kg. One kg of ice at its melting point at absorbs 0 °C 3.34 x 10^5 J/kg to convert into one kilogram of water.

$Q_f = m L_f$ ………….. Equation 5.10

Q_f = heat required to melt

m = mass of the object

L_f = latent heat of fusion.

At normal atmospheric pressure, water boils at 100 °C. The thermal energy needed to vaporize one kilogram of liquid is called the latent heat of vaporization. For water, the heat of vaporization is 2.26 x 10^6 J/kg.

$Q_V = m L_v$ ………………. Equation 5.11

Q_V = heat required to melt

m = mass of the object

L_V = latent heat of vaporization.

When we consider the opposite case of boiling i.e. the change of state from liquid to solid state, it is referred to as the **freezing point** or **crystallization point**. In the situation of melting of a substance, the addition of energy is utilized to break down the bonding between the smaller particles. Whereas in freezing, energy has taken away from the smaller particles which is the cause of bonding between them. There is no change in the kinetic energy of the smaller particles rather it is the change in the bonding energy between the smaller particles.

For most substances, the melting point and the freezing points are more or less same. For instance, the melting point and freezing point of the mercury is 234.32 Kelvin or −38.83 °C. The melting point of ice at one (1) atmospheric pressure is near to 0 °C (32 °F, 273.15 K), this is also known as the ice point.

Evaporation takes place when molecules jump from the liquid state to the gaseous state at temperatures lower than the boiling point. Evaporation takes energy away from a liquid. When the energy is taken away, the left average energy of molecules becomes low. As a result, the process of evaporation brings cooling effect for the surface of a liquid. In the evaporation process the high-speed molecules run away and also carry energy with them**.**

From the oceans, the evaporation process accounts for 80% of the water discharge. This type of evaporation at high altitudes and at low temperatures causes the cloud formation. The speed of evaporation depends upon:

- Wind speed: the greater the speed of wind, the more evaporation occurs.
- Humidity: the minimal humidity in air cause the evaporation rate high.
- Temperature: Higher temperatures produce excessive evaporation.

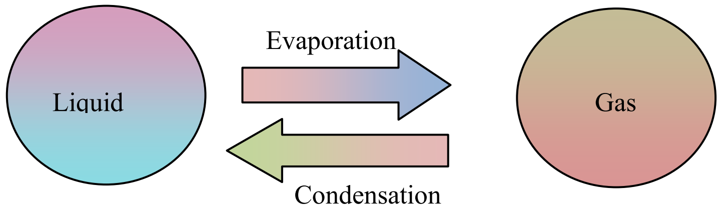

Fig: 5.9 Phase change between solid and liquid

Condensation is the transformation of the gaseous phase into the liquid phase, and this process is opposite of vaporization. Condensation is started by the creation of small clusters of atomic particles within its gaseous state i.e. rain drops or snow-flake creation within clouds. The transformation from the gaseous state to the solid state immediately, the change is called deposition.

Condensation is the conversion of water from its gaseous state (water vapor) into liquid water. In general, condensation occurs in the atmosphere when hot air rises up. This hot air looses the capacity to grasp the water vapor. Resulting, additional water vapor condenses to form water droplets. By the convection, process the empty space of the hot uplifted air is filled by the cool air in surrounding, and as a result of mixing of water drop- lets and cool air, rain is produced. By the movement of surrounding cool air, the clouds are lifted and movement of clouds happens.

5.4.3 Transfer of Heat

If you have experience the campfire while camping, you have noticed that the heat is transferred from the campfire to you and you feel warm glow on your face. If an iron utensil is placed on the fire, it becomes hot. Even someone far away of about 20 feet, also feel the warmth of the fire. In each of these cases the transfer of heat from fire to the iron utensil, to your face and the person 20 feet away has occurred.

But the principle method of heat transfer involved in each was different .The heat transfer is relating to two things, one is the temperature, and the other is the flow of heat. Temperature represents the amount of thermal energy available, whereas heat flow represents the movement of thermal energy from place to place. There are three basic methods to transfer the heat, conduction, convection and radiation.

Conduction

Heat travelled from the end of the iron utensil to the handle placed on fire by the conduction. It is simple to understand that the iron utensil like other substances is made up of molecules. In this case mostly iron molecules vibrate more vigorously when placed on fire. These in turn, strike adjacent molecules in the cooler part just outside the flame and causes them to vibrate more vigorously. This activity continues inch by inch. till the handle also become hot.

Conduction is method of heat transfer in which energy is transferred from molecule to molecule by collision. You burn your fingers when you touch a hot steel utensil (placed on fire), because the heat from the flame has started molecular activity through the hot steel utensil to your skin by conduction. Even the molecules in your skin vibrate energetically as they are heated. Since organs in your skin detect this vibration and send a special nerve message to your brain.

Not all objects conduct heat equally well. Because wood is a poor conductor of heat, we use it for the handles of pots and pans. In general, metals are better conductors than non metals. Liquids, gases such as air and nonmetal solids, all are poor conductor of heat. Therefore designated as heat insulators and are used to shield our bodies or objects from heat to prevent the loss of heat.

Convection

How was the man 20 feet away warmed by the camp fire? A layer of air directly over the fire was heated. The heat caused it to expand and thus made it lighter than the surrounding cool air. The heavier colder air around the base of the fire swept into the fire and pushed the warmer, lighter air up to the 20 feet away man. We have discussed earlier in this chapter that how the movement of air caused by the heating of sand in the beach areas. They actually cause the convection currents, which are also responsible for the heating of a room by the room heater. Warm air is heated by the room heater is pushed up and sweeps across a cooler part of the room. Cold air falls and moves towards the heater, where it is heated.

Radiation

In conduction, heat is transferred as molecule to molecule collision. In convection a whole volume of heated material gaseous or liquid circulates. The transfer of heat by radiation is quite different from both the cases. The transfer of heat from camp fire to your face is affected not by vibrating molecules or the circulating air but by a form of energy transfer called radiation.

Radiations are a most important method, because it accounts for the heating of the earth by the sun. Obviously, conduction and convection could not carry heat from the sun to the earth because most of the 93 miles between them is empty space, almost devoid of molecules. Radiant energy from the sun is transmitted in the form of waves. Most apparent are the waves that produce visible light. In addition, there are ultra violent waves. Ultra violet rays causes sun burn and tanning. These infrared rays are called heat rays, which are responsible for the heating of earth by the sun.

Infrared rays themselves should not be thought of as heat. The space between the sun and the earth is not heated by these waves, because there is practically nothing be heated. The rays might be compared to television waves originating from a broad cat station. These waves must be picked up by your TV set and convert it to picture. Similarly the infrared rays broadcast by the sun produce heat only when they strike and excite the molecules of substances. Infrared rays are invisible to the human eyes.

5.4.4 Measurement of Heat

Heat or the Thermal energy is defined as energy that is transferred between a system and its environment because of the temperature difference between them. Before scientists arrived at a correct understanding of heat, the units in which heat was measured had already been developed. One of the most widely used is the calorie (cal) , defined as the heat required to raise the temperature of 1g of water from 14.5°C to 15.5°C. a related unit is the Kcal . 1Kcal = 10^3 cal. The unit if heat in the British Engineering System is the British Thermal Unit (BTU), defined as the heat required raising the temperature of 1 lb of water from 63°F to 64°F.

Because heat is now recognized as energy being transferred, scientists are using increasingly SI unit of energy, the Joule (J), for the quantities of heat.

$$1 \text{ cal} = 4.186 \text{ J}$$

5.4.5 Measurement of Temperature

The common thermometer used to measure temperature is essentially a sealed glass tube containing a liquid such as mercury or colored alcohol, the principle involved in the functioning of a thermometer is that fluids generally expand when heated and contract when cooled. (Solids expand and contract too but the glass, in a thermometer does not expand enough to affect the reading materially). The hollow inside the thermometer, the bore, is very narrow, in some thermometers it is finer then a human hair, thus, a small change in temperature causes enough in temperature causes enough expansion or contraction in the liquid to force it a noticeable distance up or down the bore, the tube is calibrated that is marked in degrees so the expansion or contraction of the fluid can be measured in exact units.

Scales

There are two common temperatures in use, the Fahrenheit and the Celsius scale, the Fahrenheit thermometer is so calibrated that it registers 32 point of ice and 212 degrees at the boiling point water, these measurements are written 32^0F and 212^0F respectively, there are 180^0 between the melting point of ice and the boiling point of water, the scale may be extended below and above these points.

Incidentally, the zero of the Fahrenheit the thermometer does not mean, no degrees, this zero point was somewhat arbitrarily selected by its originator, Fahrenheit, who on mixing some salt and ice, achieved a low temperature that he decided are needed to determine the calibration, so a second point of 100 was selected with Fahrenheit believed was the temperature of the human body. On the Celsius scale, zero marks the melting point of ice and 100 the boiling point of water, these measurements are written 0°C and 100° C respectively.

A third scale, one sometimes useful to scientists, is the Kelvin scale, also called the absolute temperature scale, which begins with absolute zero but use degrees that have the same size as Celsius degrees, To convert from Celsius to Kelvin and 273 to the Celsius reading, some signification temperatures (approximations) are shown in the table above,

Fig: 5.10 A thermometer

Thermometers come in different shapes and size for different purposes. The clinical thermometer has a very narrow bore, so that a different of 1/10 degree is easily read. It is calibrated to read only from 92°F to 110°F. Heat forces the mercury out of the bulb and up the bore, but a constriction in the bore keeps the mercury up in the stem when the thermometer is removed from the patient even though the surrounding temperature is lower, in this way the thermometer registers the highest point to which the mercury back into the bulb.

Example Problem 03

If heat is transmitted to a 1.0 kg of iron block and its temperature rises from 25°C to 50°C. What will be the amount of heat be transmitted to the iron block.

If heat is transmitted to a 1.0 kg of iron block and its temperature rises from 25°C to 50°C. What will be the amount of heat be transmitted to the iron block.

Known quantities: m= 1.0 kg

C= 450 J/ kg-K (specific heat of iron)

T_1= 25°C + 273 = 298 K

T_2= 50°C + 273 = 323 K

Unknown quantity: Q =?

Formula to be used: **Q = mC ΔT**

Calculation:

Q= **mC ΔT** = 1.0 kg x 450 J/ kg-K x (323-298)K

=11250 J = 11.25 KJ

Answer

The heat required to heat the iron block is 11.25KJ Joule.

Activity 2

How does the constant supply of thermal energy affect the temperature of water?

Material Required

A burner, heat proof glass beaker, stand, water, thermometer, stop watch, pen and paper.

Procedures and Observations

Light up the burner on a medium flame. Allow the burner for few minutes. Pour some water into the beaker. Make a observation table of time and temperature. Record the initial reading of the water with the thermometer. The thermometer does not touch the walls of the beaker. Place the beaker on the stand and put the burner under it. Record the temperature after every 2 minutes. Record the time, when water starts boiling. Continue recording the temperature for additional 4 minutes. Carefully remove the beaker from the burner.

____

____

1. Make the data table of time and temperature and then draw a graph between them. Temperature on the vertical axis and time on the horizontal axis.

   ____

   ____

2. What is the thermal energy given to the water in the first 5 minutes? Use the relation Q= mc ΔT.

   ____

   ____

3. Compare the same procedure with the half amount of water as used in this experiment. Note the readings.

____

____

Key Points

1. Heat in a substance is the energy of the motion of its molecules.
2. Every substance has a unique value for the amount of heat required to change the temperature of 1 kg of it by 1°C and this number is referred to as the specific heat of that substance.
3. These states of matters are convertible to one another by the application or removal of heat.
4. The situation in which the flow of heat does not result in a change of temperature rather to undergo a physical change from one form/shape to another form/ shape of the matter is referred as the phase change. The symbol Q is used for the amount of charge and the unit used is coulombs .
5. The melting point of a solid is the temperature at which it changes state from solid to liquid.
6. The boiling point is the temperature at which a liquid changed its shape from liquid to vapor by the application of heat.
7. Evaporation occurs when molecules go from liquid to gas at temperatures below the boiling point.
8. Condensation is the change of the physical state of matter from gaseous phase into liquid phase, and is the reverse of vaporization.
9. Conduction is method of heat transfer in which energy is transferred from molecule to molecule by collision.
10. In convection a whole volume of heated material gaseous or liquid circulates.
11. The units in which heat is measure is the calorie (cal) , defined as the heat required to raise the temperature of 1g of water from 14.5°C to 15.5°C.
12. There are two common temperatures in use, the Fahrenheit and the Celsius scale

Self Assessment Exercise 5.4

Q.1 Answer the following questions:

i. In an electric kettle an immersed electric coil is used for heating the water by means of electricity. But the instructions are not to touch the electric coil when no water is present. Why?
ii. Concrete has a higher specific heat than does the soil. Use this fact to explain the average temperature of city is higher than the villages around.
iii. A tiled floor may feel cold at bare foot as compare to a carpeted floor at the same temperature?
iv. How does heat flow when a warmer object is in contact with a colder object?
v. Is your body a good judge of temperature? On a cold day a metal door knob feels much colder to your hand than the wooden door.

Q.2 Select the correct answer

i. The specific heat of body A is greater than body B. If equal amount of heat is supplied to both the bodies, which body temperature will be high
   a) Body B
   b) Body A
   c) No difference in both temperatures
   d) Could be A or B

ii. Some amount of heat is added to raise the temperature of ice from -10°C to -5°C.
   More heat will be required to the same quantity of water for raising the temperature from 15°C to 20°C, why
   a) Overcoming the latent heat of fusion of ice requires more heat
   b) The specific heat of ice is less than that of water
   c) The specific heat of ice is grater than that of water

iii. Which is the best material for the insulation
   a) Mirror
   b) Air
   c) Brass

iv. The heat from the sun reaches the earth with the help of :
   a) Conduction
   b) Convection
   c) Radiation

v. The movement of breeze from ocean to earth and earth to ocean, is due to the
   a) Low latent heat of water
   b) High latent heat of water
   c) High latent heat of air

5.5 The Nature of Light

Before the 19th century, light was thought to be steam of particles, produced by a light source, that accelerate the sense of vision on the retina of eye. The dominant inventor of this particle theory of light was Newton. He was the first, who introduced the ideas about the law of reflection and refraction with the help of known experimental facts related to the nature of light.

Most scientists recognized Newton's particle theory of light. However during Newton's lifetime another theory was proposed. In 1678 a Dutch physicist and astronomer, Christian Huygens (1629-1695) presented the wave nature of light and also gave explanations about the law of reflection and refraction. His wave theory did not be given recognition for several reasons. All the waves i.e. sound and water could travel some medium but the sun rays travel to earth through empty space. In addition it was disagreed that if light have the nature of wave, how could it can be bend around the edges of the objects. Because this is the diffraction phenomenon, not simple to observe because light waves have such short wavelengths.

Another scientist by Francesco Grimaldi in 1660 proved experimentally the confirmation about the diffraction of light. But his work did not recognized at that time. For more than a century most scientists refused the wave's theory and adhered to Newton's particle theory due to Newton's great reputation as a scientist.

The first clear demonstrations of the wave nature of light was provided by 1801 by Thomas Young (1773-1829) , who showed that under appropriate conditions, light exhibits interference behavior,. That is at certain points in the vicinity if two sources, light waves can combine and cancel each other by destructive interference such behavior could not explained at that time by particle theory.

The most remarkable advancement concerning related the theory of light was given by Maxwell in 1865. He predicted that light was a form of high frequency electromagnetic wave. His theory predicted that these waves should have a speed of 3×10^8 m/s in agreement with the measured value.

In 1905 Einstein published a paper that originated the theory of light quanta and give explanation of the photoelectric effect. He concluded that light is compiled of corpuscles, or discontinuous quanta of energy. Furthermore, he declared that light interacting with matter also consists of quanta and he brilliantly worked out the implications of the photoelectric process. More specifically Einstein showed that the energy of a photon is proportional to the frequency of the electromagnetic wave.

$$E= h \times f$$

Where h is the plank's constant = 6.63×10^{-34} Joule

This theory keeps hold of the features of both the wave and particle theories of light. The photoelectric effect is the result of energy of transfer from a single photon to an electron in the metal. That is, the electron interacts with one photon of light as if the electron had been struck by a particle. Yet the photon was wavelike characteristics as implied by the fact that light exhibits interference phenomena,

In view of above stated developments in history, light must be treated as having a double nature, which is in some case light acts as wave and in other acts as a particle. The classical electromagnetic wave theory presents sufficient explanations of light propagation and the results of interference. Whereas, the particle nature of light explains the photoelectric effect and other experiments engaging the interaction of light with matter. The question about the nature of light, that either it is wave or a particle is debatable. The light some time acts as wave, sometime as particle, fortunately, it never acts as both in the same experiment.

Light is the range of frequencies of electromagnetic waves that stimulates the retina of the eye. Light waves have wave length from about 400 nm (4.00×10^{-7}m) to 700 nm (7.00×10^{-7}m). The shortest wave length is seen as violet light. As the wave length increases the colors gradually change to indigo, blue, green, yellow, orange and finally red.
The journey of light in the vacuum or any other medium is always in a straight line. If light from the sun or any other source of light is made able to be seen by dust particles in the air, the path light travel is seen to be a straight line. When you stand in the sunlight, your body blocks the rays of sun and a result shadow of your body appears. The straight – line path of light has show the way to the ray model of light. The use of ray diagrams to study the travel of light is called ray optics or geometric optics.

Although many laboratory measurements of the speed of light have been made, the most prominent was a series performed by American physicist Albert A. Michelson. Between 1880 and 1920, he worked out earth based procedures to calculate the speed of light. He measured the time required for light to make a round-trip between two California mountains 35 km apart. The best result was 2.997×10^{8} m/sec. For this work, he became the first American to win the Nobel Prize.

The development of the laser in 1960 provided new methods of measuring the speed of the light. The speed of the wave is equal to the product of wavelength into its frequency.

$$c = \lambda f \qquad \text{equation 5.6}$$

c = speed, λ= wavelength f = frequency

In 1983 the International Committee on Weights and Measurements decided to make the speed of the light a defined quantity. In principle, an object's length is now measured in terms of the time required by light to travel from one end of the object to the other. The committee defined the speed of the light in a vacuum as 3.00×10^{8} m/sec.

5.5.1 Reflection of Light

When light ray travels in see-through medium come across a boundary leading into a second medium, part of the incident ray is reflected back into the first medium. In the given below figure shows numerous rays of a beam of light incident on a smooth mirror like, reflecting surface. The reflected rays are parallel to each other, as indicated in the figure. Reflection of light from such a smooth surface is called specular reflection.

On the other hand, if the reflecting surface is not flattening, the surface reflects the rays in a diversity of direction. Reflection from any uneven surface is known as diffuse reflection. A surface behaves as a smooth as long as the surface differences are small compared with the wave length of the incident light.

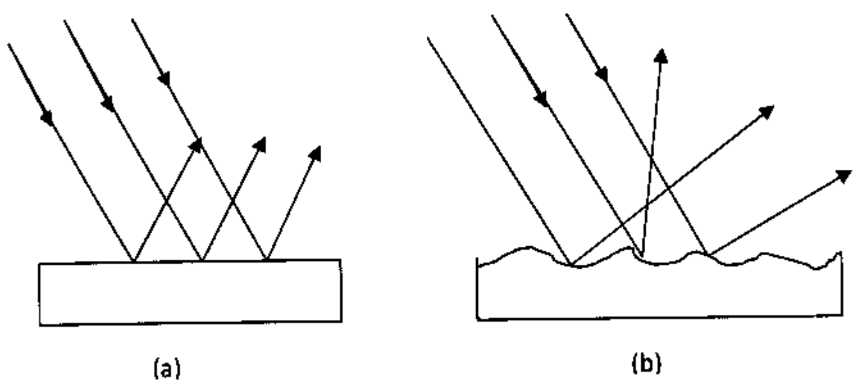

Fig: 5.11: (a) Specular and (b) diffuse reflections

Consider the two types of reflection from a road surface that one can see while driving at night. When the road is dry, light from the oncoming vehicle is spread out on the road in diverse directions and the road is able to be seen. While on a rainy night, the rain water is spread over the road, the road irregularities are filled with rain water. The surface of the road is quite smooth, but there are many abnormalities on the road that are filled with rain water and the light undergoes the specular reflection. This means that the light is reflected straight ahead, and the driver sees only directly ahead. Light from the side never reaches his eyes.

Consider a light ray traveling in air and incident at some angle on a flat, smooth surface, as shown in figure 5.11. The incident and the reflected rays make angles $\theta 1$ and $\theta 1'$, respectively, with a line perpendicular to the surface at a point where the incident ray strikes the surface. We call this line the normal to the surface. Experiments show that the angle of the reflection equals the angle of incidence.

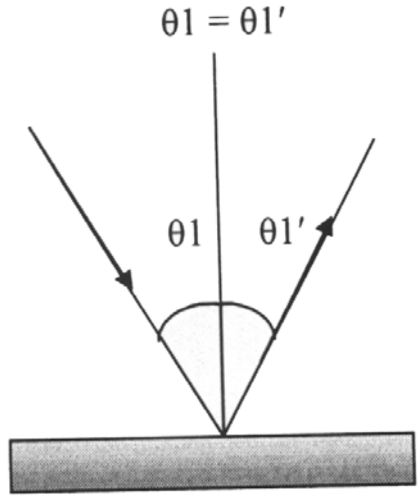

Fig: 5.12, according to the law of reflection θ1 = θ1′

You might have observed a common happening in photographs of individual's eyes appears to be glowing red. This is due to the fact that when the flash from the camera is used and the flash unit is very adjacent to the camera lens. Light from the flash unit enters the eye and is reflected back along its original path from the retina. Most of the light reflected from the retina is red, due to the blood vessels at the back of the eye, giving the red-eye effect in the photograph.

5.5.2 Refraction of Light

When a light ray traveling in a transparent medium encounters as boundary leading into another transparent medium as in figure given below, part of the ray is reflected and part enters the second medium. The rays that enter the second medium are bent at the boundary and is said to be refracted. The incident ray, the reflected ray, refracted ray and normal at the point of incidence all the lie in the same plane. The angel of refraction θ2 in figure given below 5.12, depends on the properties of the tow media and on the angel of incidence though the relationship.

$$\frac{\text{Sin } \theta_2}{\text{Sin } \theta_1} = \frac{v_2}{v_1} = \text{constant} \qquad \text{equation 5.12}$$

Where v_1 is the speed of light in medium 1 and v_2 is the speed of light in medium 2, Willebrord Snell (1591-1626) is usually credited with the experiential discovery of the relationship which is therefore know as Snell's law.

Experiments show that the path of a light ray through a refracting surface is reversible, for example the ray in figure 5.12 travels from point A to point B. if the ray originated at B, it would follow the same path to reach point A, but the reflected ray would be in the glass.

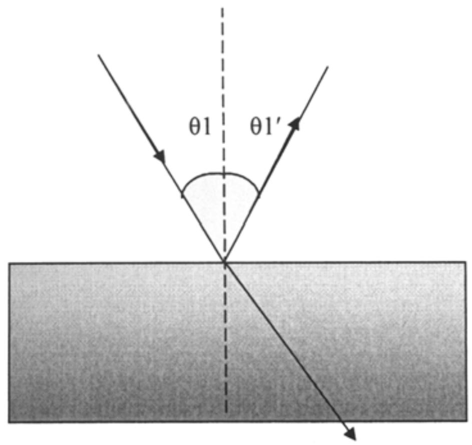

Fig: 5.13 A ray obliquely incident on an air glass interface.
The refracted ray is bent towards the normal because $v_2 < v_1$

When light moves from a material in which its speed is high to a material in which its speed is lower the angle of refraction θ_2 is less than the angle of incidence as shown in figure 5.13(a). If the ray moves from a material in which its speed is low to a material in which its speed is higher it is bent away from normal, as in figure 5.13(b).

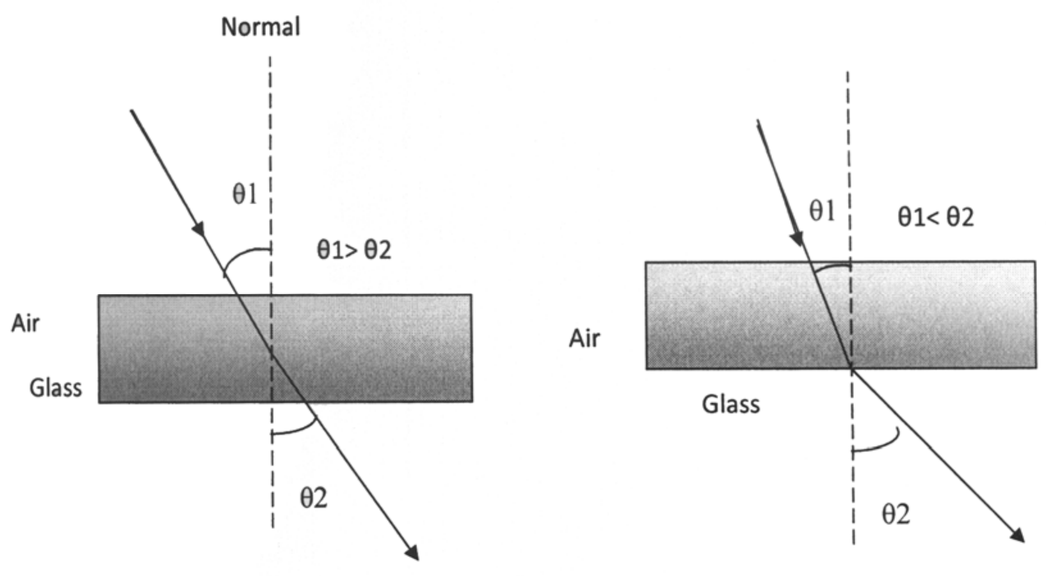

Fig: 5.14 (a) when the light moves from air into glass , its path bent towards the normal
(b) when the beam moves from glass into air, its path is bent away from the normal.

5.5.2.1 The Law of Refraction

When light passes from one transparent medium to another, it is refracted because the speed of light is different in the two media, it is convenient to defined the index of refraction , n, of a medium as the ratio.

$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in a medium}} = \frac{c}{v} \qquad \text{Equation 5.13}$$

From this definition we see that the index of refraction is a dimensionless number that is greater than unity because v is always less than c.

As light travels from one medium to another its frequency does not change.

To see why consider, figure 5.14 wave fronts pass an observer at point A in medium with a certain frequency and are incident on the boundary between medium 1 and 2. the frequency with which the wave fronts pass an observer at point B in medium 2 must equal the frequency at which they arrive at point A in medium 1. If this were not the case, either wave front would pile up at the boundary or they would be destroyed or created at the boundary. Because there is no mechanism for this to occur, the frequency must be a constant as a light ray passes from one medium into another. Therefore, because the relation $v = \lambda f$ must be valid in both media and because $f_1 = f_2 = f$, we see that

$$v_1 = \lambda f_1 \quad \text{and} \quad v_2 = \lambda f_2$$

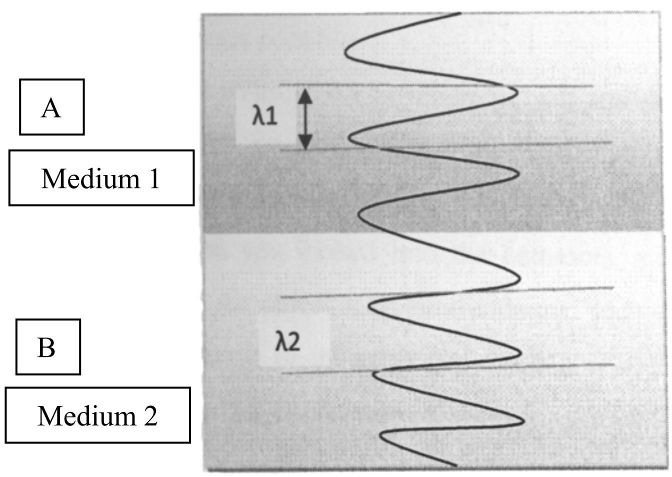

Fig: 5.15: As the wave moves from medium 1 to medium 2, its wavelength changes but its frequency remain the same.

A relationship between index of refraction and wavelength can be obtained by dividing these two equations and making use of the definition of index of refraction

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{c / n_1}{c / n_2} = \frac{n_2}{n_1}$$

$$\lambda_1 n_1 = \lambda_2 n_2$$

Let medium 1 be the vacuum so that n_1 =1. From the above equation it follows that the index of refection of and medium be expressed as the ratio.

$$n = \lambda_{\circ} / \lambda_n \qquad \text{Equation 5.14}$$

Where $\lambda_{\circ}$ is the wavelength of light in vacuum and λ_n is the wavelength in a medium with index of refraction n .We are now in a position to express Snell's law in an alternative form. This is the most widely used and practical form of Snell's law.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 \qquad \text{Equation 5.15}$$

5.5.3 Mirror and Image Formation

Mirrors are the oldest optical instruments. Undoubtedly, prehistoric humans saw their faces reflected in the quite water of lakes and ponds. Almost 4000 years ago, Egyptian used polished metal mirrors to view their images. Jean Foucault, a French scientist, developed (1857) a method of coating glass with silver. After that sharp, well defined reflected images possible.

If you looked yourself in a bathroom mirror, you saw your image in a plane mirror. A plane mirror is a flat, smooth surface from which light is reflected by regular reflection rather than by diffuse reflection. In describing mirror the word object in a new way. You were the object when you looked into the bathroom mirror. An object is a source of spreading light rays. An object may be aluminous, such as candle or bulb. But often an object, such as the moon or the page you reading is illuminated. An illuminated object usually reflects light in all directions.

Let's assume that from a point O rays strike to the mirror. The angle of incidence and reflection are shows for three ways.

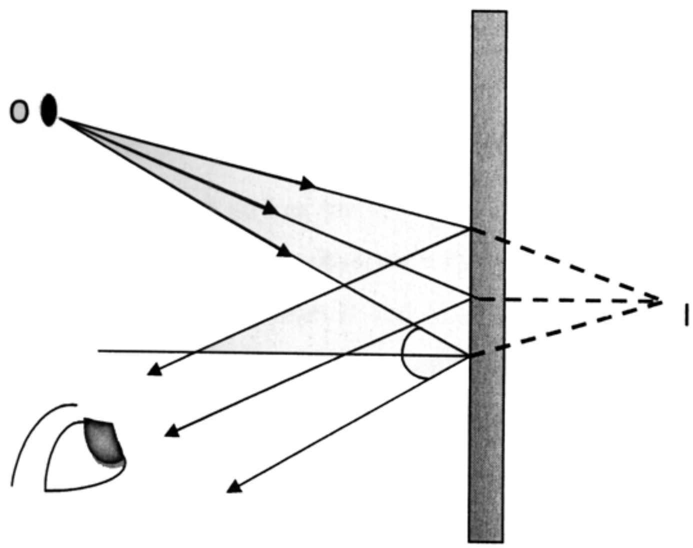

Fig: 5.16: The reflected rays that enter the eye appear to originate at a point behind the mirror.

Notice that they diverge, when they leave the point O and they continue to diverge after they are reflected from the mirror. The person sees those rays that enter the pupil of his eye. The dashed lines are sight lines, the backward extensions of the rays leaving the mirror. They converge at point I. The eye and the brain interpret the rays as having come from point I. This point is called the image of the point O. because the rays do not actually converge on that point, this kind of image is a called a **virtual image.**

Where is the image located? Suppose two rays leave an object from point P. One ray strike the mirror at B, the other at M. Both rays are reflected with equal angles of incidence and reflection.

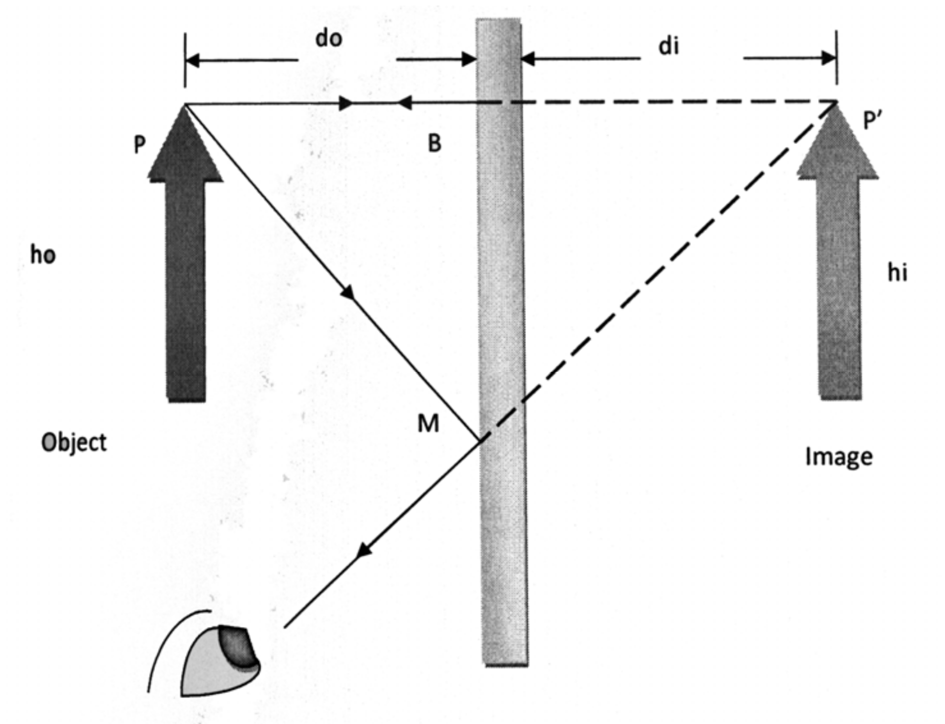

Fig: 5.17: light rays leave a point on the object

Ray PB which strikes the mirror at an angle of 90°, is reflected back on itself. Ray PM is reflected into the observer's eye. Sight lines as shown in the figure as dashed lines, are extended back from B and M, the positions at which the two rays are reflected from the mirror. The sight lines converge at point P′ , which is the image of point P. the distance between the object and mirror, the object distance , is line PB which has a length of d_o . Similarly the distance between the image and the mirror is the length of line P′B and is called the image distance, d_i . The object distance and the image distance d_o and d_i, respectively, are corresponding sides of the two congruent triangles PBM and P′BM. Therefore, $d_o = d_i$.

How large is the image? of you drew the paths and the sight lines of two rays originating from the bottom of the arrow, you would find that they converge at the bottom of the image. Therefore, the object and the image have the same size. Also $h_o = h_i$. The image and the object are pointing in the same direction, so the image is called the **erect image**.

5.5.3.1 Concave Mirror

Look at your reflection in the inside of a spoon. The spoon acts as a concave mirror. A concave mirror reflects light from its inner "carved in "surface. In a spherical concave mirror, the mirror is part of the inner surface of a hollow sphere, as shown in fig 5.12. The sphere of the radius "r" has a geometric center. Point A is the center of the mirror and the line CA is the principle axis, that is, the straight line perpendicular to the surface of the mirror at its center.

How does the light reflect from a concave mirror? Think of a concave mirror as a large number of small plane mirrors arranged around the surface of the sphere. Each mirror is perpendicular to a radius of the sphere. When a ray strikes a mirror, it is reflected with equal angles of incidence and reflection.

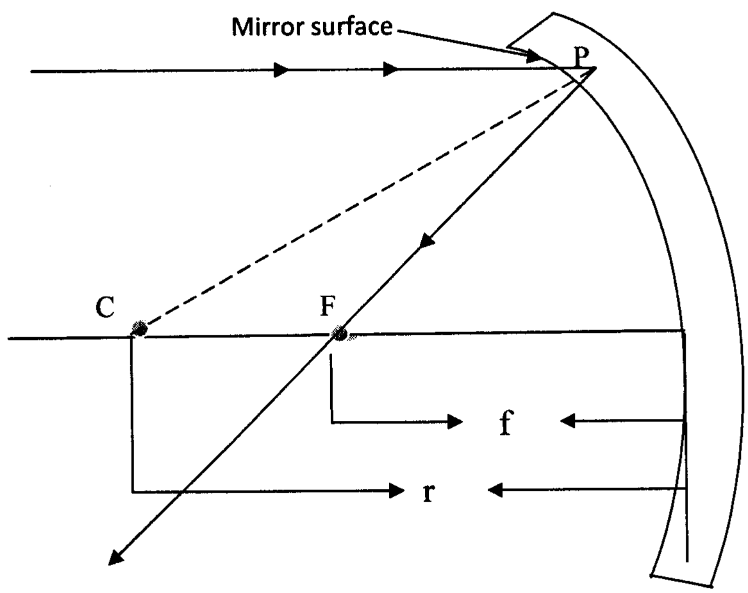

Fig: 5.18 the focus of a spherical concave mirror is located halfway between the centre of curvature and the mirror surface.

The above figure shows that a ray parallel to the principal axis is reflected at P and cross the principal axis at some point F. this point F is called the focal point of the mirror. Two sides FC and FP of the triangle CFP are equal in length, thus the focal point F is half the distance between the mirror and the center of curvature, C. The distance from the focal point to the mirror along the principal axis is called the focal length, **f** of the mirror.

You can relate the focal length of the mirror, f to the distance from the object to the mirror d_o and the distance from the image to the mirror d_i. The equation is called the mirror equation

$$\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i} \qquad \text{Equation 5.16}$$

Another useful equation is the definition of magnification. Magnification m, is the ratio of the size of the image h_i to the size of the object h_o.

$$m = \frac{h_o}{h_o}$$ Equation 5.17

5.5.3.2 Convex Mirror

A convex mirror is a spherical mirror that reflects light from the outer surface. Rays reflects from a convex mirror always diverge. Thus a convex mirror does not form a real image. When drawing the ray diagram, the focal point F will be placed behind the mirror, at a distance halfway between the mirror and center of a curvature.

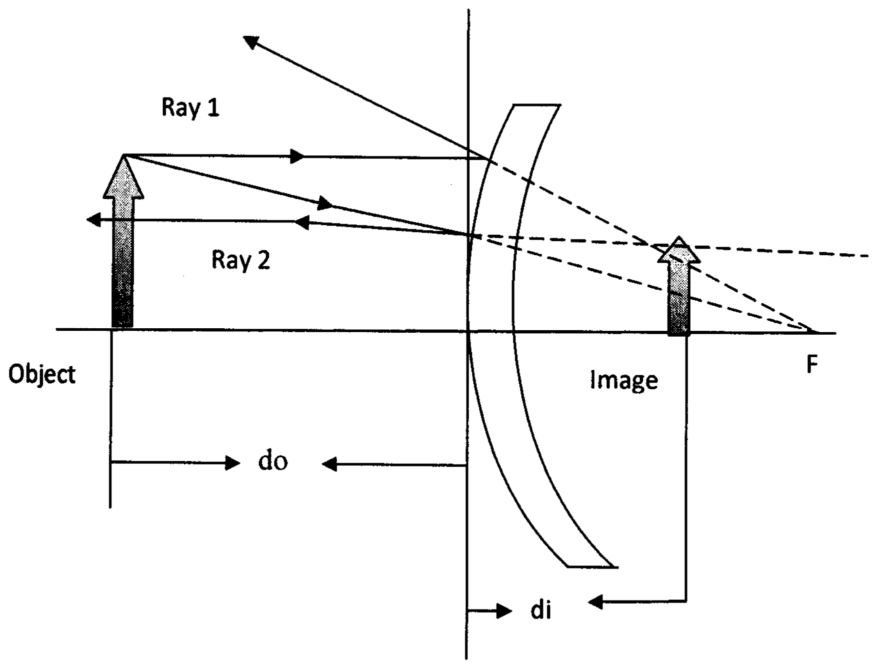

Fig: 5.19 No real image is formed by a convex mirror. An erect, virtual image, reduced in size, is formed at the apparent intersection of the extended rays.

The ray diagram shows how an image is formed in a convex mirror. Ray 1 approaches the mirror parallel to the principal axis. To draw the reflected ray, draw a dashed line from the focal point, F to the point where ray 1 strikes the mirror. The reflected ray is in the same direction as the dashed line. Ray 2 approaches the mirror on a path that, if extended behind the mirror, would pass through F. the reflected part of ray 2 is parallel to the principal axis. The two reflected rays diverge, as it coming from a point behind the mirror. The image, located at the apparent intersection of the extended rays behind the mirror, is vertical, erect and reduced in size.

Convex mirrors from images reduced in size and therefore the images seen farther away. But the convex mirror also reflects an enlarged field of view. Rear view mirrors used in cars are often convex mirrors, as are mirrors used in stores to observe the shopping persons. If the ordinary glass is curved outward, it will act as a convex mirror. You can see reduced images of yourself if you look into someone's eye glasses.

5.5.4 Lenses and Image Formation

Eye glasses were made from lenses as early as the thirteen century. Around 1610, a famous scientist Galileo used two lenses as a telescope. With the help of this telescope he discovered the moons of Jupiter. Since that time to till now the lenses are used in may devices i.e. cameras and microscopes.

A lens is made of transparent material, such as glass or plastic, with a refractive index larger than that of air. Each of the lens is a double face of a sphere, may be concave, convex and flat. Lenses in eyeglasses correct the deficiencies in our eyes. Lenses in telescope extend our view into space. In microscope, the use of the lens permits us to penetrate into the mysteries of the minute. They are useful because they are effective light benders. They are designed to refract light according to the purpose of the optical devices they are used in

5.5.4.1 Convex Lens

A lens is called a **convex lens** if it is thicker at the centre than at the edge. They are also called the converging lens because they reflect parallel light rays to the light rays they meet. By positioning the convex lens on the dry leafs, you can produce fire, because rays of sun converge on leafs.

The image is real and the rays converge on a small point, enough energy is being concentrated there that it could set the leaf ablaze. The rays of the sun are examples of light rays that are almost exactly parallel to the principal axis because they have come from such a distant source. After being refracted in the lens, the rays converge at a point called the focal point, F of the lens. The convex lens has two focal points, on each side of the lens shown in the given below figure. This is because the lens is symmetrical and light can pass through it in both directions. The distance from the lens to a focal point is the focal length, **f**. The focal length depends upon the shape of the lens and the refractive index of the lens material.

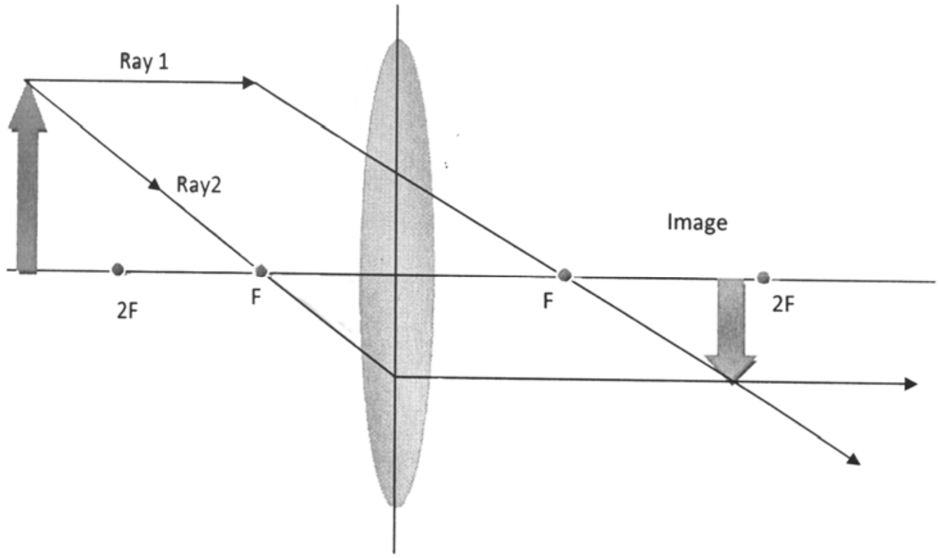

Fig: 5.20 when an object is placed well beyond the principal focus of a convex lens, the image is real, inverted and reduced in size.

You can trace from an object located far from a convex lens. Ray 1 is parallel to the principal axis. It refracts and passes through F on the other side of the lens. Ray 2 passes through F on its way to the lens. After refraction, its path is parallel to the principal axis. The two rays intersect at a point F and locate the image. Rays selected from other points on the object would converge at corresponding points on the image. Note the image is real, inverted and smaller than the object.

5.5.4.2 Concave Lens

A lens is called **concave** if it is thinner at middle than the edges. A concave lens causes all rays to diverge. Ray 1 leaves the object and approaches the lens parallel to the principal axis. It leaves the lens in the direction; it would have if it had passed through the focal point. Ray 2 passes directly through the centre of the lens without bending. Ray 1 and 2 diverge after passing through the lens. Their apparent intersection is I, on the same side of the lens as the object. The image is virtual, erect, and reduced in size. This is true no matter how far from the lens the object is located. The focal length of a concave lens is negative.

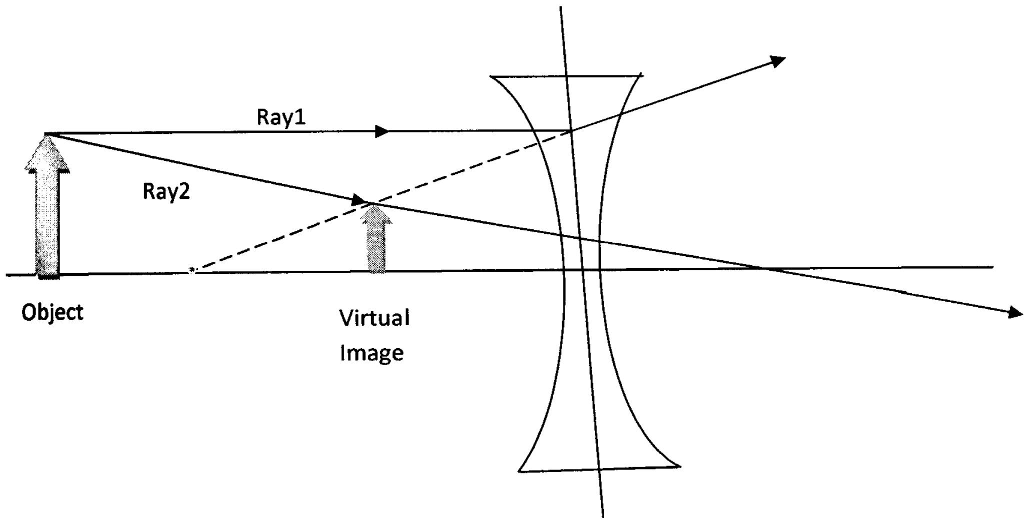

Fig: 5.21 Concave lenses are used in eyeglasses to correct the nearsightedness and in combination with convex lenses in cameras and telescope.

Example Problem 04

An object 5.0 cm high is placed 10.0 cm in front of a concave mirror with a focal length of 12 cm. How large is the image and where it is located.

Known quantity:

$h_o = 5.0$ cm
$d_o = 10.0$ cm
$f = 12.0$ cm

Unknown quantities: h_i =? and d_i =?

Formula to be used:

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$$

Calculation:

$$\frac{1}{12} = \frac{1}{10} + \frac{1}{d_i}$$

$d_i = -2.72$ cm
$m = h_i \ / \ h_o = - \ d_i \ / \ d_o$
$h_i = - \ d_i \ h_o \ / \ d_o$
$h_i = \ -2.72 \times 5.0 \ / \ 10.0 \ = \ 1.36$ cm

Answer
The height of the image is 1.36 cm and the distance of image from the mirror is -2.72 cm.

Key Points

1. Light is the range of frequencies of electromagnetic waves that stimulates the retina of the eye.
2. The speed of the wave is equal to the product of wavelength into its frequency $c = \lambda f$
3. Reflection of light from such a smooth surface is called specular reflection.
4. If the reflecting surface is not smooth, the surface reflects the rays in a variety of Direction this type of reflection is known as diffuse reflection.
5. Refraction is the bending of light rays at the boundary between two media. Refraction occurs only when the incident ray strikes the boundary angle.
6. When light goes from a medium with a small n to one with a large n, it is bent toward the normal.
7. Light going from a material with a large n to those with a small n is bent away from the normal.
8. Mirror is a source of diverging light rays.
9. The image in the mirror is the same as the object. It is far behind the mirror as the object is in front of the mirror. The image is virtual and erect.
10. Concave mirrors from real, inverted images if the object is farther from the mirror than the focal point, the virtual, up right images of the object is between the mirror and the focal point.
11. Convex mirrors always produce virtual, upright, reduced images.
12. Convex lenses are thinner at their outer edges than at their centers. They produce real, inverted image if the object is farther from the lens than the focal point. If the object is closer, enlarged image is formed.
13. Concave lenses are thicker at their outer edges than at their centers. They produce virtual, upright, reduced images.

Self Assessment Exercise 5.5

Q.1 Answer the following questions:

i. The color of an object is aid to depend on wave length. So if you view colored objects under water, in which the wave length of the light will be different, does the color change?

ii. Does the angle of reflection from the surface of the material depends upon the wavelength?

iii. Why **does** a diamond flashes color when observed under white light?

iv. When looking through a glass window to outdoors at night, you sometimes see a double image of yourself, why?

v. When one looks at the stars on a clear night, they seems to be twinkling, as compare to the astronauts looking from space shuttle do not observe the twinkling effect, why?

Q.2 Select the correct answer

i. The focal length of the concave mirror is
   a) Positive
   b) Negative
   c) Small
   d) Don't exist

ii. The magnification is the ratio of the
   a) Height of object to height of image
   b) Height of image to height of object
   c) Height of mirror to height of image
   d) Height of object to height of mirror

iii. On the blind rounds of hilly areas what type of mirror are placed?
   a) Concave
   b) Convex

iv. A person who use glasses for the short sightedness will use the
   a) Concave lens
   b) Convex lens

v. Light source emits light in air with a wave length of 490nm. When passing through the water the wave length reduces to 429nm. The index of refraction will be
   a) 1.26
   b) 1.29
   c) 1.33
   d) 1.14

5.6 Sound

Sound is important to the human experience. You are already familiar with several of the characteristics of sound such as volume, tone and pitch. Much of the sound you hear during a day falls into specific patterns. Some sound patterns are characteristics of speech; other patterns are characteristics of music.

How is sound produced? Put your fingers against your throat as you hum or speak. Can you feel the vibration? Have you ever put your hand on the loudspeaker of a boom box? Figure 5.16 shows a vibrating piston that represents your vocal cords, a loud speaker, or any other sound source. As it moves back and forth, the piston moves forward, air molecules are driven forward; that is, the air molecules bounce off the piston with little or no change in velocity. When the piston moves backward, air molecules bounce off the piston with small velocity.

The result of these velocity changes is that the forward motion of the piston produce a region where the air pressure is slightly higher than average. The backward motion produces slightly below-average pressure. Collisions among the air molecules cause the pressure variations to move away from the piston. You can see how this happens by looking at the small red arrows that represent the velocities of the air molecules in Figure 5.16. The molecules converge just after the passing of a low-pressure region and the molecules diverge just after the passing of a high-pressure region. If you were to focus at one spot, you would see the value of the air pressure rise and fall, not unlike the behavior of a pendulum. In this way, the pressure variation is transmitted through matter.

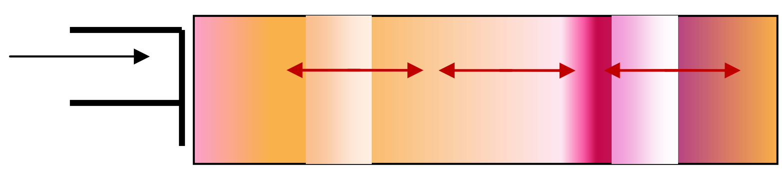

Fig: 5.22 a vibrating piston produces sound waves. The dark areas represent regions of higher pressure and light areas regions of low pressure.

A sound wave is simply a pressure variation that is transmitted through matter. Sound waves move through air because a vibrating source produces regular oscillations in air pressure. The air molecules collide, transmitting the pressure variations away from the source of the sound. The pressure of the air varies, or oscillates, about an average value, the mean air pressure, as known in Figure 5.17. The frequency of the waves is the number of oscillations in pressure each second. The wavelength is the distance between successive regions of high or low pressure. Because the motion of the air molecules is parallel to the direction of motion of the wave, sound is a longitudinal wave.

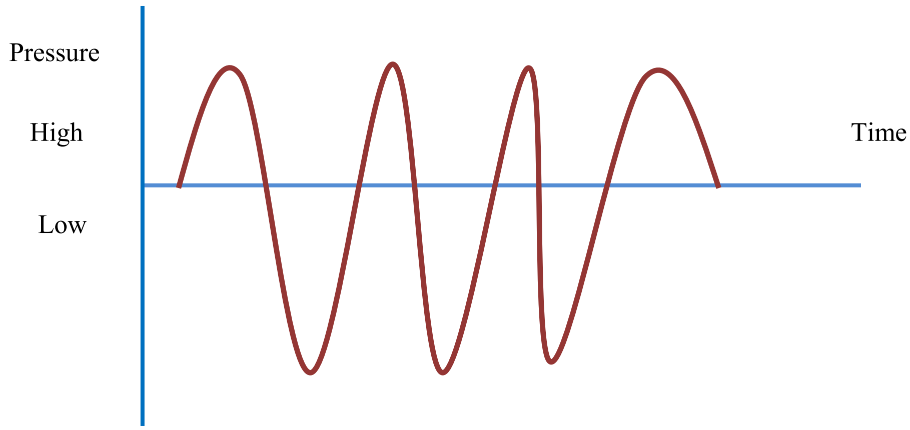

Fig: 5.23 a graphic representation of the change in pressure over time in a sound wave.

The speed of a sound wave in air depends on the temperature of the air. Sound waves move through air at sea level at a speed of 143 m/s at room temperature (20°C). Sound can also travel through liquids and solids. In general, the speed of sound is greater in solids and liquids than in gases. Sound cannot travel through a vacuum because there are no particles to move and collide.

Sound waves share the general properties of other waves. They reflect off hard objects, such as the walls of a room. Reflected sound waves are called echoes. The time required for an echo to return to the source and the reflective object. This principle is used by bats, by some cameras, and by ships that employ sonar. Sound waves also can be diffracted, spreading outward after passing through narrow openings. Two sound waves can interfere, causing "dead spots" at nodes where little sound can be heard. As you know, the frequency and wavelength of a wave are related to the speed of the wave by the equation $v = \lambda f$.

Another physical characteristic of the sound wave is amplitude. Amplitude is the variation in pressure along the wave. In human, the sound is detected by the ear and interrupted by the brain. The loudness of a sound as perceived by our sense of hearing, depending primarily on the amplitude of the pressure wave. Because of the wide range in pressure variations that a human ear can detect, this amplitude is measured on a logarithmic scale called sound levels. Sound levels are measured in decibels. The level depends on the ratio of the pressure variation of a given sound wave to the pressure variation in the most faintly heard sound, 2×10^{-5} Pa. such an amplitude has a sound level of zero decibels(0dB). A sound with a ten times larger pressure amplitude 20×10^{-4} pa is 20 dB.

5.6.1 Characteristics of Sound

How do we distinguish among the many sounds that we hear n, for example, we listen to a full orchestra playing a piece of music? There are three characteristics by which we identify sounds: loudness, pitch, and quality.

Loudness depends also on the distance of the listener from the source of the sound. If sound waves were visible, a sounding drum would be seen to be in the center of a series of concentric spheres, each sphere representing a compression of air particles. We recall that sound is form of energy. The energy in this instance is first imparted to the drumhead to the surrounding air. As the sound waves advances from sphere to sphere the energy is "spent" in setting more and more air particles in motion. The loudness or volume decreases with distance. In an auditorium, this loss is partially compensated for by the reflection and concentration of sound by the sides, back, and top of the hall.

The strings of a piano, on the other hand, are not large enough to cause very much of a "splash" in the air. To make their sounds louder, the strings are connected to a sounding board, which is set vibrating by the strings connected to it. Its broad area permits it to set a large amount of air into motion at any given moment. The same principle applies to the violin, cello, and all other stringed instruments.

To demonstrate this principle, rap the prongs of a tuning fork against the heel of your shoe and listen for the sound. Do this again, but this time press the end of the handle against a wooden table. The sound is louder because the fork's vibration is transmitted to the table, which, in turn, causes a large amount of air surrounding it to begin vibrating.

The loudness of a sound may be measured by means of a sound level meter. The unit for measuring sound is the decibel ("bel" from alexader Graham Bell). The resulting leaves in a light breeze have a rating of about 10 decibels; sound within the average home about 20 decibels; traffic at a busy intersection about 55 decibels; a machine shop 100 decibels; a plane taking off 110 decibels; and very loud thunder 120 decibels. At 120 decibels sound becomes physically painful. Continuous noise above 150 decibels is thought to be harmful to a person's emotional well-being. The problem of "noise pollution" in modern life is one that is compelling more and more attention.

Loud sounds are not universally disliked. Most young people eagerly attend a pop music concert that produces sound intensity levels in excess of 110 decibels. The audience is not immune from the risk of hearing impairment, but the band members are almost certain to sustain permanent hearing loss due to greater exposure time and closeness to the speakers.

Pitch: If sound is compared to an ocean wave, then loudness, as we have seen, is associated with the height, or amplitude, of the wave. Pitch, by the same analogy, is a characteristic determined by the frequency, the number of waves that pass a point in given period of time. In the science of sound we say that pitch depends on the number of vibrations per second made by the vibrating body. By definition one vibration, sometimes called a cycle, includes both the backward and forward motion of the vibrating body. (The international unit for frequency is the Hertz (Hz, defined as one cycle per second.)

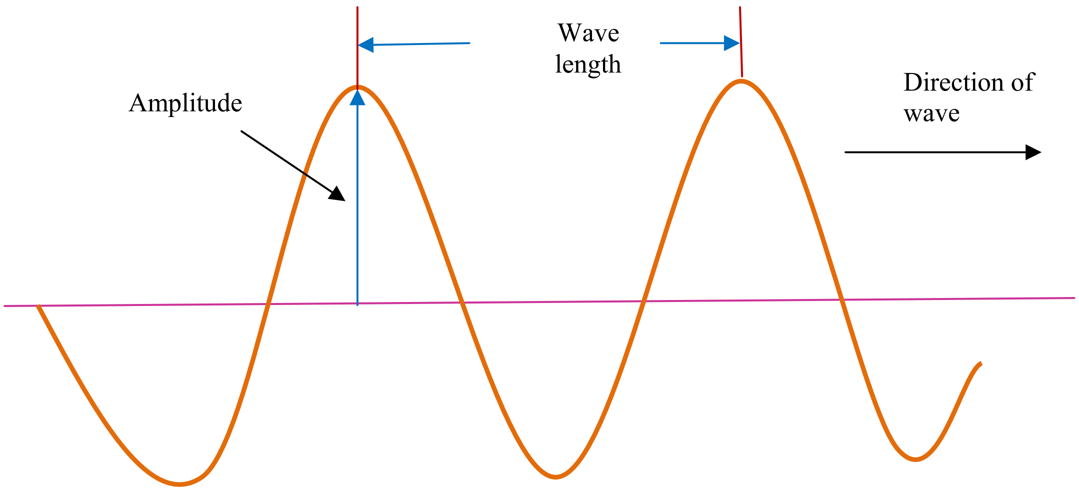

Fig: 5.24: Graphic representations of a sound wave the amplitude, or height of the crests above or below the baseline, determine the loudness of the sound. The wavelength determines the pitch of the sound: the longer the wave length, the lower the pitch.

The ear of human being is able to pick up vibrations ranging from 16 to 20,000 vibrations per second (children exceed this upper limit), with the greatest sensitivity around 1,000 to 5,000 vibrations per second. It is no accident that sirens and emergency vehicles' horns are pitched near these frequencies. Insects and other animals may detect sound that humans cannot. Special dog whistles produce a high-pitched ultrasonic sound that is audible to dogs but not to human beings.

How are sounds of different pitch produced in string instruments? If you look inside a piano you will see that three factors are responsible for the difference in pitch of the various strings: length, weight per unit of length (which depends on the thickness and the material used), and tightness. Low notes are produced by long, heavy, loose, strings whereas high notes by short, light, more tightly stretched strings. In general, a long string (or a heavy or loose one) vibrates slowly; consequently a low-pitched note is produced. A short string (or a light or more tightly stretched one) vibrates rapidly, producing a high pitched sound.

Quality: We recall that loudness depends on the strength and that pitch depends on the frequency of the sound wave. Quality depends on the "shape" imposed on the sound waves by the overtones. The production of overtones can be demonstrated by a simple experiment.

If you stretch a guitar string between two screws that are firmly set in a board, and pluck the string, it will vibrate throughout its entire length, producing a musical tone. This, the lowest tone that the string is capable of producing, is called its fundamental. If you now press down the middle of the string tightly with one finger and pluck either half string, that part will vibrate to produce a tone one octave higher than when the whole string vibrates. This note is called the first overtone. Now, if you remove your finger quickly while half of the string is vibrating, the string will vibrate not only in half its length but also as a whole-at the same time. You then should hear two sounds-the note made by the string vibrating in half its length.

If you now place your finger one third of the way from the end of the string (at either end) and hold it down, plucking this third of the string will produce a note higher than the first overtone. This is the second overtone. Many other overtones are possible.

In the playing of musical instruments a large number of overtones are produced simultaneously with the fundamental tone. The number and intensity of the overtones are different in different instruments. Thus, a flat on a clarinet sounds different from a flat on a violin. In singing or speaking, some individuals are able to produce more overtones than others. They can do this in part because they are skilled in controlling their voices. The number of overtones given off by a violin and other musical instruments depends on their construction, as well as on the skill of the musician. The difference in character of two tones of the same pitch and loudness is due, then, to the difference in the relative prominence of the fundamental and the various overtones.

5.6.2 The Ear

The human ear is a device that collects pressure waves and converts them to electrical signals. The human ear is divided into three regions, the outer ear, the middle ear and the inner ear. The outer ear consists of ear canal (open to the atmosphere), which terminates at the ear drum. Sound waves travel down the ear canal to the ear drum, which vibrates in and out in phase with the pushes and pulls caused by the alternating high and low pressures of the sound wave. Behind the ear drum are three small bones of the middle ear, called the hammer, anvil and the stirrup because of their shapes. These bones transmits the vibration to the inner ear, which contains the cochlea, a snail shaped tube of about 2 cm long. The cochlea makes contact with the stirrup at the oval window and is divided along its length by the basilar membrane, which consists of small hairs and nerve fibers. This membrane varies in mass per unit length and in tension along its length and different portions of it resonates at different frequencies. (Recall that the natural frequency of the string depends upon on its mass per unit length and on the tension on it.) Along the basilar membrane are numerous nerve endings, which sense the vibration of the membrane and in turn transmits impulse to the brain. The brain interprets the impulse a sound of varying frequency, depending on the locations along the basilar membrane of the impulse- transmitting nerves and on the rate at which the impulses are transmitted. This is simplified description of the complex functioning of the ear.

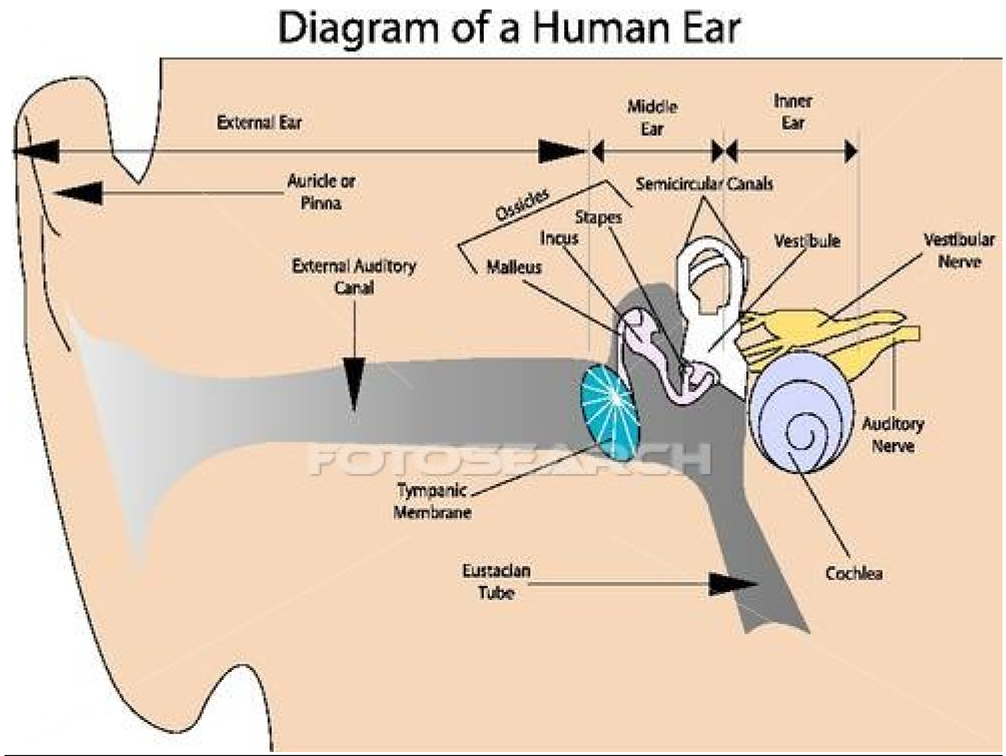

Fig: 5.25 graphical representation of human ear

Example Problem 05

A tuning fork produces a sound wave in air with frequency of 250 Hz. At room temperature the speed of sound is 450 m/sec. What is the wave length?

Known quantities: $f = 250$ Hz

$v = 450$ m/sec

Unknown quantity: $\lambda = ?$

Formula to be used: $\mathbf{v = \lambda f}$

Calculation:

$v = \lambda f$, $\lambda = v/f$

$$\boldsymbol{\lambda} = \frac{450\,\text{m/sec}}{250\text{Hz}}$$

$\lambda = 1.8$ meter

Answer: The wave length of the tuning fork is 1.8 meter.

Key Points

1. A sound wave is simply a pressure variation that is transmitted through matter. Sound waves move through air because a vibrating source produces regular oscillations in air pressure.
2. The speed sound of the wave is equal to the product of wavelength into its frequency.
   $c = \lambda f$
3. The speed of a sound wave in air depends on the temperature of the air. Sound waves move through air at sea level at a speed of 143 m/s at room temperature (20°C).
4. The loudness of a sound as perceived by our sense of hearing, depending primarily on the amplitude of the pressure wave.
5. Pitch depends on the number of vibrations per second made by the vibrating body. By definition one vibration, sometimes called a cycle, includes both the backward and forward motion of the vibrating body.
6. The human ear is a device that collects pressure waves and converts them to electrical signals.

Self Assessment Exercise 5.6

Q.1 Answer the following questions:

i. If you have a series of identical glass bottles, with varying amounts of water in them, you can play musical notes by either striking the bottles with a spoon or blowing across the open tops of the bottles. When hitting the bottles, the frequency of the note decreases as the water level rises. When blowing on the bottles, the frequency of the note increases as the water level rises. Why is the behavior of the frequency different in these two cases?

ii. Why does a vibrating guitar string sound louder when placed on the instrument than it would be allowed to vibrate in the air while off the instrument?

iii. In the thunder storm the lightening effect produce a giant and rolling sound, why?

Q.2 Select the correct answer

i. Two sirens are sounding so that the frequency from A is twice the frequency from B. Compared to the speed of sound from A, the speed of sound B is

(a) twice as fast
(b) half as fast
(c) four time as fast
(d) one fourth as fast
(e) the same

ii. When two tuning forks are sounded at the same time, a beat frequency of 5 H_Z occurs. If one of the tuning forks has a frequency of 245 H_Z, what is the frequency of the other tuning forks?

(a) 240 H_Z

(b) 242.5 H_Z

(c) 247.5 H_Z

(d) 250 HZ

(e) More than one answer could be correct.

Answers

Answers of Self Assessment Exercise 5.1

Q.1

i. When a bowling ball rolls on a marble floor, the earth gravity has the attraction towards the bowling ball but the friction between the marble ball and the bowling ball is very less.

ii. If three objects exert forces on a single object, if their directions are the same then the resultant force will act an action either push or pull. But if the directions of the three forces are different then the resultant force will be the summation of x and y components of these forces. These resolved forces uses sign conventions positive in one direction and negative in another direction.

Q.2

i. b
ii. c
iii. a
iv. c

Answers of Self Assessment Exercise 5.2

Q.1

i. The kinetic energy formula is $\frac{1}{2} mv^2$. Heavier bodies with great mass possess the great kinetic energy and light weights have less mass so less kinetic energy. The higher kinetic energies led the high speeds also.

ii. 125

Q.2

i. a
ii. a
iii. b

Q.1 Answers of Self Assessment Exercise 5.3

i. Less force is necessary with a larger ramp, but the force have to act over the long distance to do the same work.

ii. No motion means no work done on the rope. No work is done on the pullers or the ground. But the energy is required by the pullers to pull the rope.

iii. A car accelerates because of the frictional force between the road and the tires. This force is in the direction of the movement of the car and produces an increase in the kinetic energy.

Q.2

i. d
ii. a
iii. c

Answers to the self Assessment exercises 5.4

Q.1

i. When the coil is immersed in water, the coil depends upon the convection of the water at safe temperature. In boiling water the temperature cannot go more than 100ºC. In the normal air the convection process is reduced and the upper limit of the 100ºC is removed. As a result the temperature can go above the 100ºC and which is very dangerous.
ii. The large amount of energy stored in the concrete during the day as the sun falls on it, released at night resulting an overall high temperature than the village areas. The heated air of the city becomes hot and replaced by the cooler air of the village. Thus in the evening the air blow from the village areas to the city.
iii. The tile is a better conductor of heat than carpet. Thus energy is conducted away from your feet more rapidly by the tile than by the carpeted floor.
iv. The hotter objects transfer energy to the colder objects and as a result the motion of the molecules got energized until the cool object is in equilibrium with the hot object.
v. The conductivity of metals is more than the wood so in the cold day the door knob is at the near temperatures of the environment than the wood.

Q.2

i. b
ii. c
iii. a
iv. c
v. b

Answers of Self Assessment Exercise 5.5

Q.1

i. The color will not change. First, despite the fact color depends upon the wave length but it actually depends upon the frequency of the light, which does not change under the water. When the light enters the, it travels through the fluid within the eye. Thus, even if color did depend upon the wave length, the important wave length is that of the light in ocular (eye) fluid, which does not depend on the medium through which the light travelled to reach the eye.
ii. There is no dependence of the angle of reflection on wave length, the light does not enter deeply into the material during reflection, it only reflects from the surface.
iii. The diamond acts like a prism in dispersing the light into its spectral components. Different colors are observed as a consequence of the manner in which the index of refraction varies with the wave length.
iv. Reflection occurs whenever there is an interface between two substances. For the glass in the window, there are two surfaces, the first is the inner surface of the glass, and the other is the inner surface of the glass. Each of the interfaces has an image.
v. The twinkling effect is due to the refraction of light from a star as it enters in the earth's Atmosphere. Atmospheric turbulence causes rapid variation in local air density and a change in the air density results in index of refraction. The rapid

change in the index of refraction cause the light to enter the eyes from slightly varying directions, resulting in the twinkling effect.

Q.2

i. a
ii. b
iii. c
iv. a
v. d

Answers of Self Assessment Exercise 5.6

Q.1

i. When the bottles are struck, standing wave vibrations are established in the glass material of the bottles. The frequencies of these vibrations are determined by the tension in the glass and the mass of the glass material. As the water level rises, there is more mass, because the glass is in contact with the water. This increased mass decreases the frequency. On the other hand, blowing into a bottle establishes a standing wave vibration in the air cavity above the water. As the water level rises, the length of this cavity decreases, and the frequency rises.

ii. A vibrating string is not able to set very much air into motion when vibrated alone. Thus it will not be very loud. If it is placed on the instrument, however, the string's vibration sets the sounding board of the guitar into vibration. A vibration piece of wood is able to move a lot of air, and the note is louder.

iii. When lightening strikes, a channel of ionized air carries a very large electric current from the cloud to the ground. This result in a rapid temperature increase in the channel of air as the current moves through it. The temperature increase causes a sudden expansion of air. This expansion is so sudden and intense that a tremendous disturbance is produced in the air.

Q.2

i. e
ii. c

Unit–6

ELECTRICITY & MAGNETISM

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CONTENTS

Introduction

As you know that electricity is such a common tool that we often take it for granted. Its importance is never truly considered until it is missing. Electric energy is essential in our daily life because it can easily be changed into others form of energy i.e. sound, thermal energy, light and motion. Electric energy provides the means to transfer large quantities of energy at high potential differences through power lines.

In the 18A.D, a famous scientist named Benjamin Franklin did vast research in the field of electricity. He had joined a metal key at the end of a string of kite and then flown the kite in a storm-endangered sky in 1752 A.D. A series of electrical sparks reached to his hand through the key attached, so he revealed that lightening was actually electrical in nature.

You all know that electrically charged particles reached to the earth from sun in streams. These electrically charged particles smash together with the atoms in the earth's vicinity and enable them to release energy in the forms of flashes of light. The existence of magnets and magnetic fields has been recognized since 2000 years . Today magnets are playing an important role in our daily lives.

We all know that electricity and magnetism are inter-link together. Magnets have the property to create electricity and the electricity can generate magnetic fields. With the change of magnetic field, an electric field is produced. Magnetism and electricity are co-related with each other; you cannot separate them. Loud Speakers, generators, electric motors, T.V sets and computer screens depend on the magnetic effects of electric current.

Objectives

After reading the unit, you will be position to:

- recognize electric forces that charged objects exert.
- explain the connection between the current, electric circuit and potential differences.
- illustrate the relationship among magnetism, electric charges and electricity.
- calculate electric current, the voltage drops from the devices attached in series and parallel circuits.
- describe how changing magnetic fields can generate electric current and potential differences.
- illustrate the transfer of electrical energy through heavy transmission line over long distances.
- describe that magnetism of the materials is the property that take action at an atomic or subatomic level in the presence of applied magnetic field.
- explain the role of magnetic compass and its uses in daily life.

6.1 Static Electricity

A nylon garment often crackles when it is taken off. We say it has become charged with static electricity the crackles are used by the eclectic sparks which can be seen in the dark. When you comb your hair, the transfer of electrons from your hair to the comb makes it negative charge, so, when the comb is brought near the small pieces of paper. The negatively charged electrons attract the positive charges of the small pieces of paper and this attractive electrical force attracts the paper pieces in the upward direction working against the force of gravity.

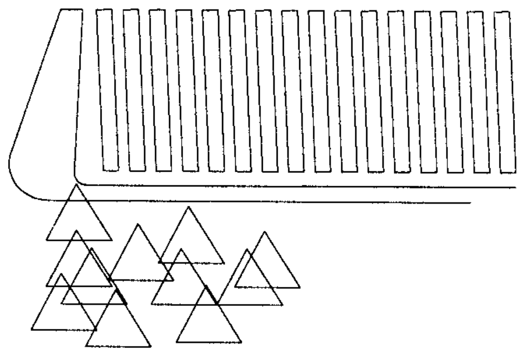


Fig: 6.1 Running a comb, the hair transfer electrons to the comb.

Electrical effects produced this way are called static electricity. In nature two types of charges are present, the positive and the negative charge. Material such as polythene can be charged by friction when a strip of polyphone is rubbed with a dry woolen marital it becomes negatively charge. The formation of the charges on the polythene strip by friction can be explained in terms of the movement of electrons, with wool, some of the loosely held electrons in wool are transferred to the polythene.

6.1.1 Charge Objects

An object that exhibits electrical interaction after rubbing is said to be charged , when a plastic strip is rubbed with the woolen cloth it becomes charged if it is hung up and another rubbed plastic strip/role is bought near, it repels attraction occurs when a rubbed cellulose acetate strip approaches. This shows that there are two kind of electric charge that on cellulose acetate is taken as positive (+ve) and on polythene is negative (–ve) . It also shows that like charged (+ve and +ve, -ve and -ve) repel and unlike charge (+ve and -ve) attracts. The force between electric charges decreases as their separation increases.

Electrical charges exist within atoms. In 1980, a famous scientist J.J Thomson revealed that all materials in nature contains light negatively charged particles, he named electrons. Between 1909 and 1911 Ernest Rutherford discovered the atom has massive positively charged nucleus, if the positive charge of the nucleolus exactly balance the negative charge of the surrounding electrons then the atom is neutral.

With the addition of energy the outer electrons can be removed from atoms. An atom with missing electrons has an overall positive charge. The free electrons can remain unattached are become attached to other atoms, resulting in negatively charged particles. From a microscopic view acquiring charge is a process of transferring electrons.

The charge on electrons is negative charge and protons possesses positive charge, which are opposite in sign. Usually, symbol Q is used to denote the amount of charge and unit of charge is countered in coulombs. Both the charges has the same amount if charge of approximately 1.6022×10^{-19} coulomb. There is a positive charge on proton whereas the -ve charge was assigned to electron.

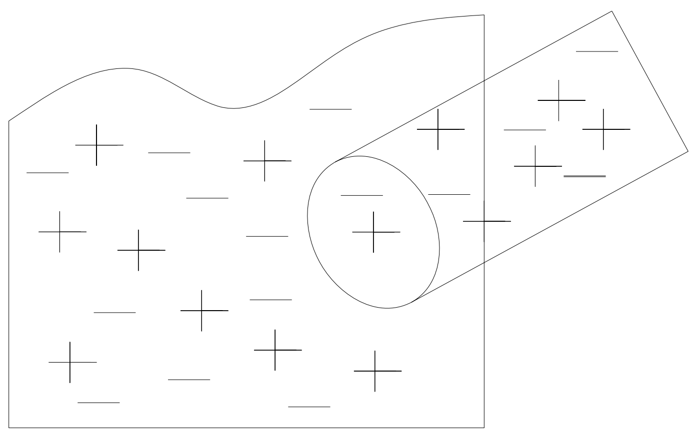


Fig. 6.2 The rubber rod rubbed with the wool, electrons removed from the wool passes to the rubber rod

If two neutral objects are rubbed together each can become charged. For instance plastic rod and wool are rubbed together electrons from atoms on the wool are transferred to the plastic rod and the extra electron on the plastic rod result in a net negative charge. The electrons omitted from the wool effect in a net positive charge. The combined total charge of the tow objects remain the same, what happened was that the positive and negative charges were separated though a transfer of electrons.

6.1.2 Coulomb's Law

As we all know that there is a force of attraction between the charged objects. This condition is a qualitative analysis, but the quantitative analysis was first done by a French scientist Charles Coulomb in 1785A.D. His experiments show that the electric force has the following properties:

- ❖ The attractive force is inversely proportional to the distance between the two charged objects and along the line joining them.
- ❖ This force is directly proportional to the product of the two charges ie. q1 and q2.

So by these statements the law of attraction **Coulomb's Law** was generated, which states

> **"Charged bodies have attractive or repulsive force, which is directly proportional to the product of the two charge and inversely proportional to the distance between them"**

$$F \propto q_1 q_2$$

$$F \propto 1 / r^2$$

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = ke \frac{q_1 q_2}{r^2} \qquad \text{Equation 6.1}$$

q_1 = charge on the first body

q_2 = charge on the Second body

r = distance between them

Ke = Coulomb Constant

Ke is Coulomb constant and its value is 9×10^9 Newton. m^2 / C^2

$$ke = \frac{F \times r^2}{q1 \times q2}$$

$$ke = 9 \times 10^9 \text{ Newton} . m^2 / C^2$$

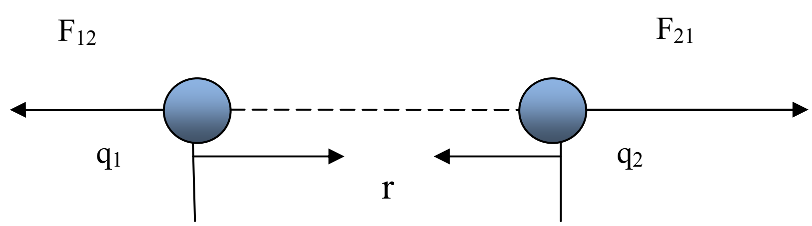


Fig. 6.3 Two similar point charges separated by a distance r exert a repulsive force on each other

While talking about the Coulomb force, it must be remember that force is a vector quantity. The coulomb's law is applicable only to point charges and to spherical distribution of charges. Electric force obeys Newton third Law that F_{12} is equal to F_{21} in magnitude but opposite in direction.

6.1.3 Conductors and Non Conductors (Insulators)

Conductance is the quantity that measures a substance's capacity to conduct an electric current. Material such as metals that allow charges to canyon conducts. Electrons carry or conduct electric charge through the metal. Metals are good conductors because it is easy to remove the electrons from the outer shells of the atoms of the metals. These electrons move freely all over the outer shells of atoms of metals.

In an atom the electrons have certain energy levels, when large numbers of theses energy levels are grouped together, they form energy bands. These bands are generally dependent upon the number of electrons present in the atom and their distribution across the atom. In case of conductors, the electrons move freely in these bands throughout the whole material when some potential difference is applied. Copper is an excellent conductor that is used commercially to carry electricity

Given below figure illustrates how charge behave when placed on a conductor or an insulator.

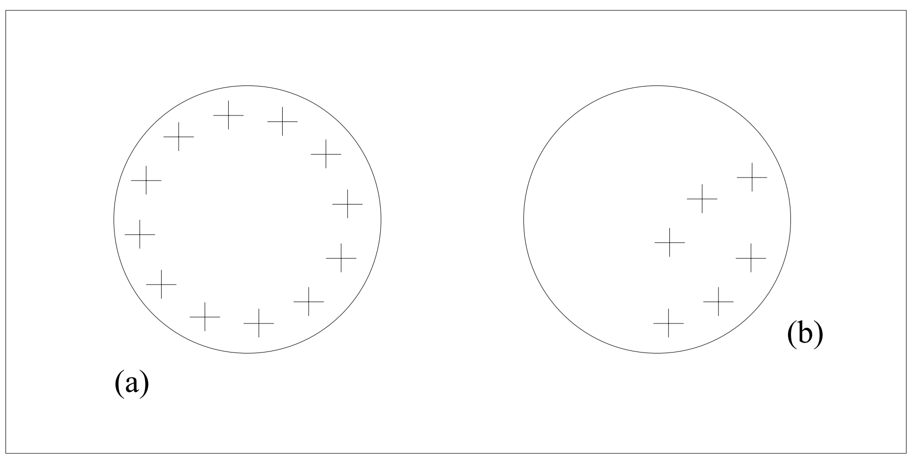


Fig. 6.4(a) Charges placed on a conductor will spread over the entire surface

(b) Charges placed on an Insulator will remain where they are placed.

Material through which charge will not move easily are called electrical insulators or non-conductor. Glass, dry wood, plastics, cloth and dry air are all good insulators. Some material such as polythene by holding them in hands and rubbing with dry cloth become charged, Moreover it is not possible to do likewise with materials like copper, aluminum or steel. In insulators, the electrons exist in a prohibited band of energy levels, so a large amount of energy is required to energize these electrons.

Good Conductors	Semiconductors	Insulators
Silver Copper Aluminum Tungsten Iron	Carbon Germanium Silicon	Plastic Glass Rubber Nylon Paper

Table 6.1 Electrical Conductors & Non conductors

We have discussed about the conductor and their properties at atomic levels.

The Property that enables a conductor to pass current is the conductivity of that material. The opposite criteria of conductivity is the resistivity, is a measure of how powerfully a material resists the flow of electric current.

The unit of the resistivity is (ohm-meter) Ω m. The resistivity of a material mainly depends upon the length, cross sectional area and temperature of that substance. If R is the resistivity, then

$$R \ \alpha \ L$$

$$R \ \alpha \ 1/A$$

$$R \ \alpha \ L/A$$

$$R = \frac{\rho L}{A} \qquad \text{Equation 6.2}$$

L= length of conductor, A = Cross sectional area, ρ = resistivity of the conductor

The equation 6.1 reveals that the as the length of the substance increases then the resistance also increases. The greater cross sectional area means large space for the electrons to flow, so low resistance. This case is similar to the flow of water in a pipe, the longer the length of the pipe, the flow of water is slow, as the diameter of the pipe is large, and the flow rate is also large.

With the rise in temperature of the conductors, the motion of the particles of the molecular structure increases. Therefore it creates difficulty to the flow of “free” charge carrier to pass through, hence the level of resistance increases. We can say that the resistance will be high if temperature will be increases. The situation is different in semiconductors and insulators.

Activity: 1

Are there different types of electric charges?

Material Required

Two glass rods, two ebonite rods, piece of silk cloth, piece of woolen cloth, stand, and fine thread.

Procedures and Observations

4. Rub a glass rod with a piece of silk. Test it to see if it is electrically charged. Write down how you did the test and what the result was.

   ____

   ____

5. Suspend the charged rod with the help of the thread. Rub another glass rod with a piece of silk and bring it near to the suspended rod. Describe what happens.

   ____

   ____

6. Repeat step 2 with two ebonite rods rubbed with a woolen cloth. Describe what happens.

   ____

   ____

7. Now bring a charged ebonite rod close to the suspended charged glass rod. Describe what happens.

   ____

   ____

Key Points

4. Two kinds of electrical charges are present in nature, positive and negative. Similar charges repel each other and dissimilar charges attracts each other.
5. The transfer of electrons makes the objects positively charged.
6. The symbol Q is used for the amount of charge and the unit used is coulombs
7. Each electron and proton carries the same amount of charge of approximately 1.6022×10^{-19} coulomb.
8. Charging is the separation of electrons from their shells, not the creation of electrical charge on the charged object.
9. Charged bodies have attractive or repulsive force, which is directly proportional to the product of the two charges and inversely proportional to the square of the distance between them.
10. Materials through which charge will not move easily are called electrical insulators or non-conductors.
11. Through electrical conductors charge can pass easily.
12. The property that enables a conductor to pass current is the **conductivity** of that material.
13. The opposite criteria of conductivity is the **resistivity**, is a measure of how powerfully a material resists the flow of electric current.
14. The Charges added to a conductor quickly spread over the surface of the object.
15. With the increase of temperature of a conductor, the resistance will be high.

Self Assessment Exercise 6.1

Q.1 Answer the following questions:

- i. Can you describe how substances become electrically charged?
- ii. Name the type of charge developed on:
  - a) A glass rod when it is rubbed with a piece of silk cloth.
  - b) An ebonite rod when it is rubbed with a piece of woolen cloth.
- iii. There are two wires, one wire's diameter is double the diameter of the second wire, and in your opinion electricity with least resistance will pass through which wire, the large diameter wire or the small diameter wire?
- iv. What property makes a metal a good conductor and rubber a good insulator?

Q.2 Fill in the Blanks

i. In an atom each __________________ has a negative charge.

ii. If the excess of electrons are removed from any atom, it becomes _____________ charged.

iii. This is the property of the similar charges that they _______________ each other and the dissimilar charges ________ each other.

iv. The unit of charge is _____________.

v. The amount of charge on an atom is __________________ Coulomb.

vi. Charles coulomb is a ____________ scientist.

vii. Attractive force between two dissimilar charges is inversely proportional to ______________ between them.

viii. According to coulomb law if the distance between the two charges becomes double then the amount of force between them is ____________________.

6.2 Electric Field

Michael Faraday was the first to introduce the concept of the electric field . An electric field is produced by a charged body in the environment around it. This exerts a force on any other charged body located within the field. The electric field is generated between two charges in the same manner as the force of attraction exists between two objects in the gravitational field. The electric field can be generated as a result of either attractive forces or repulsive forces.

Electrostatics is called the study of electric fields generated by the stationary charges in their vicinity. The field may be imagined as aligned imaginary lines whose direction is the same as that of the field at any point. This concept was first introduced by Faraday, and the term "lines of force" are still in use.

The field lines are the paths made by a point positive charge would make as it was forced to move in the vicinity of the field. Actually these are imaginary lines with no physical existence.

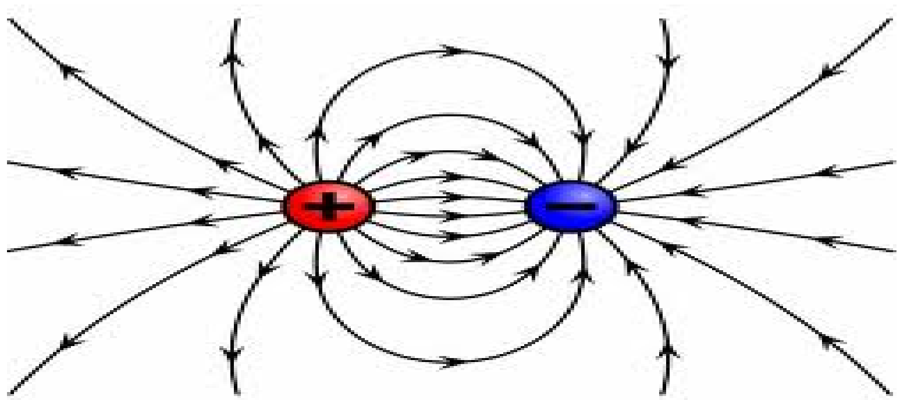


Fig 6.5 Electric lines of forces in a unit charge & between two opposite charges

Field lines emerging from stationary charges have the key property that they originate from positive charges and terminate at negative charges. The field strength is greatly affected by nearby conducting objects, and it is particularly intense when it is forced to curve around sharply pointed objects.

According to the Coulomb's law, the electrostatic force is directly proportional to the charges. If the amount of the test charge is doubled, the force is double. Any charge placed in an electric field experiences a force on it resulting from the electric field at that location.

The strength of the force depends on the magnitude of the electric field E, and the amount of the charge, q. To each point in an electric field is associated with a quantity known as electric field intensity.

"The electric field intensity at a point in an electric field is the force per unit charge acting on a positive charge placed at that point".

Thus $\mathbf{E = F / q}$ and Equation 6.3

$\mathbf{F = E\ q}$ Equation 6.4

The direction of the electric field is the direction of the force and the magnitude of the electric field is measured in Newton per coulomb, N/ C.

6.2.1 Electric Potential

The notion of electric potential is very much associated to that of the electric field. If a charged body is placed inside in an electric field, it experiences a force. To bring that charge to that point against the electric force requires work. This electric potential at any point is defined as the energy required bringing a unit test charge from an infinite distance to that point. It is commonly measured in Volts. One volt is the potential for which one joule of work must be spent to bring a charge of one coulomb . Potential difference is the energy required to move a unit charge between two specified points.

"The potential difference between two points in a circuit is 1 volt if 1 joule of electrical changed into other forms of energy when 1 coulomb passes from one point to the other".

It is a scalar quantity, that is, it has no direction and only has magnitude. It may be visualized as similar to height. As an object is released by some height will fall by a gravitational field, so a charge will "fall" across the voltage caused by an electric field.

The **Power** of energy delivered per second is represented by the following Equation:

$P = VI$ Equation 6.5

V= Volt, I = Ampere P = Watt

And **Electric energy** $E = Pt$ Equation 6.6

= Watt (Joules/sec) x sec = Joules

6.2.2 Electric Current

Electric current is simply the flow of electric charges. In metals electrons are free to move. Fig.6.6 shows two conductors A and B which are connected by a wire conductor C, Charges flow from the high potential difference of B to A through C. This flow of positive charge is called the conventional current. The flow stops when the potential difference of A, B and C is same. How could you keep the flow going? You would have to maintain a potential difference between A and B. This could be done by pumping charged particles form conductor A back to conductor B. The electric potential energy of the charges would have to be increased by any source of electric energy e.g. dry cell.

Conventionally, the direction of current was defined as in the direction of flow of positive charges. Current defined in this manner is called conventional current .

The motion of negatively charged electrons around an electric circuit is one of the most familiar forms of current. It is considered as positive charge because its direction is opposite to the direction of the electrons. However, an electric current can consist of a flow of charged particles in either direction.

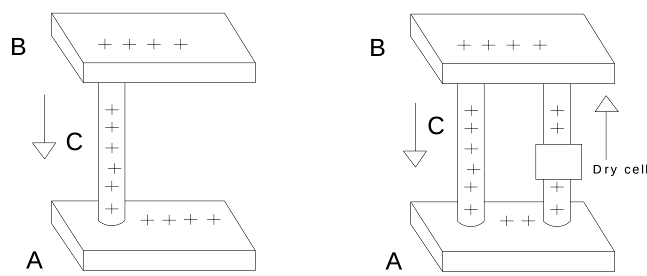


Fig 6.6 Conventional Current

In metals, the charge is carried by free electrons, whereas in electrolytes, such as acidified water, the charge carriers are negative and positive ions. Electric current is measured in Amperes and denoted by symbol “A”. The Ampere is the base unit. The unit of charge, Coulomb C is defined in terms of the amperes. “One coulomb is the charge passing through any point in a circuit, when a steady current of 1 ampere flows for 1 second”. Since current is the rate of flow of charges in a closed circuit. The current “I” and charge “Q” can be related by the equation.

$$I = dQ / dt$$

Ampere = Coulomb / second

If a constant current “I” flow for a time “t”, the charge that flows through is

$$Q = It \qquad \text{Equation 6.7}$$

Example Problem 01

An electric field is measured with a positive test (p) of 10.0×10^{-5} C. The test charge feels a force of 1.0 N acting at an angle of 20 degree. What is the direction and magnitude of the electric field at the location of the test charge?

Sketch of the problem

First of all sketch the force vector on the test charge p at an angle of 20 degree.

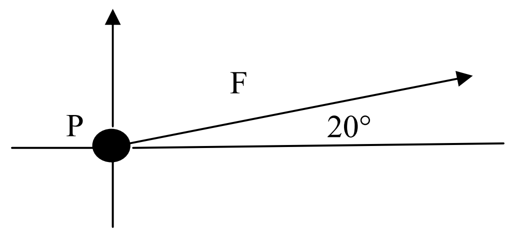


Fig. 6.7 the charge has 20 º orientations

Known

P= 10.0×10^{-5} C
F= 1 .0 n at 20°

Unknown

E =? at 20°

Formula **E= F/q**

Calculation

$$E= F/ q =1.0 \text{ N} / 10.0 \times 10^{-5} \text{ C}$$

$$E= 10.0 \times 10^{3} \text{ N/ C at } 20°$$

Example Problem 02

If the 15 Amp current flows through a wire, what charge it posses in

a) 25 seconds

b) 5 minutes

c) 30 seconds.

Known

I = 15 Amp

T = 25 sec, 5 min, 30 sec

Unknown

Q =?

Formula Q = It

Calculation

i) Q= I x t = 15Amp x 25 sec = 375 coulomb
ii) Q= I x t = 15 Amp x 300 sec = 4500 coulomb
iii) Q= I x t = 15Amp x 30 sec = 450 coulomb

6.2.3 Capacitors

As you know, charge cannot be store on a conductor for a long time. The force between the reserved charges can't hold them and therefore they can be leaked out from the conductor. To store the charges for long time, a device is used which is called capacitor. It consists of two parallel plates separated by small distance. Any sheet of insulator or air is placed between the plates, which is called dielectric. It is called a parallel plate capacitor.

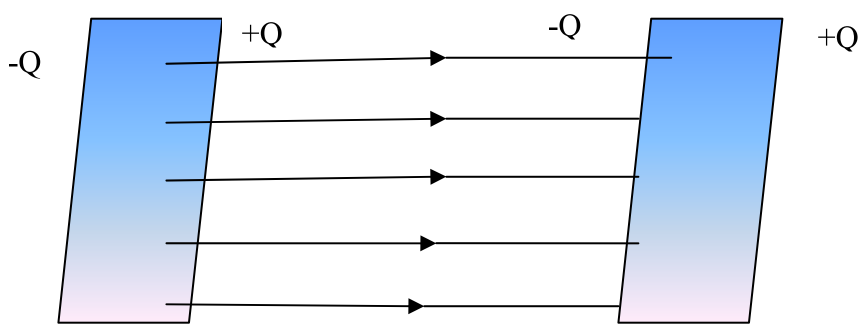


Fig 6.8 A parallel plate capacitor

When used in an electric circuit, the plates are connected to the positive and negative terminal of the battery or some other voltage source. When this connection is made, electrons are pulled off one of the plates, leaving it a charge of +Q and transferred through the battery to the other plate, leaving it with a –Q charge, as shown in the figure 6.7. This charge transfer stops when the potential difference across the plates equals the potential difference of the battery. Thus a charged capacitor acts as a store house of charge and can be used whenever needed for some application.

To conduct a charge on a body some work is done on the conductor, due to which the potential of the conductor increases. As the addition of charge is taking place, simultaneously the potential is increases. The charge of the conductor Q and the potential V are directly proportional to each other.

$$Q \propto V$$

$$Q = CV \qquad \text{Equation 6.8}$$

Where C is the proportionality constant and is called the capacitance

$$C = Q / V \qquad \text{Equation 6.9}$$

Capacitance is defined as a ratio between the quantity of stored charge and the value of the potential difference between the plates of the capacitors. The unit of capacitance is coulomb per volt or Farad, F. 1 F = 1 C/V. The capacitance of a device depends upon the geometric arrangement of the conductors. The capacitance of the parallel plate capacitor whose plates are separated by air is $C = \varepsilon o\, A / d$. Where A is the area of the plate, d is the distance between the plates and εo is called the permittivity of free space. $\varepsilon o = 8.85 \times 10^{-12}\ C^2/N.m^2$.

Commercial capacitors are often made using metal foil intermingled with thin sheets of paraffin- impregnated paper or Mylar, which serves as the dielectric materials. These alternate layers of metal foil and dielectric are then rolled into a small cylinder. A high voltage capacitor commonly consists of a number of inter-woven metal plates immersed in silicone oil. Small capacitors are constructed from ceramic materials. Variable capacitor usually consists of two interwoven sets of metal plates, one fixed and the other moveable, with air as the dielectric.

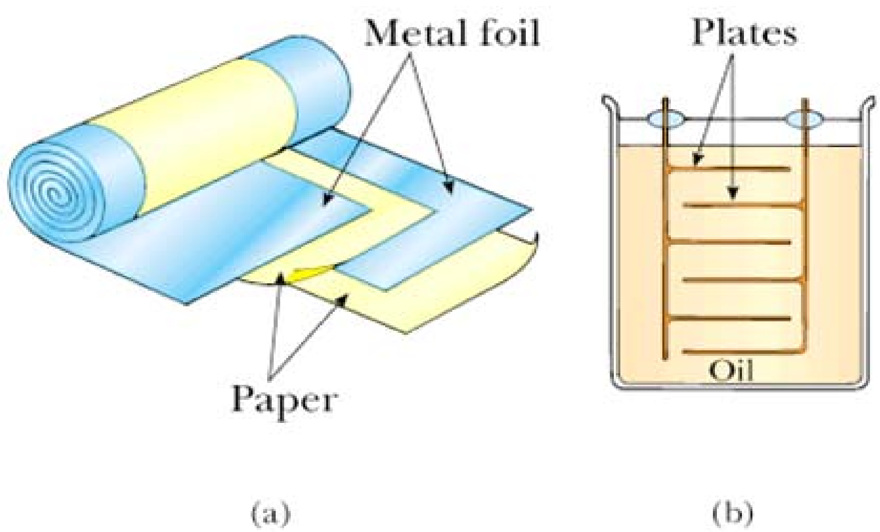


Fig 6.9 A parallel plate capacitor

Key Points

1. Flow of charged particles in either direction causes an electric current.
2. One coulomb is the charge passing through any point in a circuit, when a steady current of 1 ampere flows for 1 second. Since current is the rate of flow of charges, the current I and charge Q can be related by the equation:

$$I = dQ / dt$$

3. An electric field exists around any charged object. The field exerts force on other charged bodies.
4. The electric filed intensity is the force per unit charge.
5. Electric potential difference is the change in the potential energy per unit charge in an electric field. Electric potential difference is measured in volts.
6. To store the charges for long time, a device is used which is called capacitor. It consists of two parallel plates separated by small distance.
7. Capacitance is defined as a ratio between the quantity of stored charge and the value of the potential difference between the plates of the capacitors.
8. The unit of capacitance is coulomb per volt or Farad, F. 1 F = 1 C/V.

Self Assessment Exercise 6.2

Q.1 Answer the following questions:

i. In a uniform electric field, if a proton is discharged from rest position, will its potential energy enhances or become low.
ii. Why is it unsafe to touch the high voltage capacitor even the applied source is removed from it?
iii. Could you assume that the electric field lines cross each other?
iv. Can you imagine at a point the value of electric potential is zero (0)?
v. If the applied voltage across the capacitor is double, how much energy will be stored in the capacitor?

Q.2 Tick (√) the correct answer

i. What is the current in a circuit, when the charge passing through each point is .....
   a) 12 Coulomb in 3 sec
   b) 15 Coulomb in 50 sec
   c) 180 coulombs in 5 minutes.

ii. In an electric field at appoint if 2 coulomb positive charge is placed and 6 N force acts on it. What will be the intensity?
   a) 6 N / C
   b) 3 N/C
   c) 12 N/C

iii. The device used for the storage of charge is
   a) Conductor
   b) Capacitance
   c) Capacitor

iv. The electric field intensity is
   a) Force per unit charge
   b) Charge per unit force
   c) Charge per unit current.

v. The unit of potential difference is
   a) Ampere
   b) Farad
   c) Volt.

6.3 Electric Circuits

An electric circuit is a combination of the different electric components that makes the electric charge to flow along a closed path called a **circuit.** Electricity travels in closed loops, or circuits. The word circuit is originated from the word "circle". It must have a complete and closed path so that the electrons can travel. The electrons cannot flow if a circuit is open. When we switch on a light bulb, we actually close a circuit. The electricity flows through the electric wire to the light bulb and back into the wire. When we turn the switch off the circuit opens and hence no electricity can pass to the light.

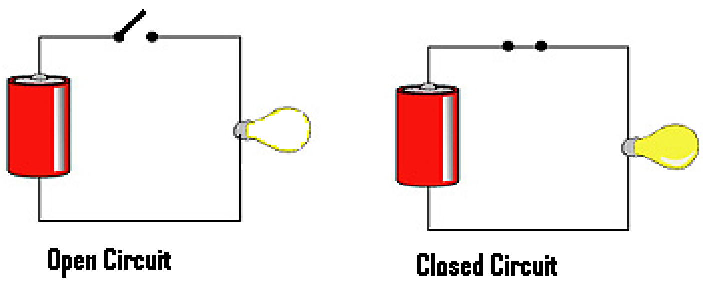


Fig. 6.10 Open and Closed Circuit

A circuit includes power source, which increases the potential energy of the charges and connected to a device that uses the potential energy through wires. The potential energy lost by the charges, in moving through the device is usually converted into some other form of energy i.e. electric motor convert electrical energy to kinetic energy and a lamp changes into heat. The signs or symbols used for various parts of an electrical circuit are shown below:

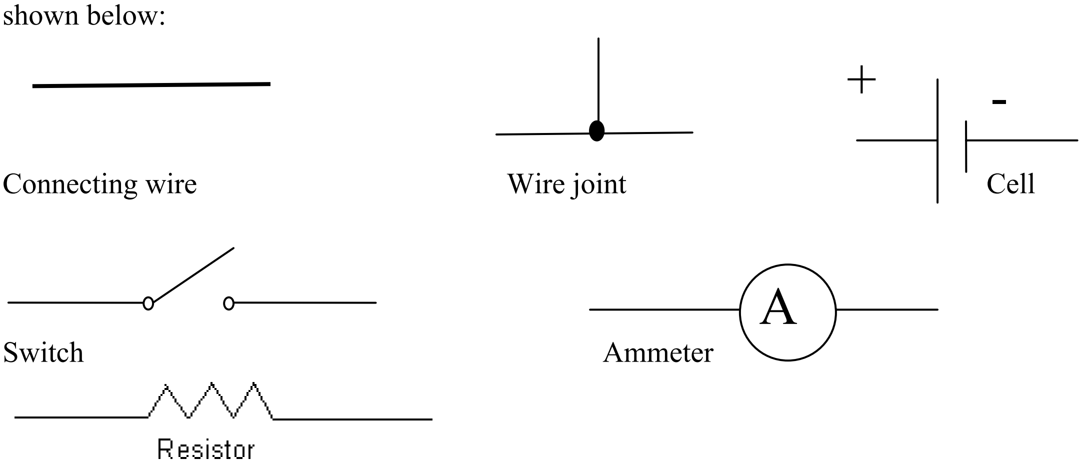


Fig 6.11 Symbols used in simple circuits

Resistance

The opposition to the flow of current is called resistance. It is the property that determines how much current will flow in a circuit. Resistance is measured by placing a potential difference across two points on a conductor and measuring the current. Resistance R is defined to the ratio of the potential difference to the current and measured in Ohm.

$$R = V / I \qquad \text{Equation 6.10}$$

One ohm Ω is the resistance that permits a current of "1" Amp to flow when a potential difference of "1" Volt is applied across the resistance.

Given below is the schematic representation of a simple circuit consisting of a resistance of 30Ω and a power supply of 6V and the current shown in ammeter is 0.2A.

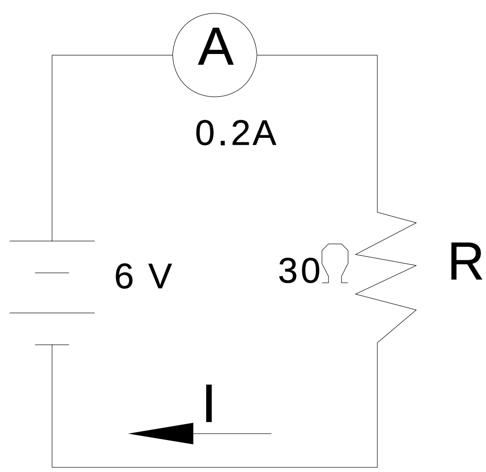


Fig 6.12 A simple circuit

6.3.1 Series Circuit

A circuit in which all current travels through device is called a series circuit. If we connect three resistors in series, the same current will flow through each resistor and the total potential difference will be sum of voltages applied across the three resistors.

From the principle of conservation of energy, the total potential difference is the sum of the three potential differences i.e. V_1, V_2 and V_3. This is because the total energy dissipated when one coulomb charge moves through the three resistors is equal to the sum of the energy dissipated in each of the resistors with resistances R_1, R_2 and R_3.

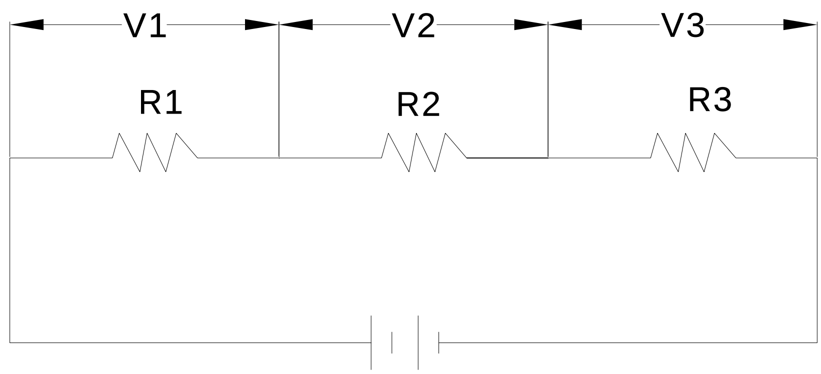


Fig 6.13 Three resistors in series

Since $V = V_1+V_2 + V_3$

and $V_1= IR_1 \quad V_2= IR_2 \quad V_1= IR_3$

So the above equation will be $IR = IR_1 + IR_2 + IR_3$

Dividing both sides by I will give $R = R_1 + R_2+R_3$

6.3.2 Parallel Circuit

A circuit in which there are several paths is called the parallel circuit. In a parallel circuit, the total current is the sum of the currents through each path and the potential difference across each path is the same.

If three resistors with resistances R_1, R_2 and R_3 connected across the same points P and Q in a circuit. The resistors are said to be connected in parallel. The current I enters the point P is divide into three parts I_1, I_2 and I_3

From the principle of conservation of charge, the charge that enters the point P must be equal to the sum of the charges that leave the point Q flowing through the R_1, R_2 and R_3. Hence

$$I = I_1+ I_2 + I_3$$

$$I_1 = V / R_1 \quad ,$$

$$I_2 = V / R_2$$

$$\text{and } I_3 = V / R_3.$$

$$I = V / R_1 + V / R_2 + V / R_3.$$

$$I = V\,(1/R_1 + 1/R_2 + 1/R_3)$$

$$I/V = (1/R_1 + 1/R_2 + 1/R_3)$$

Since $I/V = 1/R$

$$1/R = (1/R_1 + 1/R_2 + 1/R_3)$$

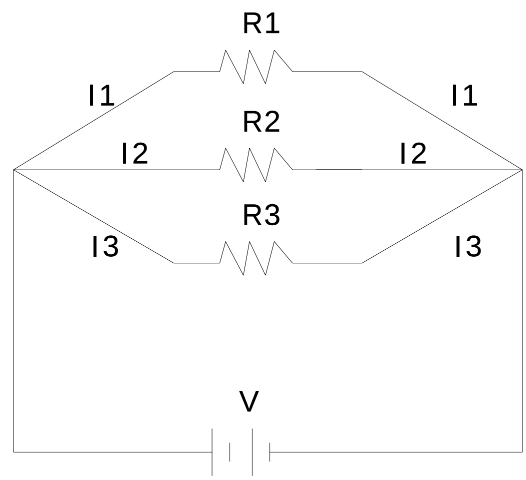


Fig 6.14 Three resistors in Parallel

Example Problem 03

A 25 volt battery is connected to 5 kΩ and 10 kΩ, find the following

a) The amount of current across each resistance

b) Sum of resistances

Known V= 25.0V

$R_1 = 5$ kΩ , $R_2 = 10$ kΩ

Unknown I_1, I_2=? , R equivalent =?

Formula $\mathbf{I_1 = V/R_1}$, $\mathbf{I_2 = V/R_2}$

R equivalent = $\mathbf{R_1 + R_2}$

Calculation

$I_1 = V/R_1 = 25.0\text{ V}/5\text{ k}\Omega = 0.005$ Amp

$I_2 = V/R_2 = 25.0\text{ V}/10\text{ k}\Omega = 0.0025$ Amp

R equivalent = 5+10 = 15 kΩ

Answer:

The current across first resistance is 0.005 Amp and across second 0.0025 Amp and R equivalent is 15 kΩ.

Activity 2

What is the difference between parallel and series circuits?

Material Required

Two bulbs, power supply with voltage wires with clips, copper wire about half meter, electrical tape and scissors

Procedures

1. First of all cut out the wire into five identical parts.
2. Take off little insulation from both ends of the wires.
3. The positive side of the dry cell is connected through the wire to the left side of the first light bulb.
4. The negative side of the dry cell is attached with another wire and connects to switch.
5. Then another bulb is added in the circuit in series connection on the right side of the first bulb by wounding the wire to the right side of first bulb and then left side of the second bulb.
6. Take another wire and attach the switch to the right side of the second light bulb.
7. Now the circuit consisting of two bulbs in series is completed.

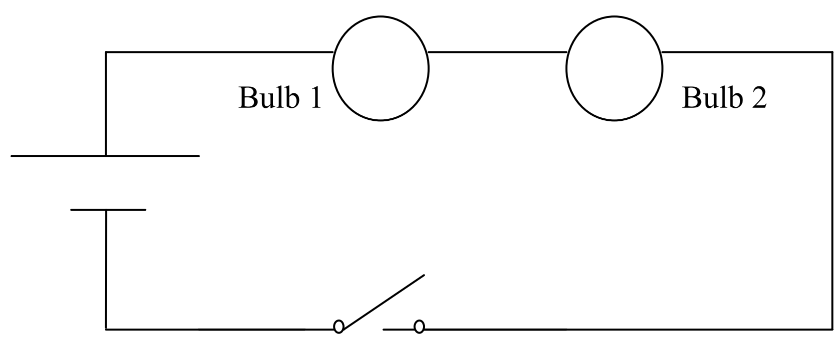


Fig 6.15 Connection of two bulbs in series

Observations

1. This is how we made the parallel circuit, if the connection of second bulb is removed, this will not affect the brightness of the first bulb, why?

   ____

   ____

2. With the same materials make the series circuit and analyze why the first bulb is brighter than others?

   ____

   ____

3. Why are parallel circuits better than series circuit? In home appliances what type of circuits are used.

   ____

   ____

Key Points

1. In an electric circuit, electric energy is transmitted from a power source to a resistor / bulb or any other device which converts the electric energy into other forms of energy.
2. The sum of the voltage drop in a series circuit is equal to the potential difference applied across the circuit and the current is same throughout the circuit.
3. In a parallel circuit, the voltage drop across all branches is the same but the total current is equal to the sum of the currents in the branches.

Self Assessment Exercise 6.3

Q.1 Answer the following questions:

i. Why the potential difference across each resistance in parallel circuit is same?

ii. Why the current remain same in series circuit?

iii. If the batteries are connected in series then the supplied voltage will increase its emf and if they are connected in parallel, what happen?

iv. A closed circuit consists of a bulb, a capacitor, switch and the power supply. In a closed circuit a bulb and a capacitor is connected in series. What will happen if the switch is closed and the capacitor is uncharged?

v. If 5 kΩ and 10 kΩ are in a parallel circuit, and 4V is supply, what is the equivalent resistance and current across each resistance?

Q.2 Tick (√) at the correct answer

i. When resistances are connected in series, their current will remain
   a) Change
   b) Zero
   c) Same

ii. The unit of resistance is
   a) Volt V
   b) Ohm Ω
   c) Ampere Amp

iii. How many method s are present to connect the circuits
   a) Two
   b) Three
   c) Four

iv. If the resistances are connected in series:
   a) The summation is the sum of them.
   b) Equal to the highest resistance
   c) Equal to the lowest resistance

v. The opposition to the flow of current is called
   a) Capacitance
   b) Voltage
   c) Resistance

6.4 Generating Electricity

During the International Electricity Exhibition held at Frankfurt in 1891, the first transmission of three-phase A.C (alternate current) using high voltage was carried out. Two cities Lauffen and Frankfurt were connected by the transmission line of 25 KV, and the length of the transmission line was 175 km long. After 23 years, more than 50 transmission systems were operating at 70 kV. The highest voltage used at that was 150 kV. In 20th century the rapid revolutions in the industrializations made utilization of the electrical transmission lines and grids stations as a vital part of the infrastructure in most developed nations. This is the requirement of World War II to connect the local generation plants and small distribution networks.

Electricity is different category from the primary sources of energy. In contrast of petroleum, coal and solar energy, electricity is a **secondary source** of energy. This means that another form of energy is used for the production of electricity. Most of the electricity we use is generated by large power plants.

Many types of fuels are used for the running of these power plants. Thermal power plants consume petroleum, biomass, coal and natural gas to generate steam from water. This steam then runs the generator to produce electricity. Nuclear power plants use fission to produce the heat. Geothermal power plants use heat from inside the earth. Wind farms take benefits from the kinetic energy present in the wind to generate electricity, while hydropower plants take the advantage of the energy from the water in motion.

6.4.1 Path of the Electricity

The path of the electricity means that how the production of electricity through huge power plants and how it is supplied to the consumers. First, the electricity is generated at a power plant. This power plant is run by the power of water stored in the dams. This **hydroelectric energy** is transmitted through long distances. The **large generators** in the power plants generate the electricity and then the **transformer steps up** the **voltage**.

This is the rule that at higher voltages along the length of the power lines, the loss of electricity is less so, the Power plants step up the voltage. The electricity is then supplied to a countrywide network of **transmission lines**. The transmission takes place through the large diameter cables of high conductivity. These cables are costly and heavy. Transmission lines are the huge tower lines you see along the highway. The transmission lines are interconnected, so if one line fails, another can take over the load.

Through the transmission lines it then goes to the Step**-down transformers**, located at substations along the lines, which reduces the high voltage from 350,000 to lower volts of 12,000 volts. **Substations** are small fenced-in buildings that contain transformers, switches, and other electrical equipment. The electricity is then supplied to the **distribution lines** that deliver electricity to consumers. These distribution lines are of two types, one is overhead and the other is underground. The overhead distribution lines are those power lines you see along roads.

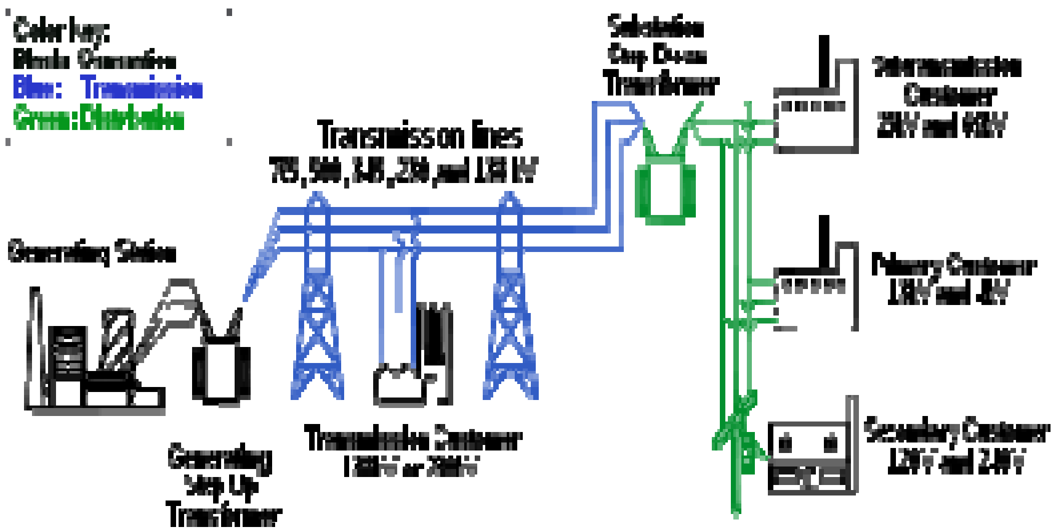


Fig 6.16 Power Generation

The voltage is again step down through transformers before the supply of electricity to the customers. The transformer is usually commonly a large gray metal box placed on an electric pole. This transformer reduces the electricity to the 120 volts that are used to operate the appliances in your home.

A three-wire cable is used for the supply of electricity to your home. Wires are run from the circuit breaker or fuse box to outlets and wall switches. An electric meter measures how much electricity you use so that the utility company can send you the bill.

6.4.2 Transformers

Edison was the first who invented the electrical power distribution system in 1880. It was originated for low voltages but this system experiences considerable energy loss. The second generation of power distribution systems was recommended by Tesla. His idea was to generate AC power of any convenient voltage, then step up the voltage for transmission with less loss, and finally step down its voltage for consumption.

A transformer is a device that converts one AC voltage to another AC voltage at the same frequency. It consists of one or more coil(s) of wire wrapped around a common iron core. These coils are usually not connected electrically together. However, they are connected through the common magnetic flux confined to the core. The transformer has mainly three parts:

1. *Primary coil* – the incoming voltage V_p (voltage across primary coil) is connected across this coil.
2. *Secondary coil* – this provides the output voltage V_s (voltage across the secondary coil) to the external circuit.
3. *Laminated iron core* – this links the two coils **magnetically**.

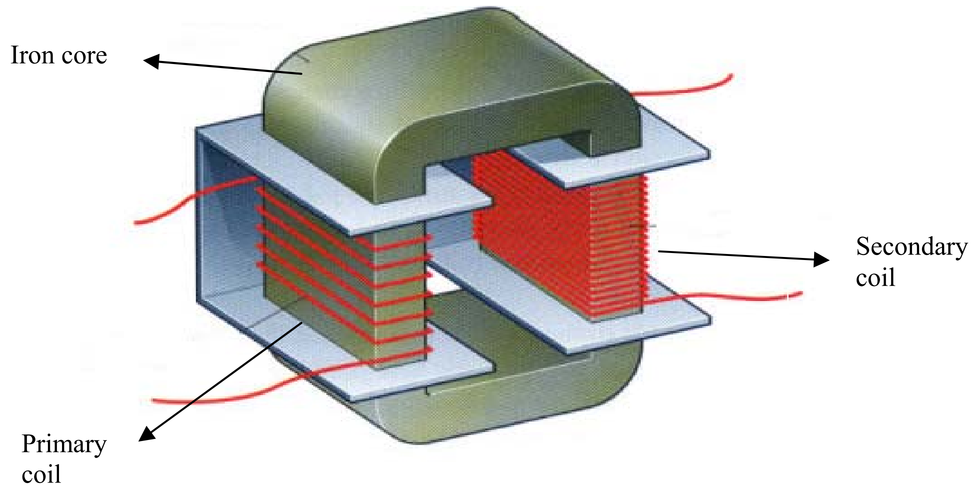


Fig 6.17 parts of transformer

The step**-up transformer** increases the voltage because there is more number of turns of the secondary coil than on the primary coil.

A **step-down transformer** decreases the voltage as there are fewer turns of the secondary coil in comparison of the primary coil.

The relationship between the voltage applied to the primary winding v_p and the voltage produced on the secondary winding v_s is called the turn ratio.

$$\text{Turn ratio} = \frac{\text{Voltage across the primary coil}}{\text{Voltage across the primary coil}} = \frac{\text{Number of turns on primary}}{\text{Number of turns on secondary}}$$

Turn ratio = Vp / Vs = Np /Ns

Where V_p = primary voltage

Vs = secondary voltage

N_p= Number of turns in primary coil

N_s = Number of turns in a secondary coil.

6.4.3 Unit of Electrical Energy

While electric companies often are called "power" companies, they really provide energy. When consumers pay their home electric bills, they actually pay for electric energy, not power. The electric energy used by any device is its rate of energy consumption in joules per second (watt) times the number of seconds. It is operated in joules per second times second i.e. J /s .s equals total joules of energy.

It is a relatively small amount of energy. So the electric companies measure the electric energy sales in a unit of a large number of joules called a Kilowatt-hour. A **kilowatt-hour** is equal to 1000 watts delivered continuously for 3600 seconds (1hour). 1KWh = (1000J/s) (3600s) = 3.6 x10^6 J.

Not many devices in homes other than electric stoves, electric heaters, and curling iron and hair dryers require more than 1000 watts of power. Ten 100 watt light bulbs operating all at once would use one kilowatt hour of energy if they were left on for one full hour.

Example Problem 04

A television sets consumes 5.0 Amp when 120V electricity is supplied. Calculate

a) What is the amount of power does the set consume?

b) If the set is operated for an average of 5.0 hour / day, what energy in KWh does it consume per month?

Calculations

Known

V= 120V

I= 5.0 Amp

t= 5.0 hour / day (30 days)

Unknown

E =?, Total cost =?

Formula **P = VI & E = Pt**

Calculation

P= VI = 120 V x 5.0 A= **600 Watt**

E= Pt = 600W x 5.0 h/day (30 day) = 90000 W hour (h)

= **90 KWh**

6.4.4 Other Sources of Electric Current

Electricity is generally generated in Pakistan by the hydroelectric means. In hydroelectric systems the power stations runs the generators by the spill of water, in this way the kinetic energy of flowing water is used. Other sources to run the generators are nuclear energy and wind energy. There are many other technologies that can be and are used to generate electricity such as solar photovoltaic and geothermal power.

There are many methods of transforming other forms of energy into electrical energy:

- **Electromagnetic induction**: Where an electrical generator, dynamo or alternator transforms kinetic energy (energy of motion) into electricity, this is most used form for generating electricity.
- **Electrochemistry**: The direct transformation of chemical energy into electricity, as in a battery.
- **Photoelectric effect**: The transformation of light into electrical energy, as in solar cells
- **Thermoelectric effect**: Direct conversion of temperature differences to electricity, as in thermocouples, thermopiles, and Thermionic converters.
- **Nuclear transformation**: The creation and acceleration of charged particles

Key Points

1. The electricity is generated at a power plant and then transmitted through long distances. The large generators in the power plants generate the electricity.
2. Electricity is different from primary sources of energy. Unlike coal, petroleum, or solar energy, electricity is a **secondary source** of energy.
3. The electric companies measure the electric energy sales in a unit of a large number of joules called a Kilowatt-hour. A **kilowatt-hour** is equal to 1000 watts delivered continuously for 3600 seconds (1hour).
4. A transformer is a device that converts one AC voltage to another AC voltage at the same frequency.
5. The step**-up transformer** increases the voltage because there are more number of turns of the secondary coil than on the primary coil.
6. A **step-down transformer** decreases the voltage as there are fewer turns of the secondary coil in comparison of the primary coil.
7. In hydroelectric systems the power stations runs the generators by the spill of water, in this way the kinetic energy of flowing water is used.
8. There are many other technologies that can be and are used to generate electricity such as solar photovoltaic , nuclear, wind and geothermal power.

Self Assessment Exercise 6.4

Q.1 Answer the following questions:

i. How electricity is a secondary source of energy?
ii. How many types of fuels are used for the running of power plants?
iii. Name the three basic parts of transformer.
iv. An electric heater consumes 15 Amp from a 120 volt source. It is operated on the average of 5 hours per day.
   a) How much power does the heater use?
   b) How much energy in KWh does it consume in 30 days?
v. By what means the electricity comes to your home?

Q.2 Fill in the Blanks

i. The transmission line consists of large ________cables of high conductivity.
ii. The step-up transformer the ____________voltage because there is more number of turns of the secondary coil than on the primary coil.
iii. Electricity is generally generated in Pakistan by the ________________means.
iv. This is the rule that at higher voltages along the length of the power lines, the loss of electricity is ____________.
v. The ratio between the voltage applied to the primary winding v_p and the voltage produced on the secondary winding v_s is called the ____________.

6.5 Magnetism

The relationship between electricity and magnetism was first understood in 1819 by Hans Christian Oersted, a professor at the University of Copenhagen, who accidently discovered that an electric current could have an effect on a compass needle. This milestone experiment is known as Oersted's Experiment. In 1831, Michael Faraday discovered that a time-varying magnetic flux through a loop of wire induced a voltage and others conclusions relates magnetism and electricity together.

Sir James Clerk Maxwell analyzed and further extends these above findings into Maxwell's equations. He united electricity, magnetism, and optics into the field of electromagnetism. In 1905, Einstein used these laws in inspiring his theory of special relativity. He also added that the laws held true in all inertial reference frames.

A magnet is a material or an object that produces a magnetic field. This magnetic field is invisible but is responsible for the most distinguished property of a magnet, a force that attracts other ferromagnetic materials, such as iron. If you suspend a bar magnet from a thread, when the bar magnet comes to rest, it lines up with the north south direction. Put a mark on the magnet end that points north. If you rotate it away from the direction, it will return. From this simple experience, you can conclude that a magnet is polarized i.e. two ends, one of which is seeking the north Pole is North end and the other is south end.

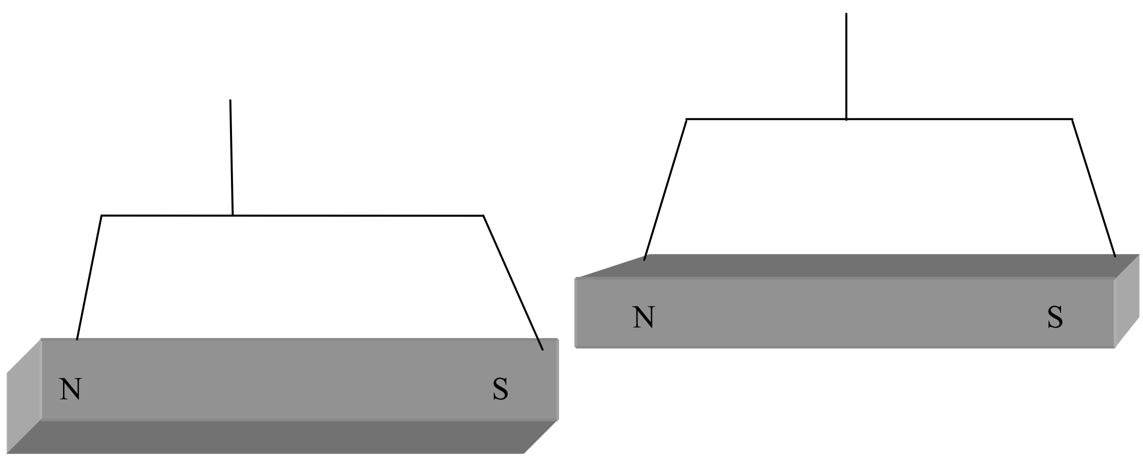


Fig 6.18 Different poles attract each other.

Knowing that magnets always orient themselves in North-South direction means attraction of magnet towards earth magnet. If the North Pole of suspended bar magnet is placed near the south pole of another bar magnet, they are attracted, but if same poles are placed together, they repel.

If an iron nail is placed over a magnet, the nail becomes itself a magnet because the magnet becomes polarized. The direction of the polarization of the nail depends on the polarization of the magnet. If the iron nail is pull away, the nail's magnetism disappears. A permanent magnet consists of the materials that are magnetized and creates its own persistent magnetic field naturally. An everyday example is a refrigerator magnet used to hold notes on a refrigerator door. Materials that can be magnetized, which are also the ones that are strongly attracted to a magnet, are called ferromagnetic.

Magnetism is a property of materials that reacts at an atomic level when placed in an applied magnetic field. In magnetic materials, sources of magnetization are the electrons' orbital angular motion around the nucleus. The magnetic behavior of a material depends on its structure, particularly its electron configuration, for the reasons mentioned above, and also on the temperature. At high temperatures, random thermal motion makes it more difficult for the electrons to maintain alignment.

6.5.1 Magnetic Lines of Forces & Magnetic Fields

Magnetic field is a mathematical depiction of the influence of magnetic properties of electric currents and magnetic materials. The magnetic field is a vector quantity so it can be specified at any point by both direction and magnitude. The magnitude of the magnetic field is actually its strength (strength of magnetic field). The applications of magnetic fields were very common in ancient times and still common in modern society. The earth produces its own magnetic field, which is important in navigation. The principle of rotating magnetic fields is utilized in both electric motors and generators.

The magnetic field can be drawn easily from a bar magnet with the help of a compass needle. Just mark the position of needle from one end of the bar magnet to the other end of the magnet and then connect the points to form "magnetic **field lines**". To recognize the difficult mathematical relations of fundamentals of magnetic field it is easy to develop the magnetic lines of forces, if drawn carefully.

A field line diagram contains the same information as the vector field it represents. The magnetic field could be predictable at any point on a magnetic field line diagram (whether on a field line or not) using the direction and density of the nearest magnetic field lines. A higher concentration of nearby field lines indicates a stronger magnetic field.

The direction of a magnetic field strength is defined as the direction in which the N-pole of a compass points when it is placed in the magnetic field. Outside the magnet, the field lines come out of the magnet at its N-pole and enter the magnet at its S-pole. What happens inside the magnet?

There are no isolated poles on which fields lines can start or stop, so magnetic field lines always travel inside the magnet from the South Pole to the North Pole to form close loop. What kind of magnetic fields are produced by pairs of bar magnet? You can visualize the fields by placing a sheet of paper over the poles of two magnets. Then sprinkle the paper with iron fillings. The fig 6.10 shows the field lines between two like poles.

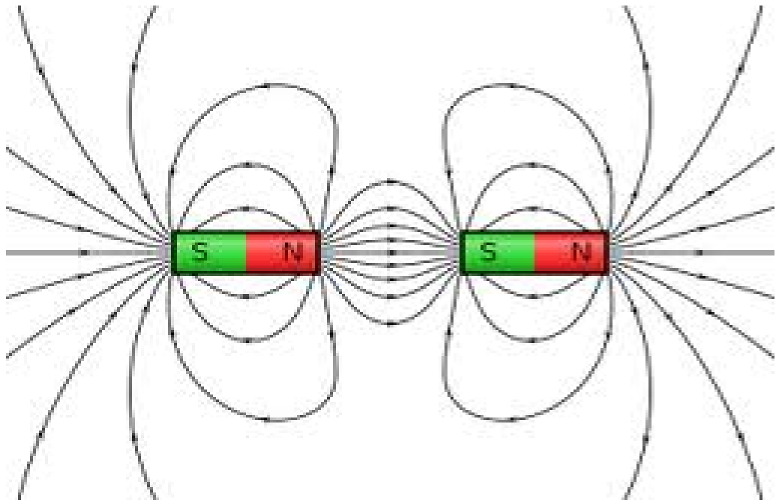


Fig 6.19 Magnetic lines of forces

6.5.2 Properties of Magnetic Fields

- The Magnetic field is denoted by symbol "B".
- Charges in motion (currents) cause the magnetic fields.
- The SI Unit of magnetic field strength is a Telsa (T). A "1" coulomb charge moving through a "1" Telsa B field with a velocity of "1" m/s perpendicular to the field experiences 1 Newton of force.
- CGS unit of magnetism is a Gauss (G), $1T = 10^4G$.
- As we all know that "**E"** is defined as intensity of the electric field as electric force per unit charge acting on a test charge placed at that point in space and "**B"** is defined similarly as the magnetic force that would be exerted on a moving charge "q" placed at a point in the field.
- Charge and velocity are both directly proportional to the magnetic force.
- The magnitude and direction of the magnetic force depend upon the direction of the **B** field the velocity and of the charged particle.
- When a charged particle moves along a path that is not parallel to the magnetic fields lines it feels a magnetic force due to the presence of the field. This force is proportional to the magnitude of the charge, the strength of the field and the velocity of the particle

F= q v B   or F= q v B Sinθ

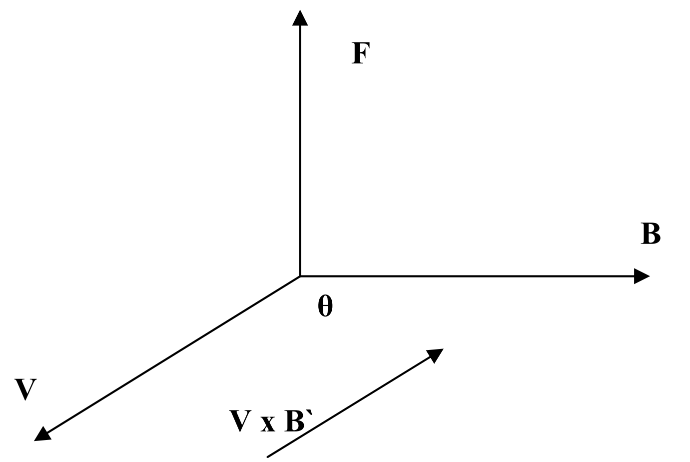


Fig 6.20 Right hand rule

Where F = Magnetic force
V = Magnitude of charge
B = Magnetic field

- For a positive charge be in motion in a magnetic field, the direction of the magnetic force is at right angles to the plane containing magnitude of charge V and the magnetic field B, and can be determined by principle of the right hand rule.
- To apply the RHR (right hand rule) , pick the wire in the right hand, then the thumb will indicate the direction of current and the curled fingers represents the direction of the magnetic field.

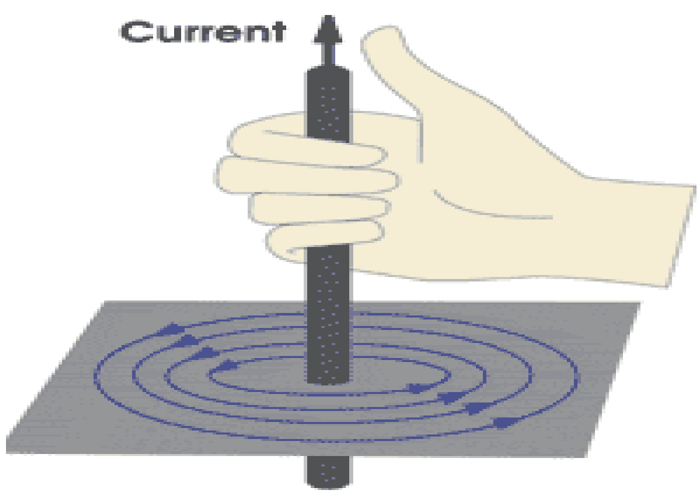


Fig 6.21 Right hand rule

6.5.3 Electromagnet

How does electric charge affect a magnet? When you bring a magnet near a charged strip of transparent tape, there is no effect on the magnet or the tape. However, there is a marked effect on the magnet when the charge moves as an electrical current .In, 1820 Danish physicist Han Christian Oersred was experimenting with electric current in wires. He laid a wire across the top of a small compass and connected the ends of the wire to complete an electrical circuit.

He had expected the needle to point towards the wire or in the same direction as the current in the wire. Instead, he was amazed to see that the needle rotated until it pointed perpendicular to the wire. The forces on the compass magnet's poles were perpendicular to the direction of the current in the wire; he also found that when there is no current in the wire, no magnetic forces exist.

If a magnet compass turns when placed near a wire carrying current, it must be resulted of a magnetic field created by the current. You can easily show the magnetic field around a current carrying wire by placing a wire vertically through a horizontal piece of card board on which irons filling are sprinkled. When there is a current, tap the cardboard. The filling will form a pattern of concentric circles around the wire.

The circular lines that indicate the magnetic field lines around current carrying wires from closed loops in the same way that fields lines about the permanent magnet form closed loops. The strength of the magnetic field around a long, straight wire is proportional to the current in the wire. When a wire is looped several times to form a coil and a current is allowed to flow through coil, the field around all the loops is always in the same direction as. An electric current in a coil of wire has a magnetic field like that of a permanent magnet. Thus, the current carrying coil has a North Pole and a North Pole. This is called the **electromagnet.**

The strength of the electromagnet is proportional to the current. The magnetic field produced by each loop of a coil is the same as that produced by any other loop. Because these fields are in the same direction, increasing the number of loops in an electromagnet increases the strength of the magnetic field.

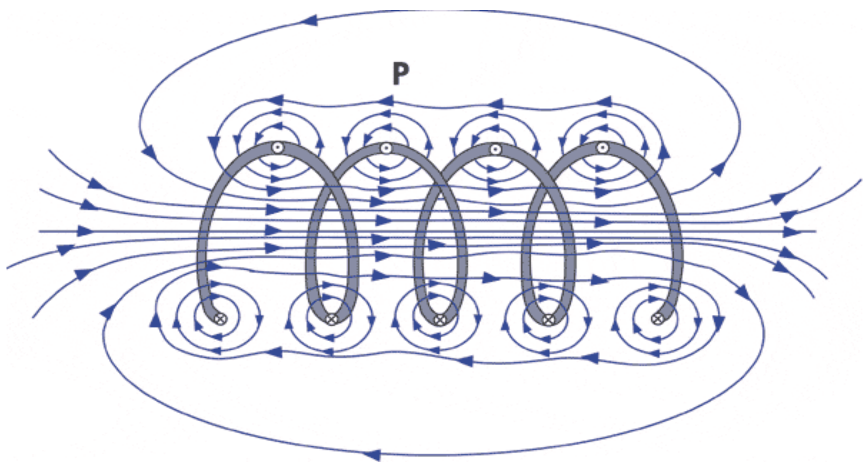


Fig 6.22 Electromagnetism

The magnetic field generated by a coil of wire carrying current gives us a hint as to what might cause certain materials to reveal strong magnetic properties. The magnetic properties of many materials are explained by the fact that an electron not only circles around in an orbit but also spins on its axis like a top.

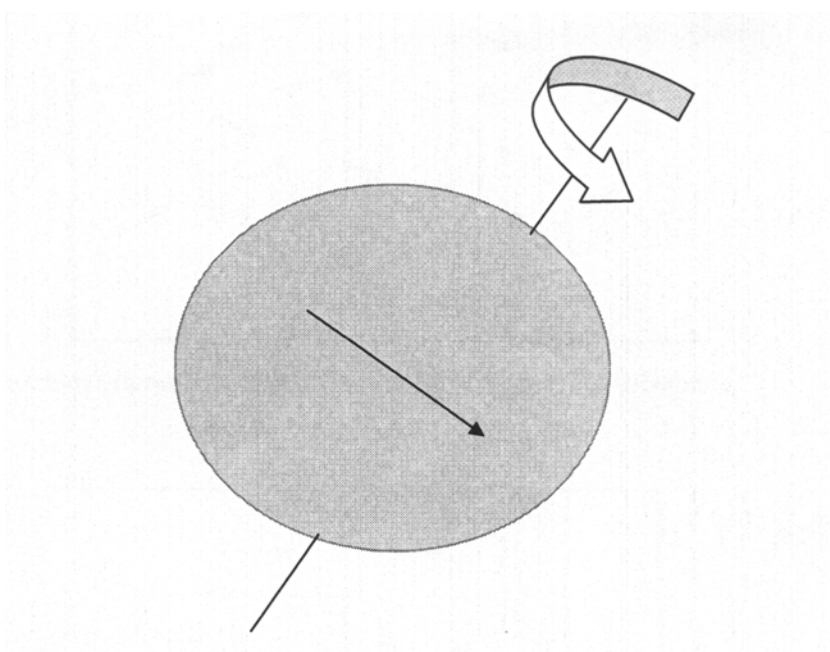
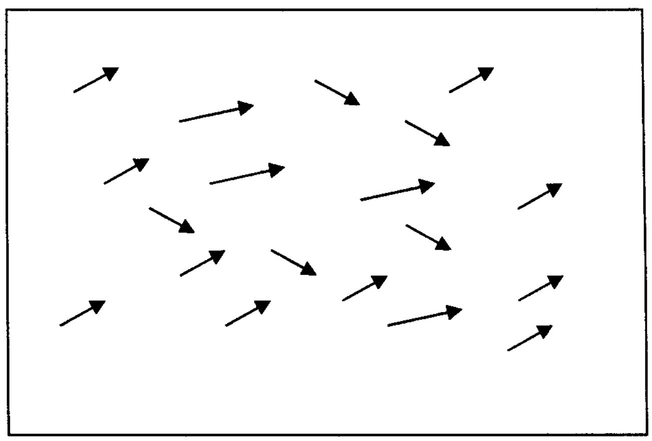


Fig 6.23 Spinning of electron around its axis

The spinning of the electron represents as charge in motion that produces a magnetic field. The field due to the spinning is stronger than the field due to the orbital motion. In atoms containing many electrons, the electron usually pair up with their spins opposite each other, so their fields cancel each other.

This is why most substances are not magnets. **However, in strongly magnetic materials such as iron, cobalt, and nickel. Such materials are said to be ferromagnetic**. In ferromagnetic materials, strong coupling occurs between neighboring atoms, to form large groups of atoms whose spins are aligned. Typically, the sizes of these groups range from about 10^{-4} to 0.1 cm. In an un-magnetized substance the groups are randomly oriented such as given in Fig 6.22(a).

When an external field is applied the magnetic field of each group tends to come nearer alignment with the external field, resulting in magnetization such as 6.22(b)



(a) Random orientation of groups in an un-magnetized substance.

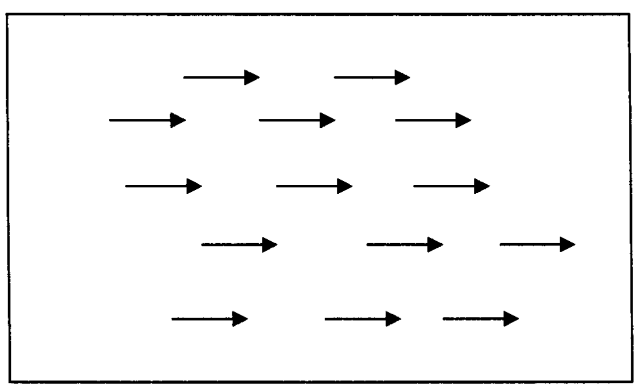


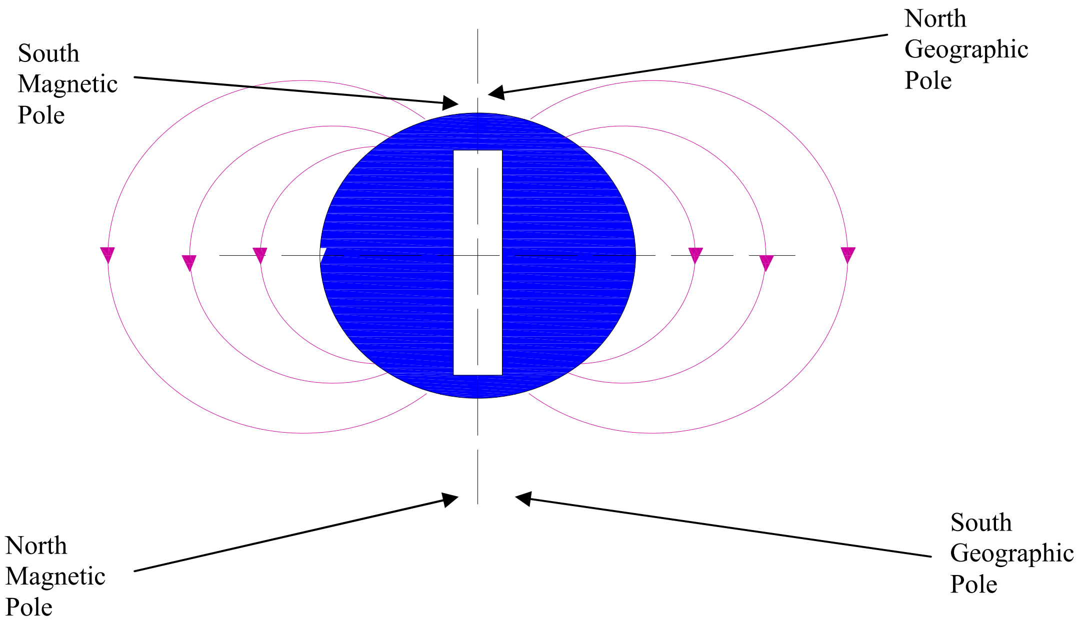
Fig 6.24 (b) Alignment of groups in a magnetized substance.

6.5.4 Magnetic Compass

The magnetic compass was first invented in the period of the Chinese Han Dynasty after the two centuries of BC and was used for navigation. The magnetic compass was introduced around 1300 AD and was supplanted in the early 20th century by the liquid-filled magnetic compass. The magnetic compass is an instrument which comprises of a magnetized pointer which aligns itself freely with earth's magnetic field. It is can indicate the direction of the earth's magnetic north . The face of the compass indicates the fundamental directions of north, south, east and west.

Fig 6.25 Magnetic compass

The function of a compass is to point towards the "north" of earth because the magnetized needle of the compass aligns itself with the lines of the earth's magnetic field. The earth's magnetic field exerts a force upon the needle of the compass.



6.26 The earth magnetic field lines.

The needle of compass as having north and south poles, should properly say that it has north seeking pole a south seeking pole , because the geographic north pole corresponds to a magnetic south pole and the geographic south pole corresponds to a magnetic north pole. The given below figure is actually the earth's magnetic field.

The needle of a compass is mounted on a low-friction pivot point. A jewel bearing is used in better compasses to turn easily. In the professional compasses, the bar magnet is stick to the underside of a disk pivoted in the center so it can turn, called a "compass card", with the fundamental points marked on it.

6.5.6 Uses of Magnetic Compass

Usually the magnets are used in such places that we can't think about them. Magnets can be generally categorized into two types - permanent magnets and electro-magnets .However, in real life without good magnets, it would be difficult to survive. Many common uses of magnets are in speakers, electric motors, hard disks in computers, transformers and seals in the refrigerators.

Loudspeakers changes electrical energy to sound energy using a coil of fine wire mounted on a paper cone and placed in a magnetic field. Sound waves can be created by exerting on a current carrying wire in a magnetic field.

Electric motors have electromagnets as part of their means of operation in place of the permanent magnets. In an electric motor, an apparatus that converts electrical energy to kinetic energy.

Computer hard drives have their data stored on them in the form of tiny magnets or areas on the ferromagnetic coating of the platter that are created when the read/write head applies a magnetic field for an instant over a particular location on a particular track.

Bank cards and other transaction or identification cards have magnets have been formed on the "magnetic stripe"**.** Certainly there are plenty of toys and gadgets in which magnets play an integral part. Magnetic fields in transformers, like those in motors, make them work.

Activity: 3

What are magnets?

Material Required:

A bar magnet, two steel balls of 5 mm dia., a piece of paper

Procedures

1. Place a bar magnet on the piece of paper.
2. Roll a 3 mm steel ball at the magnet.
3. Place the second steel ball on the paper touching the magnet and the first steel ball.

Observations:

1. What will happen when the second ball touches the first ball?

____

____

2. Before touching the second ball to the first ball, does the first ball magnetized?

____

____

3. Does the two steel balls were magnetized after the touching of second ball to magnet.

____

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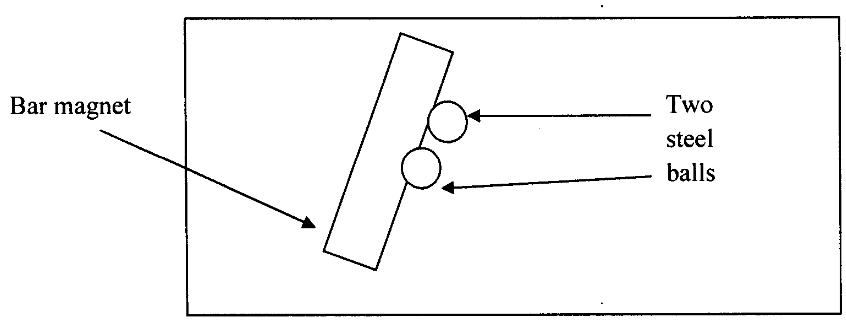

Fig 6.15 A bar magnet with two steel ball

Activity: 4

What is the magnetic field?

Material Required:

A bar magnet, compass, paper, lead pencil

Procedures:

1. Place a bar magnet on the piece of paper.
2. Place the compass at the one end of the bar magnet.
3. Now see the position of the needle of compass showing the North Pole.
4. Mark the needle position with the lead pencil as a dot.
5. Now place the compass at the dot and notice the direction of the compass needle.
6. Again mark the needle position with lead pencil as dot.
7. Repeat the procedure until the compass travels to the other end of the bar magnet.
8. Now connect the dots with the lead pencil, this is the one possible magnetic line of force.
9. Repeat the experiment with different positions of compass near the bar magnet.

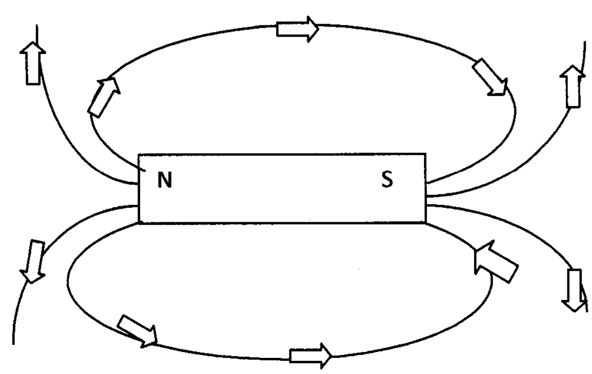

Fig 6.28 Magnetic lines of forces

Activity: 5

Construction of Electromagnet

Material Required:

A steel nail of about 2 inches long, ½ meter insulated wire, dry cell, tape , paper clips

Procedures

1. Wrap the 15 turns of insulated wire around the steel nail in such a manner that Leave some wire hanging free.
2. Tape the ends of the wire to a dry cell battery.
3. As the connection with the dry cell is connected the steel nail becomes electromagnet.
4. Bring some paper clips near the steel nail, they will be attracted.
5. Remove the wire connection with the dry cell and then bring the paper clips near the steel nail, they will not be attracted.

Observations:

1. How the steel nail become electromagnet.

____

____

2. Why after the removal of wires from the dry cell the paper clips do not attracted towards steel nail?

____

____

3. How can you increase the magnetization of the steel nail?

____

____

Activity: 6

Construction of Magnetic Compass

Material Required:

A plastic bowl, a small plastic container, tape, small bar magnet

Procedures

1. Tape the magnet to the bottom of the small plastic container.
2. Float the container and magnet on the surface of the plastic bowl which is partially filled with water.
3. The magnet and the small container should rotate and come to the equilibrium with the magnet pointing towards north or south.
4. The compass you have constructed is similar to the type used by early sailing vessels.

Observations:

1. Explain in your words the alignment of magnetic compass according to the earth's magnetic compass.

____

____

2. Are the earth's magnetic lines of forces are similar to daily common use magnet's magnetic lines of forces.

____

____

Key Points

1. In magnets similar magnetic poles repel each other and dissimilar magnetic poles attract each other.
2. Magnetism is a property of materials that respond at an atomic level to an applied magnetic field.
3. The magnetic behavior of a material depends on its structure, particularly its electron configuration.
4. The magnetic field is a vector quantity so it can be specified at any point by both direction and magnitude.

5. The magnet produces the magnetic field which exits from the north pole of a magnet and enters its south pole. The strength of the magnetic field is measured in Tesla.
6. According to the RHR (right hand rule), the fingers points in the direction of the moving positive charge, and the palm of the hand in the direction of the magnetic field and the thumb points in the direction of the magnetic force.
7. A coil of wire that carries current has a magnetic filed. The field about the coil is like the field about the permanent magnet.
8. The strength of the electromagnet is proportional to the current
9. The Ferromagnetic materials have the property to attract towards magnetic materials such as iron, cobalt, and nickel.
10. The magnetic compass is an instrument which comprises of a magnetized pointer which aligns itself freely with earth's magnetic field
11. Many common uses of magnets are in speakers, electric motors, hard disks in computers, transformers and seals in the refrigerators The strength of the electromagnet is proportional to the current.

Self Assessment Exercise 6.5

Q.1 Answer the following questions:

i. Explain why magnets orient themselves in north-south direction.
ii. Explain the magnetism?
iii. What are the characteristics of the magnetic lines when compass moves away from the bar magnet?
iv. Does the magnetic lines of forces are congested near the north and south poles?
v. Explain, if you broke a magnet in two how many north and south poles are present in both the magnets.

Q.2 Tick (✓) the correct answer

i. Select one material which is non-magnetic.
   a) Iron
   b) Glass
   c) Copper

ii. The magnetic field is a
   a) Scalar quantity
   b) Vector quantity

iii. The strength of the electromagnet is proportional to the
   a) Applied voltage
   b) Current
   c) Electromagnet

iv. The unit of magnetic field is
    a) Gauss
    b) Volt
    c) Tesla

v. The current carrying coil has a north pole and a north pole, so it possesses the property of
    a) Magnetism
    b) Electromagnetism
    c) Conduction

Answers of Self Assessment Exercises 6.1

Q.1

i. If two neutral objects are rubbed together each can become charged. For instance plastic rod and wool are rubbed together electrons from atoms on the wool are transferred to the plastic rod and the extra electron on the plastic rod result in a net negative charge. The electrons omitted from the wool effect in a net positive charge. The combined total charge of the two objects remain the same, what happened was that the positive and negative charges were separated though a transfer of electrons.
ii. The electron and the proton. Proton is positive charge and electron is negative charge.
iii. The glass rod rubbed with silk cloth has positive charge and ebonite rod rubbed with woolen cloth has negative charge.
iv. The long cross sectional wire conducts electricity with least resistance as compare to one with a small cross sectional diameter.
v. Metals are good conductors because at least one electron on each atom of the metal can be removed easily and this is not the case in rubber.

Q.2

i. Electron
ii. Positively charged
iii. Attract, Repel
iv. Coulomb
v. 6022×10^{-19}
vi. French
vii. Square of the distance
viii. One forth

Answers of self Assessment Exercise 6.2

Q.1

i. The proton is displaced in the direction of the electric field, so the electric potential and electric potential energy decrease. When potential energy decrease then according to the law of conservation kinetic energy increase.
ii. The capacitor remains charged after the supply is disconnected. The residual charge can be lethal. So the capacitor should be handled with care.
iii. Field lines actually represent the direction of forces they cannot cross each other.
iv. No. If at some point when some charges are positive and some are negative, they can cancel each other but quantity will not zero.

Q.2

i. a) As $I = Q / t = 10/2 = 5$ Amp
   b) As $I = Q / t = 20/40 = 0.5$ Amp
   c) As $I = Q / t = 240/120 = 2$ Amp

ii. 3 N/C
iii. c
iv. a
v. c

Answers of Self Assessment Exercise 6.3

Q.1

i. This is because that there are three resistances connected in parallel so there are three paths, the charge will have to travel along three paths but the voltage each resistance is gaining the same.
ii. This is because that charge has to flow from one path only, so the current same the same but the potential difference has to divide.
iii. No increase in emf because in parallel circuit the amount of current is divided.
iv. During the charging of capacitor, the bulb will glow little but after the capacitor is fully charged, the bulb will not glow, because the full charge capacitor will not pass the current to bulb.
v. 15 kΩ , 0.266 Amp

Q.2

i. C
ii. B
iii. A (series & parallel)
iv. A
v. c

Answers of Self Assessment Exercise 6.4

Q.1

i. Electricity is different category from the primary sources of energy. In contrast of petroleum, coal and solar energy, electricity is a **secondary source** of energy. This means that another form of energy is used for the production of electricity. Most of the electricity we use is generated by large power plants
ii. Thermal power plants consume petroleum, biomass, coal and natural gas to generate steam from water. This steam then runs the generator to produce electricity. Nuclear power plants use fission to produce the heat. Geothermal power plants use heat from inside the earth. Wind farms take benefits from the kinetic

energy present in the wind to generate electricity, while hydropower plants take the advantage of the energy from the water in motion.

iii. The three basic parts of transformer are primary coil, secondary coil and iron core.

iv. a) Power = 1800 Watt
b) 270 KWh .

v. First, the electricity is generated at a power plant. This power plant is run by the power of water stored in the dams. This hydroelectric energy is transmitted through long distances. The large generators in the power plants generate the electricity and then the transformer steps up the voltage.

The electricity is then supplied to a countrywide network of transmission lines. The transmission takes place through the large diameter cables of high conductivity. Through the transmission lines it then goes to the Step-down transformers, located at substations along the lines, which reduces the high voltage from 350,000 to lower volts of 12,000 volts. Substations are small fenced-in buildings that contain transformers, switches, and other electrical equipment. The electricity is then supplied to the distribution lines that deliver electricity to consumers.

Q.2

i. Diameter
ii. Increases
iii. Hydroelectric
iv. Less
v. Turn ratio

Answers Self Assessment Exercise 6.5

Q.1

i. The magnets orient themselves in north-south direction due to the earth's magnetic field. The earth magnetic field is also consisting of North and South Pole.

ii. The magnetism is a property of materials that reacts at an atomic level when placed in an applied magnetic field. In magnetic materials, sources of magnetization are the electrons' orbital angular motion around the nucleus

iii. The magnetic lines are originated from the poles and away from poles they bulge out. The compass actually detects the presence of magnetic field so when moves away from the magnet the lines of forces will no longer exists .As they are away from the magnet.

iv. Yes, the magnetic lines of forces are congested near the north and south poles, because at the poles the magnetic field is stronger.

v. If you broke a magnet in two, there will be two north and south poles are present on both the magnets. One North and South Pole of each magnet.

Q.2

i. b
ii. b
iii. b
iv. c
v. b

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Unit–7

THE LIVING WORLD

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CONTENTS

Introduction

Living and nonliving things are two major components of our environment. We can recognize a living organism on the basis of certain characteristics which make them different from the nonliving things. Characteristics such as ability to move, breath, grow and reproduce are some we are all familiar with.

Despite the basic similarity between living things we see a vast variety of living things. Each type of living thing is different from the other and yet alike in their basic characteristics. This is what scientists call unity in diversity. To have better knowledge and understanding of the living world scientists have identified the characteristics of living things, named organisms and systematically classified them into groups. Classification of living things is based on their characteristics. In this unit, we shall study about the major characteristics of living things and their classification.

When one looks at the variety of living things and their characteristics one cannot help thinking about their structure because it is the way they are made which enables them to perform all the functions. To understand how living things function, it is essential to understand their basic structure. A major topic discussed in this unit is cell. Cell is the basic unit of structure function in living things. What is the structure of cell? How cells divide? What is the importance of cell division? You will find answers to these and other similar questions in the fifth section of the unit.

We observe that a gram seed always grow into a gram plant and animals always give birth to their own kind. We also observe that no two organisms are alike and that is why we see such a variety of organisms. What is the mechanism which ensures that parents' characteristics are transferred to the next generation? How children of the same parents are similar to their parents and siblings and yet they are different in many respects? We shall find answers to these questions in the seventh section.

It is hoped that you will find this unit interesting and informative.

Objectives

– After completing this unit, you will be able to:
– list and describe characteristics of living things
– classify plants and animals into kingdoms, classes, families and orders.
– explain the structure of cell.
– describe the process of simple cell division.
– explain the difference between mitosis and meiosis.
– define gene and their function
– explain the term biotechnology and its application.

7.1 Living and Non-Living Things

Living things and non – living things are two of the major components of the our environment. Living things include plants, animals and human beings. Non – living things include natural as well as man made things e.g. mountains, rocks, soil, rivers, manmade buildings and objects. Both the living and non – living things are essential components of the environment. Living things including man depend on their non – living environment for food, shelter and other basic needs of life. How we differentiate between a living and a non living organism? There are certain signs which tell us whether an object is a living organism or not. In the next section we shall read about characteristics of living things.

7.1.1 Characteristics of Living Things

The characteristics of living things include the following:

Characteristics of Living things
• Movement • Nutrition • Respiration • Excretion • Growth • Sensitivity • Reproduction • Definite life cycle

Movement

Ability to move their parts or whole body is a characteristic of living things which we observe first. However, do not see plants moving the way animals move. In plants there is a partial movement of their parts. Have you ever thought how branches of plants move towards sun? You may have observed sunflowers and how they turn towards sun? Plant movements are partial and non reversible i.e. once their parts move they cannot go back to previous position.

Movements allow plants to reorient themselves in relation to changes in their surroundings. Plants need sunlight so their branches grow towards sun. Similarly vines need support to climb so when their branches come in touch with a solid object like a pole or trunk of another tree they wind around it. These are examples of partial movements in plants of which non – living things are not capable.

Nutrition

All living things require energy for the sustenance of life. Living things obtain this energy from food. Assimilation and uses of food for energy, growth, replacement and repair of damaged parts is called nutrition. Food is the basic need of all living things. However animal obtain it by eating other animals and plants whereas plants prepare their own food from carbon dioxide and water using sun light as a source of energy to prepare food.

Respiration

Respiration is another characteristic feature of living things. All living things need oxygen to live which they get from their environment. The process of taking in oxygen and excreting carbon dioxide is termed as respiration. We can observe respiration in animals as they breathe. But we cannot directly observe this function in plants. Plants take in oxygen through the process of diffusion. To prepare their food they also absorb carbon dioxide through the process of diffusion. This process is called "photosynthesis" i.e. synthesis or preparation of food using light energy. The oxygen from the air spaces in the leaves and stems diffuses into the plants.

Excretion

In the body of living organisms a number of processes are going on as a result of which waste materials are produced. The body needs to get rid of waste products as they can poisonous for the body. Urea, carbon dioxide, solid waste and sweat are the waste materials produced in the body of the animals. The process through which a living organism removes the waste materials is called excretion. It is characteristic of both animals and plants. In plants carbon dioxide is produced as a result of respiration which is excreted through leaves. This process is most active at night that is the reason sitting under trees at night is dangerous.

Growth

An increase in the size of an organism which is irreversible is called growth. We sow seeds in few weeks time they grow into a plant, similarly a chick changes into a hen, and human child grows into an adult. These are all examples of growth in living organisms. You may argue that non-living object like a 'crystal' can also grow in size. However in a crystal the growth takes place due to the addition of more particles on the outer surface of the crystal. In contrast to this, growth in a living organism takes place as a result of many chemical and physical changes in the body of the organism. In this process new materials and parts are developed.

Sensitivity

Organisms as a whole or their parts respond stimuli. A change in the environment of the organisms to which they respond is called a stimulus (plural is stimuli). Sensitivity is the ability of living organisms to respond to stimuli.

Living organisms react or respond to the stimuli to seek safety from a danger, to fulfil a need. For example when a cat see a dog it runs away, or when it smells meat it tries to get it. Plants are also sensitive to various stimuli such as gravity, light, touch and change in temperature. Plant bends towards the source of light. Plants movement towards light is called phototropism. You may have seen a plant called touch me not. When we touch its leaves they fold up. You may have observed that in hot summers plant leave fold up. This is their response to increase in temperature. In this way they control evaporation of water from leaf surface.

Non-living things are not sensitive to stimuli.

Reproduction
There is continuity to life. All living organisms reproduce young ones of their own kind. Different types of organisms have different mechanism of reproduction. Some give birth to young ones, others lay eggs. Plants reproduce in many ways. Some plants reproduce through seeds, in others a part of plant body like a shoot or bud can grow into a new plant.

Definite Life Cycle
Living organisms have a definite life-cycle. They are born; they grow, reproduce, become old and die.

Key Points

1. Living things have certain characteristic features which are not found in non – living things.
2. Nutrition, respiration, excretion, growth, reproduction, sensitivity and definite life cycle are characteristics of living things.

Self Assessment Exercise 01

Q.1 Select the correct answer:

i. Which of the following is not a characteristic feature of animals?
   a) Respiration
   b) Photosynthesis
   c) Reproduction
   d) Movement

ii. In which of the following the movement is partial?
   a) Fish
   b) Insects
   c) Green plants
   d) None of these

iii. Phototropism is plant's response to...
   a) Temperature
   b) Gravity
   c) Light
   d) Touch

iv. Non – living things like crystals or rocks grow in size as the living beings do but their growth is different because it...
   a) Does not involve addition of materials.
   b) Is not a continuous process
   c) Does not involve formation of new parts.
   d) Is limited to some parts of the object

Q.2 Write brief answers

i. What is the difference in respiration and movement in plants and animals?
ii. What are the indications of sensitivity in plants?
iii. Compare the growth in non living objects with the living organisms.
iv. Give examples of movements in plants.

7.2 Animals and Plants

A number and variety of living organisms is found on this planet earth. Studying the millions of animals and plants would be very difficult without sorting them into some sort of meaningful order i.e. classifying them. Just as making a good use of a library would be difficult without grouping the books in some systematic manner. Similarly studying the enormous number and vast variety of life without classifying living organisms will be difficult if not impossible.

Classification is grouping of living organisms according to similarities and differences of their characteristics. To identify animals and plants and to learn more about them, it helps to classify them. Biologists arrange organisms into groups on the basis of characteristics i.e. traits which are common. This systematic way of classifying organisms is the basis of the field of study called taxonomy.

Figure 1: Carlolus

Carolus Linnaeus (1758) a Swedish scientist, was the founder of modern taxonomy. At the time when Linnaeus wrote the taxonomy international language was Latin and still most of the scientific names are in Latin.

This system each type of animal and plant has one and only one scientific name which is not given to any other type of the organism. Then he presented a method for organizing all these named organisms into hierarchical groups, based on their similarities and differences. It is like a filing system, with the top levels including large number of different kinds of organisms and the lowest levels containing only a single type of plant or animal. In this hierarchical system of Linnaeus clearly defined shared characteristics are used to classify organisms into each group represented by these different levels.

Under this system organisms are first divided into very large groups. The biological term for these groups is "kingdom". There are two major kingdoms: "animal kingdom" and "plant kingdom". However there are many organisms which do not share characteristics with either animals or plants or which have some characteristics of a plant while others of an animal. Some biologists have put these in separate kingdoms. So besides animal and plant kingdom there are kingdom Monera, kingdom Protista, and Fungi. However it is not universally agreed upon classification there are other classifications systems also.

Kingdoms are again subdivided into groups containing fewer organisms than kingdom but having more features in common. These groups are called "phyla" (singular phylum).

Each phylum is then divided into smaller groups called "classes". Classes are divided into orders, each order is divided into families and families into "genera" (singular genus) and genera are divided into species. All human beings are placed in genus "homo" and species "sapiens". So the biological group of human beings is "Homo sapiens"! This is the simplest classification there are other systems of classification which are more elaborate and have many more groups like sub orders and subfamilies.

Every species of organisms has been given a double name, one name for its genus the other for species. Genus name is always started with a capital letter and species name with small letter. Scientific name for domestic cat is “Felis catus”, similarly scientific name for rose is Rosa berberifolia.

Species is the name given to the group of organisms so similar that they can mate together and produce young ones of their own kind.

Activity 1

Collect different types of leaves or items of stationary or cutlery and try to classify them into groups and subgroups. Use their common characteristic such as shape, colour, and texture of leaves. You must use one major characteristic to put them in one group. For example put all round leaves into one group and long leaves into the other. Then subdivide each group on the basis of texture e.g. soft, hard surface.

7.2.1 Kingdom Monera

Bacteria and a kind of water plants named blue green algae have been placed in this kingdom. Their body is formed of only one cell however their structure is different from other organisms made of one cell.

Viruses are also included in this group. These are smallest organisms which cannot be seen with a light microscope. Electron microscope is needed to observe virus since they are hundred times smaller than bacteria.

7.2.2 Kingdom Protista

All single celled organisms (called unicellular organisms) have been place into this kingdom. We need a microscope to see these organisms. Some of the members of this group have green colour substance called chloroplast and like all green plants they make their food through the process of photosynthesis. Chlamydomonas also belongs to this group.

There are other unicellular organisms in this group which are more like animals as they take in food and digest it; Amoeba, Paramecium, Stentor are examples of these organisms. These are also called Protozoa. Some biologists put them in a separate kingdom called Protozoa.

7.2.3 Kingdom Fungi

The mould that we see growing on stale bread, rotten fruit, or other foods and mushrooms which are often found sprouting here and there after rain belong to this kingdom. Fungi live and feed on dead organisms hence are called Saprophytes. These with the exception of yeast (Yeasts are unicellular organisms, consist of oval or round cells, and reproduce chiefly by budding. We use yeast to ferment bread) are multicellular organisms. Their bodies are made of thin thread like structures called “hyphae”. In some these hyphae are spread like a network while in others they are bundled into a compact structure called “mycellium’. The stalk like structure we see in mushrooms is mycelium.

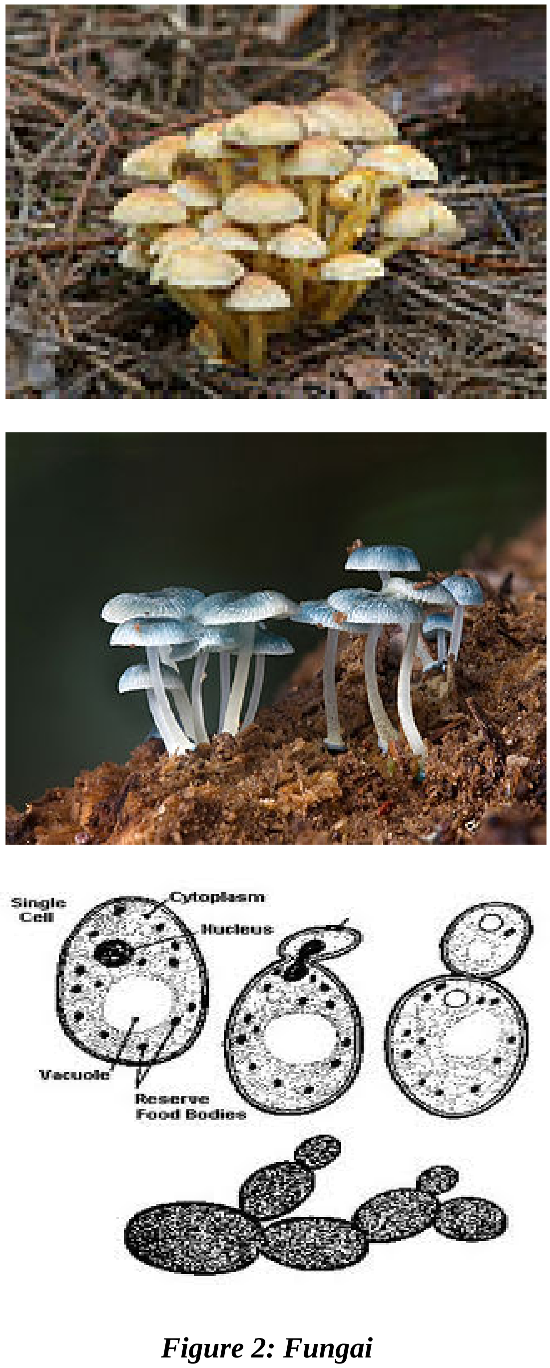
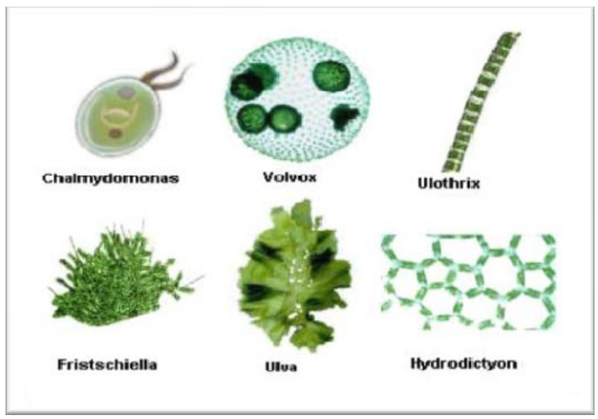


Figure 2: Fungai

7.2.4. Kingdom Algae

Algae are simple organisms. Like green plants they have chlorophyll and make their own food. They are largely aquatic organisms. They occur in a variety of other habitats: moist stones, soils and wood. Their unicellular variety has been placed in kingdom Protista. The algae reproduce by vegetative, asexual and sexual methods. Algae are of many different types, red, green, brown and golden algae are common Examples: Volvox, Ulothrix, Spirogyra and Chara are few of the examples of Algae.



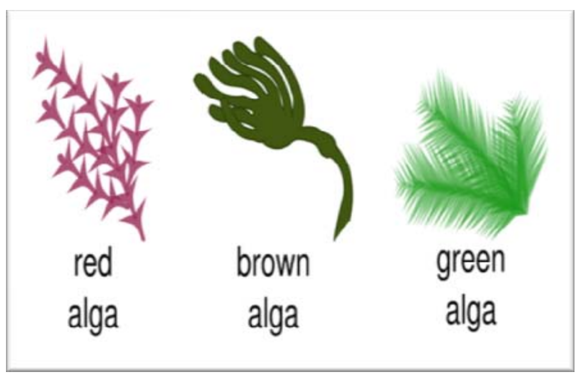


Figure 3: Different Types of Algae

Key Points

1. Classification is grouping of living organisms according to similarities and differences of their characteristics.
2. The term "kingdom" is used for the largest groups of organisms having common characteristics.
3. Kingdoms are again subdivided into groups containing fewer organisms than kingdom but having more features in common. These groups are called "phyla" (singular phylum).
4. Kingdoms are subdivided into groups having more features in common. These groups are called "phyla" (singular phylum). Each phylum is divided into smaller groups called "classes". Classes are divided into orders and orders into families, families to even smaller groups called genera and genera into species.
5. Kingdom Monera includes organisms formed of only one cell however their structure is different from other unicellular organisms. Bacteria and viruses fall in this group.
6. Kingdom Protista includes unicellular organisms. Their cell structure is different from organisms in kingdom Monera.
7. Kingdom Fungi includes moulds and mushrooms. They feed on dead organisms.
8. Kingdom Algae comprises of plants mostly living in water. These are multicellular and are autotrophs.

Self Assessment Exercise 02

Q.1 Choose the correct answer:

i. What is the biological term used for largest groups of organisms?
   - a) Phylum
   - b) Order
   - c) Kingdom
   - d) Family

ii. How is the kingdom Monera different from protista? Kingdom Monera ---
   - a) Includes only unicellular plants
   - b) Consists of multicellular organisms,
   - c) Organisms which have different cell structure
   - d) Includes primitive organisms.

iii. To which of the following kingdom mushrooms belong?
   - a) Protista
   - b) Monera
   - c) Algae
   - d) Fungi,

iv. Which of the following has chloroplast in their cell?
   - a) Chlamydomonas & Volvox

b) Amoeba & Viruses
c) Moulds & Bacteria
d) Paramecium & Yeast

v. Saprophytes is an organism which...
a) Can prepare their food
b) Live on other organisms as parasites,
c) Are beneficial for their host
d) Use dead organisms as their food

Q.2 Answer the following questions:

i. Compare the characteristics of Algae and Fungi.
ii. Which type of organisms have been categorized under kingdom Monera?

7.3 Kingdom Plantae

This kingdom is divided into two major groups: non – flowering and flowering plants.

7.3.1 Non-flowering plants

As the name indicates Non-flowering plants do not have any flowers. They only have leaves and cannot have fruits. Non-flowering plants have following groups.

Bryophytes

Plants in this group have no flowers. These are commonly found in moist shaded areas in the hills. They have multi cellular body. Some Bryophytes have leaf like body called thallus while others have a stem with leaf like structures arranged on either side. They lack true roots, stem or leaves. However, they possess structures which resemble roots and stems in higher plants. Root like structure called Rhizoids serves the function of roots. They have chlorophyll and prepare their own food i.e. they are autotrophs.

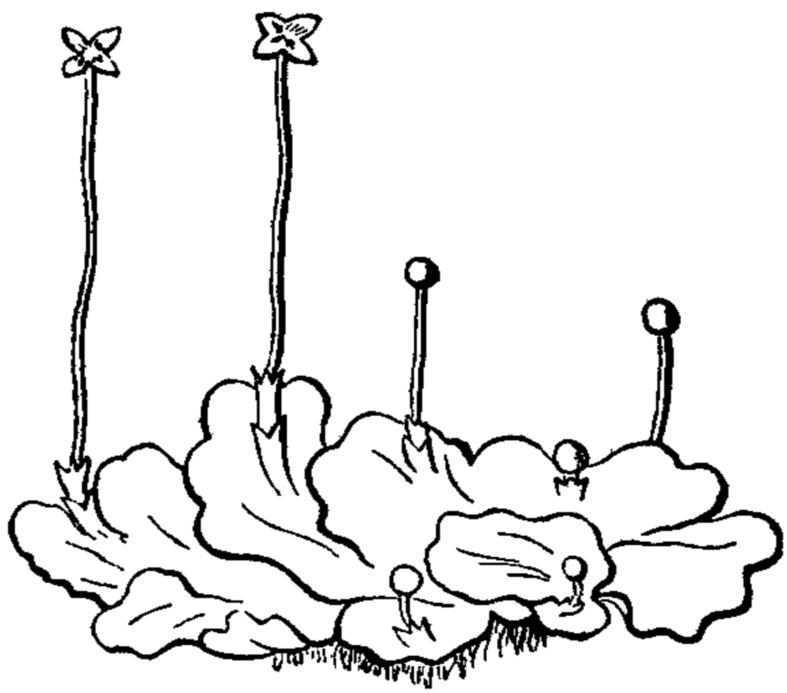


Figure 4: Bryophytes

There are two divisions of Bryophyta:

1. Liverworts
2. Mosses.

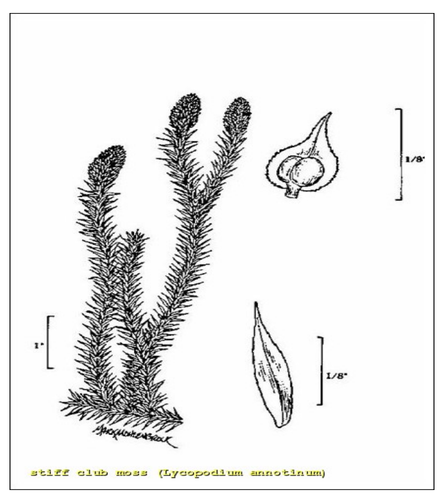
Common Examples include Funaria, Polytrichum and Sphagnum.

Pteridophytes

These are also non – flowering seed less plants. They produce spores which grow into new plant. These plants have chlorophyll and make their own food i.e. they are also autotrophs. The pteridophytes are vascular plants that they have a system of vessels for transport of food and water. The pteridophytes are found in cool, damp, shady places. Their body consists of true root, stem and leaves. Examples include horsetail, club mosses, psilotum, adiantum, pteris, and dryopteris.

Fern

Club Moss Lycopodium



Club Moss Lycopodium

Gymnosperms

These are non – flowering, vascular plants. They include pine trees you may have seen in Murree. The word "Gymnosperm" is a Greek word and it means "naked seed" (*gymno means* naked, *sperm* means seed). Unlike flowering plants which have their seeds enclosed in an ovary (i.e., fruit), seeds of Gymnosperms are exposed. Pine trees that you all are familiar with belong to this group. Other examples include; cycads, gnetum, ephedra, and welwitschia. All of them are woody trees, some shrubs, also adapted to desert life. It covers large area of earth.

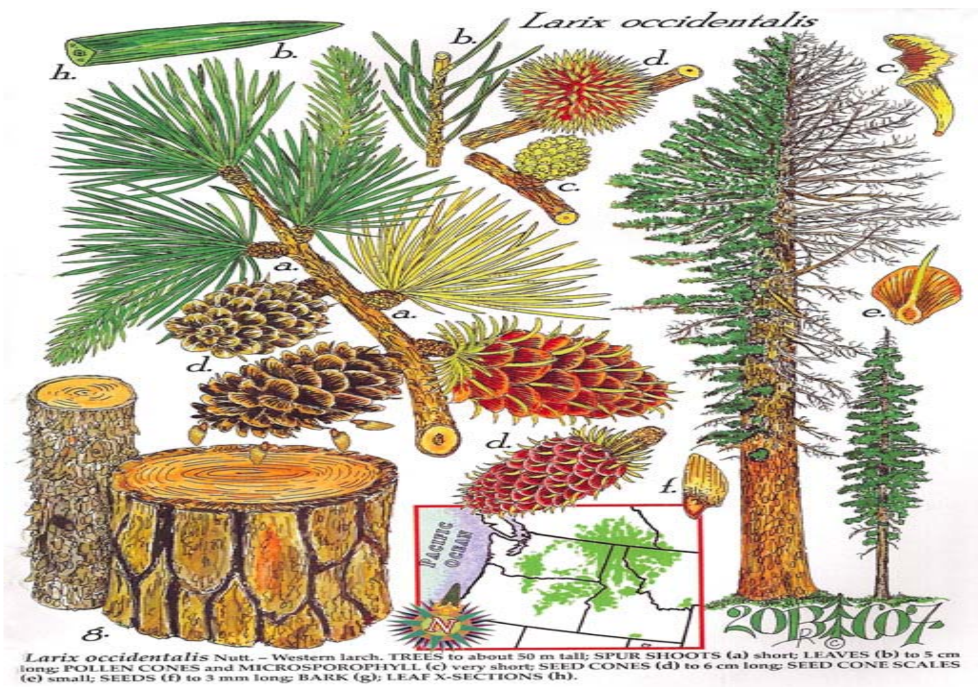


Figure 5: Gymnosperms

7.3.2 Flowering Plants

Angiosperms

This group includes all the flowering plants which we see around us. They produce seeds. Unlike gymnosperms their seeds are enclosed in fruit (ovary).

They have a well developed vascular system. The angiosperms are a large group of plants occurring in wide range of habitats. They range in size from tiny, almost microscopic Wolfia to tall trees of Eucalyptus (over 100 metres). They provide us with food, fodder, fuel, medicines and several other commercially important products. On the basis of their seed structure Angiosperms are divided into two classes:

1. Dicotyledons
2. Monocotyledons

The dicotyledons are characterized by having two cotyledons in their seeds while the monocotyledons have only one. Gram seed, kidney beans, and coriander seed are a few examples of dicotyledonous seeds. The seeds can be divided into two parts or cotyledons whereas the seeds of wheat and corn cannot be divided into two parts. The former are dicotyledonous while the latter are called monocotyledons seeds.

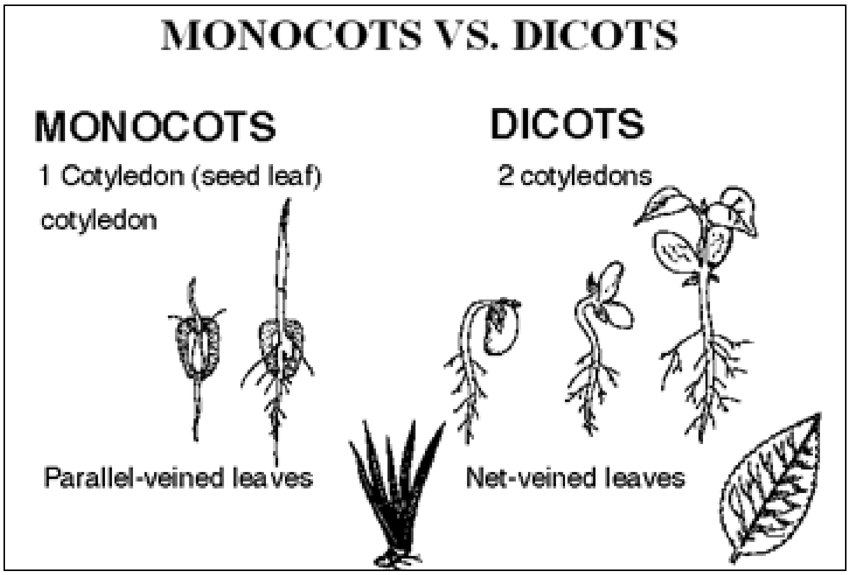


Figure 6: Monocots and Dicots

Key Points

1. The arrangement of organisms into groups and subgroups on the basis of similarities and differences is Classification.
2. The largest group of plants which consists of all plants is named as "kingdom Plantae".
3. The kingdom Plantae has been classified into flowering and non flowering plants.
4. Non flowering plants include algae, bryophytes, pteridophytes, and gymnosperms. They do not bear flowers and fruits.
5. Flowering plants or Angiosperms produce seeds, fruits, and flowers.
6. Angiosperms are divided into monocotyledons and dicotyledons, on the basis of number of cotyledons in seed.

Self Assessment Exercise 03

Q.1 Encircle the correct option.

i. Which of the following group of plants lacks true roots and stems?
 a) Angiosperm
 b) Gymnosperms
 c) Pteridiphyta
 d) Bryophyta

ii. Parallel-veined leaves are present in:
 a) Monocots
 b) Dicots
 c) Algae
 d) Ferns

iii. Mosses and liverworts are included in:
 a) Algae
 b) Bryophytes
 c) Fungi
 d) Pteridophyta

iv. Naked seeds are present in:
 a) Gymnosperms
 b) Angiosperms
 c) Ferns
 d) Algae

v. Which of the following group has well developed vascular system and has flowers?
 a) Algae
 b) Gymnosperm
 c) Pteridophyta
 d) Angiosperm

Q.2 Give short answers

i. What is the major difference between gymnosperms and angiosperms?
ii. How would you recognize monocot and dicot plants?
iii. Can you differentiate between bryophytes and pteridophytes?
iv. Write the names of groups of non-flowering plants.
v. Write a note on characteristics of flowering plants give some examples.

7.4 Classification of Animals

The animal kingdom has been divided into two large groups, Vertebrates and invertebrates. Vertebrates include the animals which have a back bone while invertebrates are animals without back bone. There are many phyla of invertebrate some of which are discussed below.

7.4.1 Invertebrates

As stated above the group invertebrates include animals without backbone.

Phylum-Protozoa

In this phylum single celled (unicellular) animals have been included. More than 50,000 living species of Protozoa have so for been described. These are very small, microscopic animals. They are found everywhere; in soil, in water and even inside the bodies of other animals including humans. Protozoa which live as paracite in human body cause diseases like malaria, dysentery, etc. Common examples: Amoeba, Parmecium, Plasmodium (malarial parasite). Some Protozoa's which live in the body of other organism benefit from the host body without causing harm to it; in some cases host benefit from the Protozoan. This type of relationship in which either of the two takes benefit is termed as "commensalism".

In Protozoa new individuals are produced by division of the organism into two, this is called binary fission (bi = two, fission = breaking), spore formation or by a process in which two organisms temporarily unite and exchange nuclear material and then each organism divide into two thus two new individuals are formed, this process is called "conjugation".

Activity 2

Carefully observe the diagram below and note down the shape of different Protozoa. See how they are different and how they are alike.

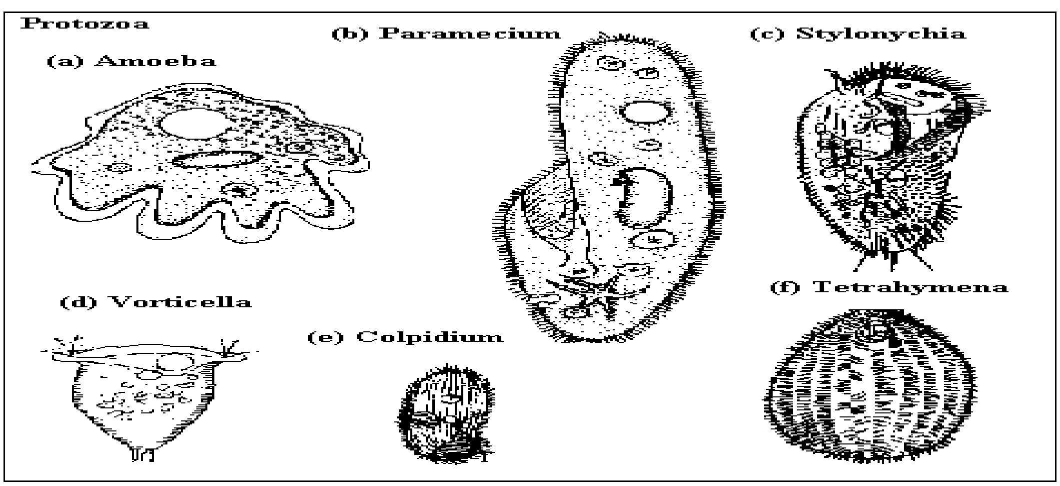


Figure 7: Invertebrates

Phylum – Porifera

Porifera are commonly known as sponges**.** The name "Porifera," means “having pores”. These are simplest form of multi-cellular animals which live permanently attached to a location in the water. There body does not have tissues, organs and systems. The body of a spore has numerous pores which let water flow through it continually. These pores open into internally into a system of canals. It has one or more larger holes which open outside. Water moves through these canals throughout the sponge's body. Special cells line these canals. The water while moving through the sponge brings oxygen and nutrients and takes away carbon dioxide and waste. Sponges reproduce by budding or by fragmentation. Sexual reproduction also takes place.

There are from 5,000 to 10,000 known species of sponges. Most sponges live in salt water - only about 150 species live in fresh water. These are primitive animals which evolved over 500 million years ago.

Sponges are found in variety of shapes, some are tube like, others have fan like body and there are some which resemble cup, cones, blobs, barrels, and crusts. Their size range in from a few millimeters to 2 meters tall.

Figure 8: Phylum – Porifera

Phylum – Coelenterata (Cnidaria)

The name “Coelentrate” means “hollow gut”. The name indicates that their body is like a gut. Hydra is one of the coelenterates. If you observe it under a microscope you will see that its body is like a hollow tube or stalk. It has a mouth opening at the top. Animals in this group live in water i.e. they are aquatic. Some are permanently attached to some support and are immovable, others are free-swimming. These are radially symmetrical animals.

Radial symmetry means that if the organism or part of it is vertically cut through the axis in any of two or more planes it will produce two halves that are mirror images of each other.

The size of coelenterate varies from 1mm (Hydra) wide to giant jelly fishes about meters in diameter. They have tentacles around their mouth. They use the tentacles for their defence and capturing prey. Jelly fish, Sea anemone and Hydra are examples. There are about 10,000 species of Coelentrates.

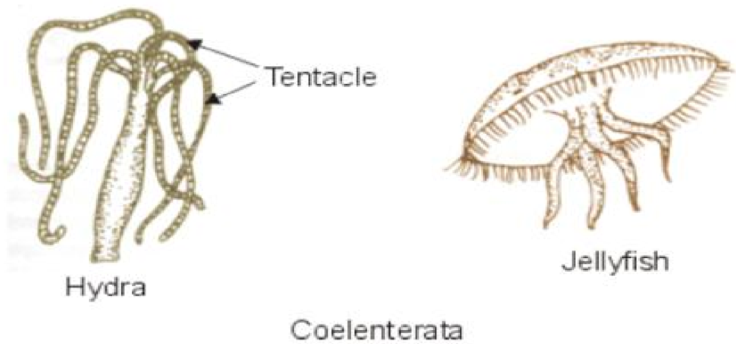


Figure 9: Phylum – Coelenterata (Cnidaria)

Phylum – Platyhelminthes

This phylum includes primitive type of animals. The upper and lower surface of these animals is flat in biological terms they have dorso-ventrally flattened body, hence are called flatworms. Flatworms are bilaterally symmetrical; that is, the left and right halves of the body are mirror images of one another. These are mostly found in the body of animals including human beings that is they are endoparasites. For example some live in the intestine of animals and human beings. Some of them absorb nutrients from the host directly through the surface of their body. Planaria, Taenia (Tapeworm), Fasciola (Liver fluke) are few examples of Platyhelminthese. About 7000 living species are described in this phylum.

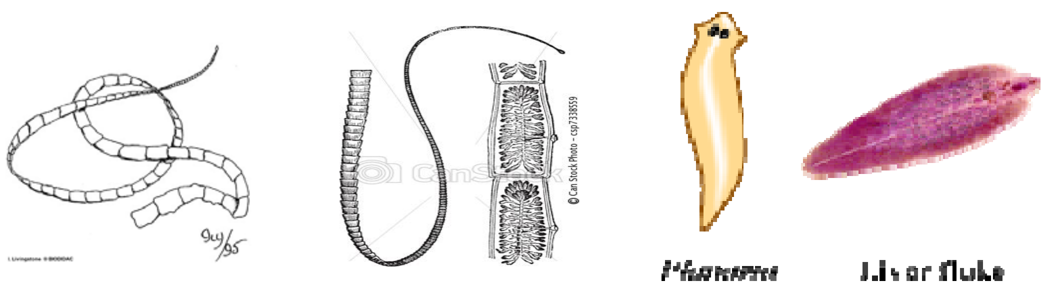


Figure 10: Phylum – Platyhelminthes

Phylum – Nematoda (Aschelminthes)

The body of the nematode is long and round, hence the name roundworms has been given to this group. They may be free living, aquatic and terrestrial or as parasites in plants and animals. Some of the examples include: Ascaris (Round Worm), Wuchereria (Filaria worm). About 500,000 living species have been described in this group.

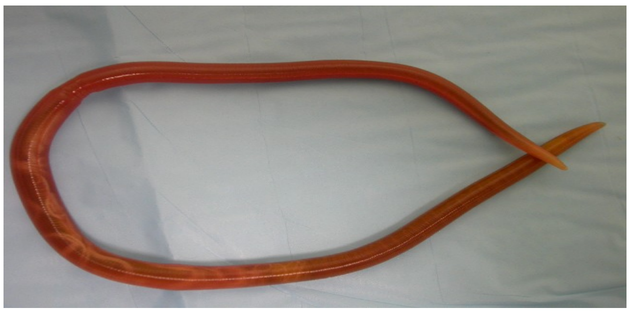
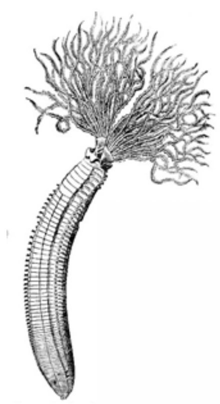


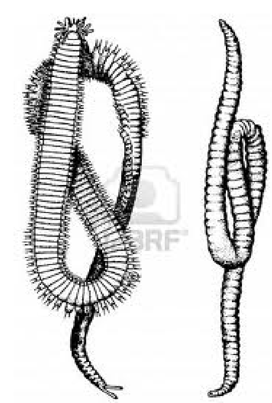
Figure 11: Phylum – Nematoda (Aschelminthes)

Phylum – Annelida (Segmented worms)

They may be aquatic or terrestrial; free-living, and sometimes parasitic. About 1,000,000 species have been described. They have bodies consisting of many similar parts called segments. Each segment is marked off from the other by a ring. Common Earthworm is one example of this phylum you all have seen. Other examples include Nereis, Blood sucking leech. About 7000 species are described in this group.



Sea Anemone



Polychaete and Earth worm

Figure 12: Phylum – Annelida (Segmented worms)

Phylum – Arthropoda

Arthropods are the most numerous animals on Earth. The Arthropods have segmented body with tough outer skin, the cuticle. Cuticle is a form of external skeleton or exoskeleton. Exoskeleton protects and supports the body. They have jointed legs.

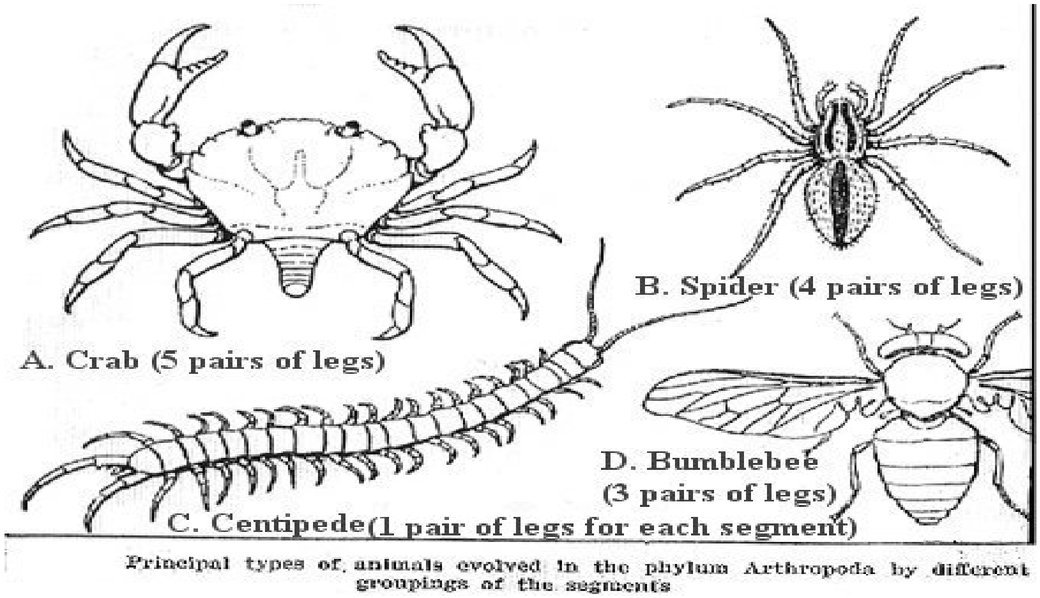
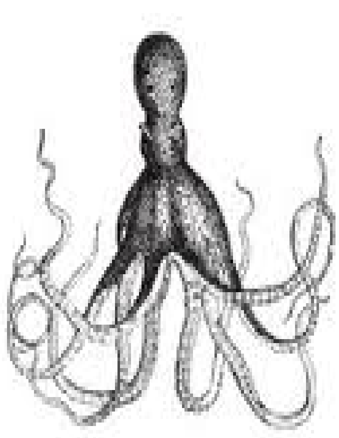


Figure 13: Some Arthropods

Phylum – Mollusca

This is the second largest animal phylum approximately 100,000 species are included in this group. Molluscs are terrestrial or aquatic. Their body is soft, covered with a shell. They have a muscular foot for locomotion. Examples: Apple snail, Pearl oyster, Sepia (Cuttlefish), Squid, Octopus.



Octopus

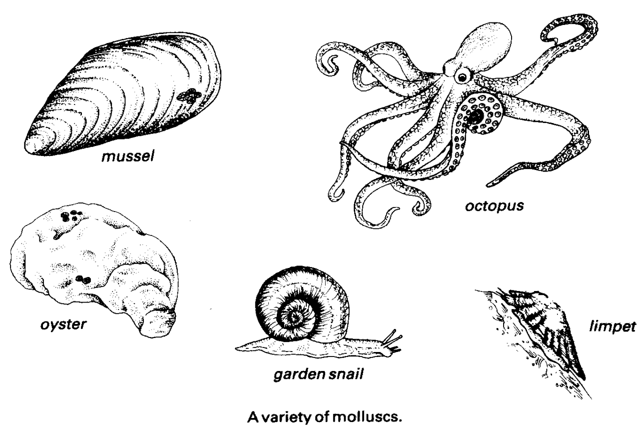


Figure 14: Some Molluscs

Phylum – Echinodermata

Exclusively marine in habitat. Approximately 6500 species are described. These animals have an endoskeleton of calcareous ossicles and, hence, the name Echinodermata (Spiny bodied).Examples include Star fish, Sea urchin, Sea lily, Sea cucumber and Brittle star.

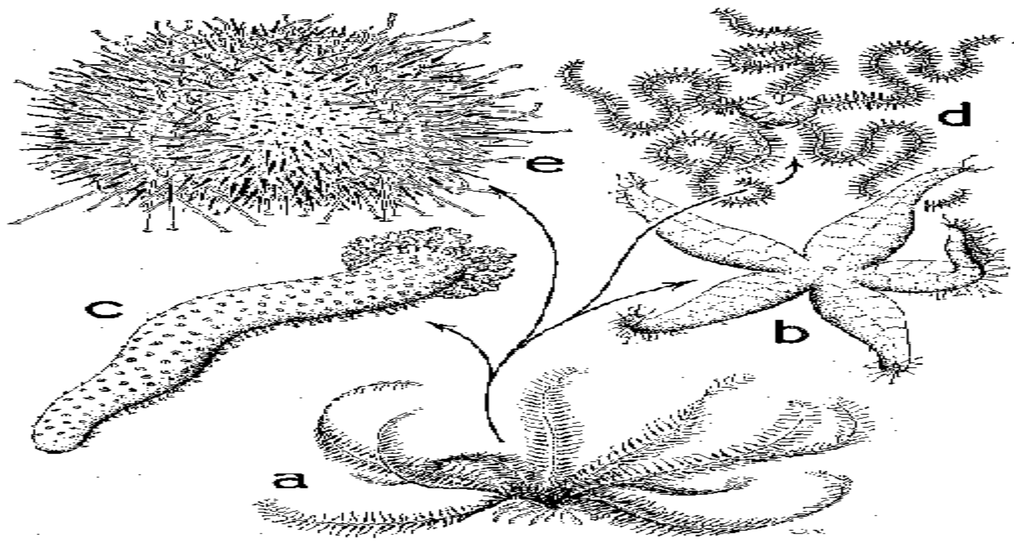


Figure 15: Echinoderms

7.4.2 Vertebrates

These are animals with backbone in their body. This group has been divided into five classes.

Class Fishes

These are aquatic animals. They have a body shape which helps them to move in water as effectively and quickly as possible. Body shape which helps to move in liquid or gas effectively and quickly is called "streamlined body". Their body is divided into head, trunk and tail. They possess fins for swimming and gills for respiration. A cover called Operculum is present on gills. Their body surface has scales. They are cold blooded animals. They live in fresh water, rivers, sea, ponds, hill streams, lakes. There size ranges from one inch (gobies) to 40 feet long (e.g. shark). Over 30,000 species have been described. They are mostly oviparous i.e. lay eggs.

Examples include Flying fish, Hippocampus (Sea horse), Labeo (Rohu), Scolcodon (dog fish) shark, trout.

Figure 16: Class fishes

Class – Amphibia

The representatives of class Amphibia live both on land and in water that is why they have been given the name, "amphibia".

Amphibians are cold-blooded animals, meaning they do not have a constant body temperature but instead take on the temperature of their environment. They have moist, scale less skin that absorbs water and oxygen. Amphibians are most often found near areas where freshwater is available. Some amphibians become inactive when conditions are unfavourable for survival. This period of inactivity is called estivation when it occurs during hot, dry weather and hibernation when it occurs in response to cold temperatures. Activity resumes when favourable conditions return.

The thin skin of amphibians contains many glands. In some species poison glands are present in the skin to protect them against predators. For example in a type of frog the poison is particularly toxic. South American Indians use this poison to coat the tips of their arrows. Some amphibians protect themselves from enemies by changing colour to blend in with their surroundings. Sexes are separate. They are oviparous and lay eggs which have no shell. Eggs are usually laid in water or in a moist environment and fertilized externally. They change from an aquatic larval stage to a terrestrial form on reaching adulthood i.e. they go through metamorphosis. Respiration takes place either separately or in combination by lungs, skin, and gills. They have a three-chambered heart consisting of two atria and one ventricle.

Toad (Bufo), Frog (Rana), Tree frog (Hyla), and Salamander (Salamandra) are some of the examples.

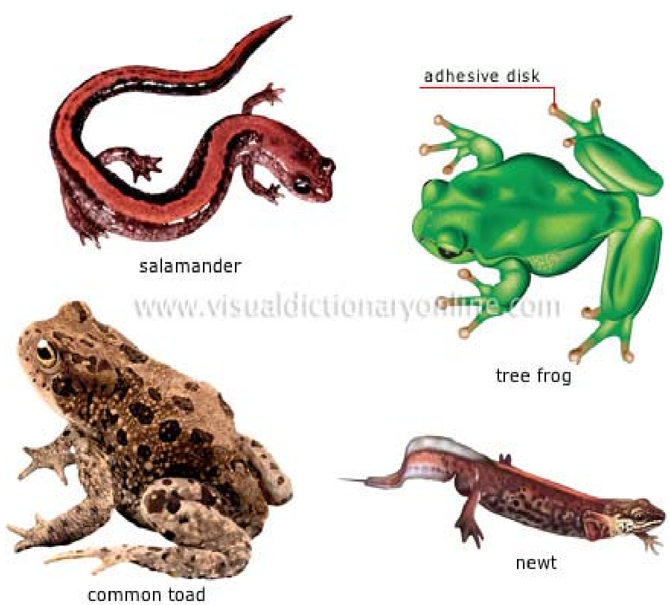


Figure 17: Class – Amphibia

Class – Reptilia

Class reptilia includes animals which are cold blooded. The skin has dry scales which prevents water loss through the skin and protect the body. Most of the Reptiles are considered as tetra pods i.e. have two sets of paired limbs. Most of these animals have five clawed toes on each limb. All reptiles have spinal columns and a strong skeletal system with a rib cage. They have a well-developed brain and a central nervous system.

They have well-developed lungs. Most of them have two lungs, except some snakes. All Reptiles except crocodile have three-chambered heart. Crocodiles have four-chambered heart like mammals and birds.
Reptiles lay eggs which have protective shell. The offspring of reptiles resemble the adults at the time of birth itself. There is no metamorphosis, as in the case of amphibians.

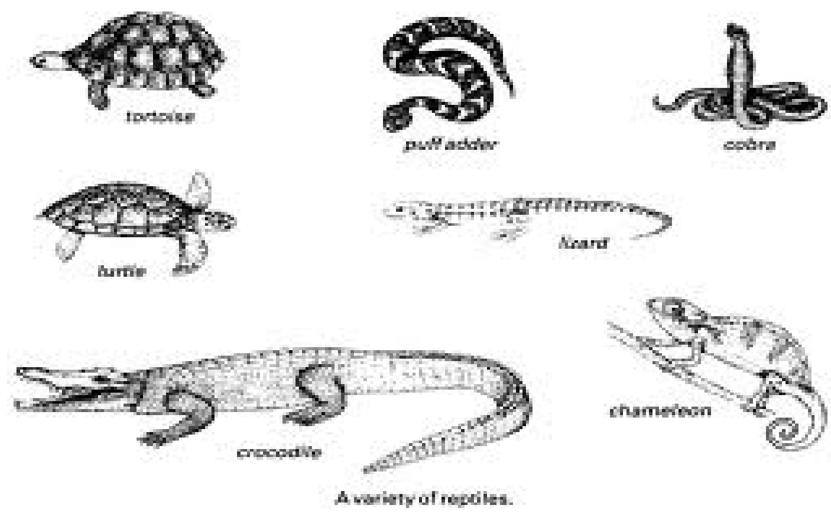


Fig 18: Class – Reptilia

Class – Aves

The characteristic features of Aves (birds) are the presence of feathers and most of them can fly except flightless birds (e.g., Ostrich). They possess beak. The forelimbs are modified into wings. The hind limbs generally have scales and are modified for walking, swimming or clasping the tree branches. Skin is dry without glands except the oil gland at the base of the tail. The digestive tract of birds has additional chambers, the crop and gizzard. They are adapted to various types of conditions e.g. they can fly in air, swim in water and walk on ground.

Heart is completely four chambered. They are warm-blooded animals. Respiration is by lungs. Sexes are separate. Fertilization is internal. They are oviparous and development is direct.

Examples: Crow, Pigeon, Parrot, Ostrich, Peacock, Penguin, Vulture.

Figure 19: Birds

Class – Mammalia

Animals in this class has the most unique characteristic that is the presence of milk producing glands (mammary glands) hence the name “Mammalia” has been given to this class. The second distinguishing feature of Mammals is presence of hair on the skin. They have two pairs of limbs, adapted for walking, running, climbing, burrowing, swimming or flying. External ears or pinnae are present.

Mammals have a four-chambered heart. They are warm blooded (Endothermic) animals i.e. they can control their body temperature. They give birth to young ones. However there is an exception egg laying platypus is a mammal. Kangaroo, Flying fox, Camel, Monkey, Rat, Dog, Cat, Elephant, Horse, Blue whale, Tiger, Lion, dolphin, sealion are few examples.

Platypus

Koala Bear

Squirrel

Tiger

Key Points

1. The animal kingdom has been divided into two large groups, Vertebrates and invertebrates.
2. Phylum protozoa include single celled animals.
3. Phylum porifera includes multicellular organisms commonly known as sponges.
4. Phylum Coelentrata include multicellular water plants having a hollow body.
5. Phylum Platyhelminthes include flat worms some of which are parasites.
6. Phylum Nematoda includes round worms. Some of these are parasites others are free living animals.
7. Phylum Annelida consists of animals which have segmented body and live as parasites or as free living organisms.
8. The Arthropods have segmented body with tough outer skin, the cuticle.
9. Phylum Mollusca includes shelled animals.
10. Echinodermata have an exoskeleton of calcareous ossicles and, have radial symmetry.
11. Vertebrates are animals having vertebral column. They are further divided into five classes.
12. Fishes are cold blooded aquatic animals, having fins for swimming and gills for respiration.
13. Amphibians live both in water and on land. They are cold blooded animals with slimy and moist skin.
14. Reptiles are cold blooded animals which lay eggs and have dry scales on body.
15. Birds possess feathers and beak. Their forelimbs are modified into wings, and hind limbs are used in walking, running and swimming. They are warm blooded.
16. Mammals have mammary glands; female nourishes her young ones on her milk. They give birth to young ones. They have hair on their body.. They are warm blooded. All except one species are viviparous.

Self Assessment Exercise 04

Q.1 Encircle the correct option.

i. Which animal is oviparous?
   a) Kangaroo b) Rat
   c) Camel d) Platypus

ii. Earthworm belongs to phylum:
   a) Annelids b) Nematoda
   c) Platyhelminthes d) Coelentrata

iii. Starfish belongs to:
   a) Shelled animals b) Spiny animals
   c) Sponges d) Fishes

iv. Animals belonging to phylum Echinodermata possess _____ symmetry.
   a) No b) Radial
   c) Bilateral d) Trilateral

v. Hydra belongs to which group?
   a) Fishes b) Nematoda
   c) Mollusc d) Coelentrate

vi. Which class includes warm blooded animals?
   a) Fishes b) Amphibians
   c) Reptiles d) Birds

vii. Mammals have _____ chambered heart.
   a) 1 b) 2
   c) 3 d) 4

viii) Which of the following animal is a mammal but lay eggs?
   a) Whale b) Platypus
   c) Dolphin d) Sea lion

Q.2 Give short answers

i. How does classification help to learn about living things?
ii. What is the common characteristic of phylum protozoa and porofera?
iii. What does the term "cold blooded animal" mean? Name some cold blooded animals.
iv. Can you classify birds into further groups? Think of the characteristics you will use to further classify the group.
v. Compare the characteristics of Nematoda and platyhelminthes. Point out their similar features and features which are different.

7.5 Cells as Basic Unit of Life

The basic building block of all living organisms is cell. Robert Hooke discovered the cell in 1665. He observed the 'cells' in the thin sections of cork. However, Hook did not study the structure of the cell. What he saw under the microscope was like the walled compartments a monk would live in. That is why he gave the name "cell" was given. The word cell comes from the Latin word, ''cellula'', meaning "a small room".

As you have studied in previous unit, some living things are made of one cell while others are made of many cells.

Cell Theory

The cell theory was developed in 1839 by M. J. Schleiden and Theodor Schwann. According to this theory:

- All organisms are composed of one or more cells.
- All cells come from pre - existing cells i.e. cells divide to produce new cells.
- All functions of an organism occur within the cells,
- All cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells.

7.5.1 The Structure of Cell

The major material of all living cells is a jelly-like substance called protoplasm. In advanced organisms protoplasm contains many complicated structures; nucleus is the most prominent part. These parts are enclosed in membranes. Each structure performs some function in the cell. Cells having membrane bound structures are called "eukaryotic" cells. The cells of some organism such as bacteria or blue green algae, lack the nucleus and other membrane bound structures. These are called "prokaryotic" cells. Organisms in kingdom Monera have prokaryotic cells. Pro means before and karyotic means nucleus. Cells of all developed organisms including human beings are eukaryotic.

There is a variety of cells having different size, shape and functions (Figure **8.1**). The smallest cells are only 0.3 µm in length while the size of bacteria ranges from 3 to 5 µm. The egg of an ostrich is the largest isolated single cell. Human red blood cells are about 7.0 µm in diameter. Our nerve cells are some of the longest cells. Cells also vary greatly in their shape. They may be disc-like, polygonal, columnar, cuboid, thread like, or even irregular. The shape of the cell may vary with the function they perform.

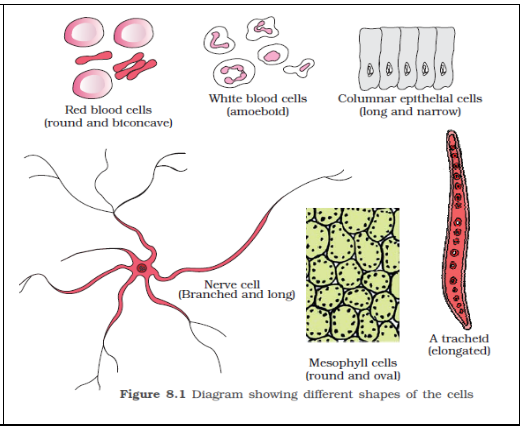


Figure 21: Different Shapes of Cells

The cells of fungi, protozoa, other more developed plants and animals is divided into two basic parts, easily distinguishable under a light microscope. These parts are called “cell organelles”. These include: a nucleus and the cytoplasm that surrounds it.

Animal cells are enclosed in a membrane. Selected materials can pass through the cell membrane. For example oxygen can enter a cell through its membrane. Similarly carbon dioxide which is a waste material is excreted through the cell membrane. Water and other simple molecules can also pass through cell membrane. Plant cells have cell wall in addition to cell membrane. Cell wall gives shape to the cell and protects it from mechanical damage and infection. Simple molecules can pass across the cell wall. Cell membrane and wall protect the cells and also provide passage for selective substances.

Let us now discuss the structure of the cell in detail.

Cytoplasm

Cytoplasm is the fluid part of the cells. Ninety percent of the cytoplasm is water with molecules of salts and sugar dissolved in it. It also contains fats and proteins. If you observe the cell under the ordinary light microscope you can see it flowing about. It contains a number of particles. Some are food reserves like oil droplets or granules of starch others are cell organelles which perform specific functions in the cell. For examples mitochondria are energy house of the cell, ribosomes prepare cell proteins. These structures can be seen under electron microscope at much higher magnification.

The Nucleus

The nucleus (the plural nuclei) is an oval or spherical structure enclosed in a membrane.. In animal cells it is found near the center of the cell. In plant cells it is found at the side of the cell. The nucleus is the controlling agent in the cell. The nucleus regulates and directs all of the cell's activities—from nutrition to reproduction of the cell. When the cells are not dividing, the interior of the nucleus is filled with network of threadlike material called chromatin. It is made up of protein and a molecule called deoxyribonucleic acid (DNA). It is visible in a dividing cell. Nucleus also controls cell division.

Plant cell is different from animal cell. Plant cell has a cell wall outside the cell membrane. Animal cell has only one envelop i.e. cell membrane. Cells of plants which make their own food have another structure “chloroplast” which is lacking in animal cells. Animal cells have sometimes small fluid filled spaces called vacuoles these are not permanent whereas plant cell has a large vacuole which is permanent.

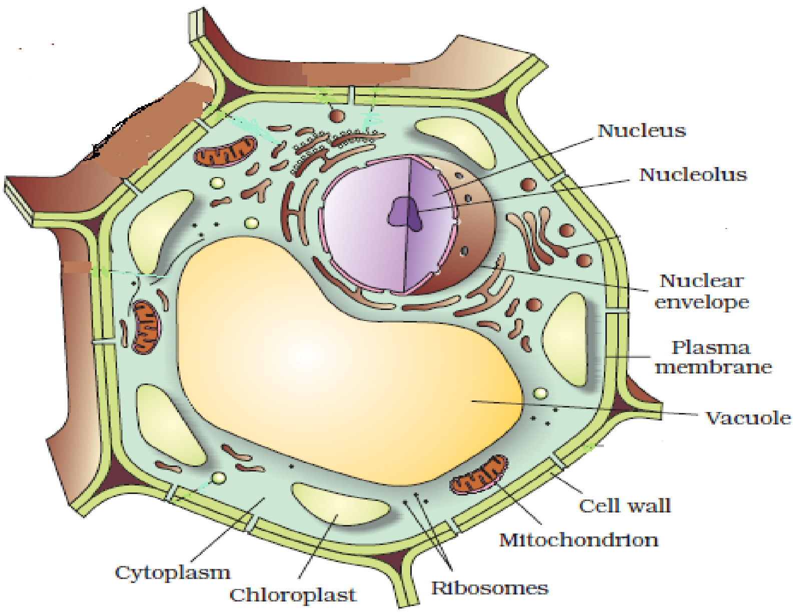


Figure 8.3 Diagram showing : (a) Plant cell

Figure 22: Plant Cell

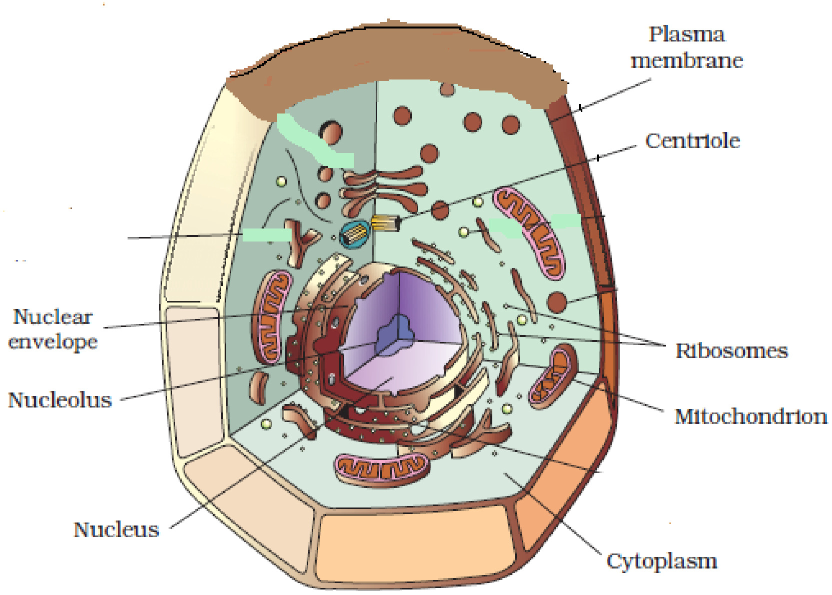


Figure 8.3 Diagram showing : (b) Animal cell

Figure 23: Animal Cell

Key Points

1. Bodies of all unicellular and multicellular organisms are formed of cells. All the body functions from feeding to reproduction are carried out at cellular level. Hence the cell is called the basic unit of structure and function in living organisms.
2. According to cell theory proposed by M. J. Schleiden and Theodor Schwann in183; all organisms are composed of one or more cells, all cells come from pre - existing cells, all functions of an organism occur at cellular level, cells contain the hereditary information which is transmitted to the next generation of cells.
3. There are two types of cells: eukaryotic and prokaryotic. Prokaryotic cells are usually independent, while eukaryotic cells are often found in multicellular organisms.
4. The prokaryote cell is simpler, lacking a nucleus and most of the other organelles of eukaryotes
5. Cells are formed of many important structures called cell organelles. Each cell organelles performs particular functions.
6. Cells are enclosed in a membrane called cell membrane. Plant cells have a cell wall along with a cell membrane.
7. Nucleus is the most important part of a cell. It controls all cell functions and contains hereditary material. It contains thread like material called chromatin material. It is visible in cell division.
8. Cells are filled with a fluid cytoplasm. Cytoplasm contains chemical substances as well as many cell organelles which are bounded in membranes. Mitochondria, ribosomes, are two of cell organelles. There are many others. Cell organelles are too small and visible only under high power electron microscope.

Self Assessment Exercise 05

Q.1 Select the best option

i. Which of the following is the control center of a cell?
   a) Mitochondria b) Vacuole
   c) Nucleus d) Ribosomes

ii. Where in a cell you will find the structure called chromosomes?
   a) Cytoplasm b) Mitochondria
   c) Vacuole d) Nucleus

iii. Which of the following is **NOT** a cell Organelles?
   a) Vacuole b) Cell protein
   c) Ribosomes d) Nucleus

iv. Which of the following becomes visible when a cell divides?
   a) Nucleus b) Chromosomes
   c) Mitochondria d) Ribosomes

v. Your teacher shows you a slide of an unknown cell under high power microscope. What would you look for to find out if it is plant or animal cell?
   a) Nucleus   b) Cell wall
   c) Ribosomes   d) Mitochondria

vi. Write brief answers.
   a) What is the role of nucleus in cell?
   b) What are the important points of cell theory?
   c) Who proposed the cell theory? Also write the names of the scientists who proposed the theory.
   d) What is the difference between a eukaryotic and prokaryotic cell? What types of cells are found in our body?

Q.2 Answer the following questions:

i. You are shown a eukaryotic and a prokaryotic cell. How can you tell which one is which?
ii. "A cell is a basic unit of structure and function", explain.
iii. Explain the structure of eukaryotic cell.

7.6 Cell Division

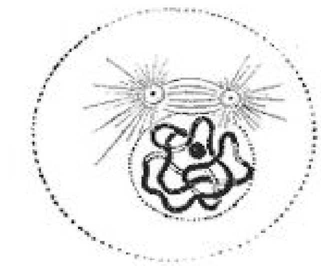
Do you know how many cells are present in our body? Well, if you stack as many sheets of paper as there are cells in our body it will make such a huge pile that you can go and come back from the moon twice! Yes, there are hundred trillion cells in our body (100, 000, 000, 000, 000,). Cells as you know are smallest living and functioning units in the body of all living organisms. It performs all the basic functions of life. It reproduces new cells by dividing. A mother cell divides into two daughter cells which are exactly like the mother cell. The daughter cells grow to a certain size and again divide in this way trillion cells of our body are produced. In all living organisms cells multiply in the same way i.e. by dividing. However cells do not just split into two cells. They go through a systematic process which involves many steps or phases. This type of cell division in eukaryotes is known as mitosis. Similar type of cell division in prokaryotes is known as binary fission.

You have studied that in sexually reproducing organisms two types of special cells one contributed by male (sperm) and the other by female (egg) unite together to form a daughter cell which through repeated divisions develops into a multicellular organism. Egg and sperm cells are formed by a special type of cell division called "meiosis". Meiosis is different from mitosis. In mitosis the chromosomes of parent cell duplicate so that when the cell divides the daughter cells should have exactly the same number of chromosomes as of parent cell. In meiosis the each daughter cells receives only half number of chromosomes. Do you know? Eggs and sperms unite to form a single cell called "zygote" and the process of union of egg and sperm is called fertilization. You know that all organisms of a species have the same number of chromosomes in each generation. For example human beings have 46 chromosomes which exist as 23 pairs. Now if the eggs and sperm have the same number of chromosomes i.e. 46 then the zygote will get 92 chromosomes (46 = 46). It is therefore necessary that egg and sperms receive half number (haploid number) of chromosomes so that the zygote resulting from their union will have 46 chromosomes (in case of human beings). Meiosis also allows genetic variation through a process of DNA (Deoxyribonucleic Acid) shuffling while the cells are dividing.

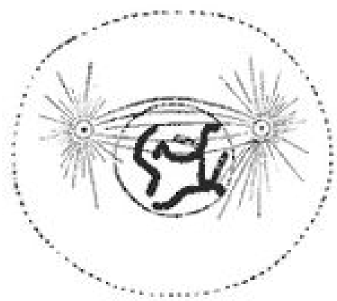
7.6.1 Mitosis

Mitosis is a fundamental process for life. New cells of any part of the body of plants and animals are formed through mitotic division of existing cells. Bone marrow produces new blood cells by mitosis. Similarly epidermal cells of our skin are replaced by mitotic division. In some parts of body, e.g. skin and digestive tract, cells are constantly sloughed off and replaced by new ones. New cells are formed by mitosis and so are exact copies of the cells being replaced. During mitosis, all contents of cell duplicate; including its chromosomes, and after that the cell splits to form two identical daughter cells. Duplication of chromosomes is important so that each one of the daughter cell have same number of chromosomes. The stages of mitosis are interphase, prophase, metaphase, anaphase and telophase.

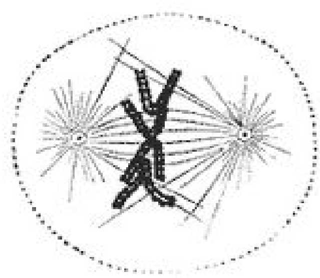
Interphase

Just before the cell starts to divide, number of long thread- like structures appear in the nucleus. These are called chromosomes. The chromosomes replicate themselves to form pairs of identical sister chromosomes, or chromatids. The centrosomes also duplicate.	

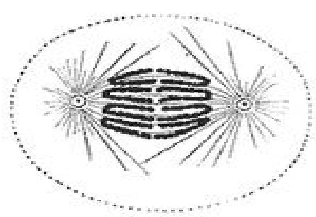
Prophase

As the prophase begins, chromosomes get thicker and shorter. Since the genetic material has already been duplicated earlier during interphase, the replicated chromosomes have two sister chromatids, bound together at the centromere. Some sets of fiber run from one centriole to the other; these are the spindle fibers. In plant cells the spindle forms without centrioles. The nuclear membrane disappears.	

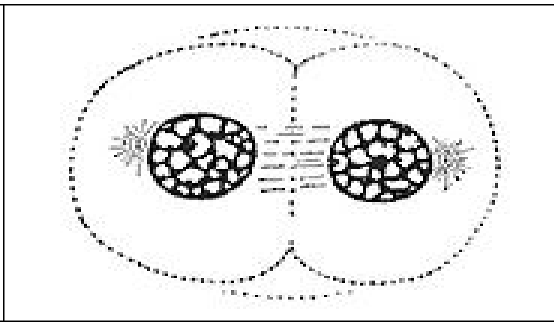
Metaphase

During metaphase the chromosomes arrange themselves at a plane midway between the two ends the spindle. This is called the equatorial plane. The cell divides at this point when nuclear division is completed. The chromatids are attached to the spindle fibers at the centromeres.	

Anaphase

During anaphase the two chromatids of each chromosome separate and become separate daughter chromosomes. Daughter chromosomes move to opposite poles, as if pulled along the spindle fibers.	

Telophase

A new nuclear envelope, forms around each set of separated sister chromosomes. Both sets of chromosomes, now surrounded by new nuclei, unfold back into chromatin. Mitosis is complete, but cell division is not yet complete.	

Cytokinesis

This is the stage at which cell divides into two daughter cells. In animal cells a dividing line called cleavage furrow is formed and finally divide the cytoplasm in half between the two daughter cells. In plants a cell plate is formed and cell is divided into two cell.

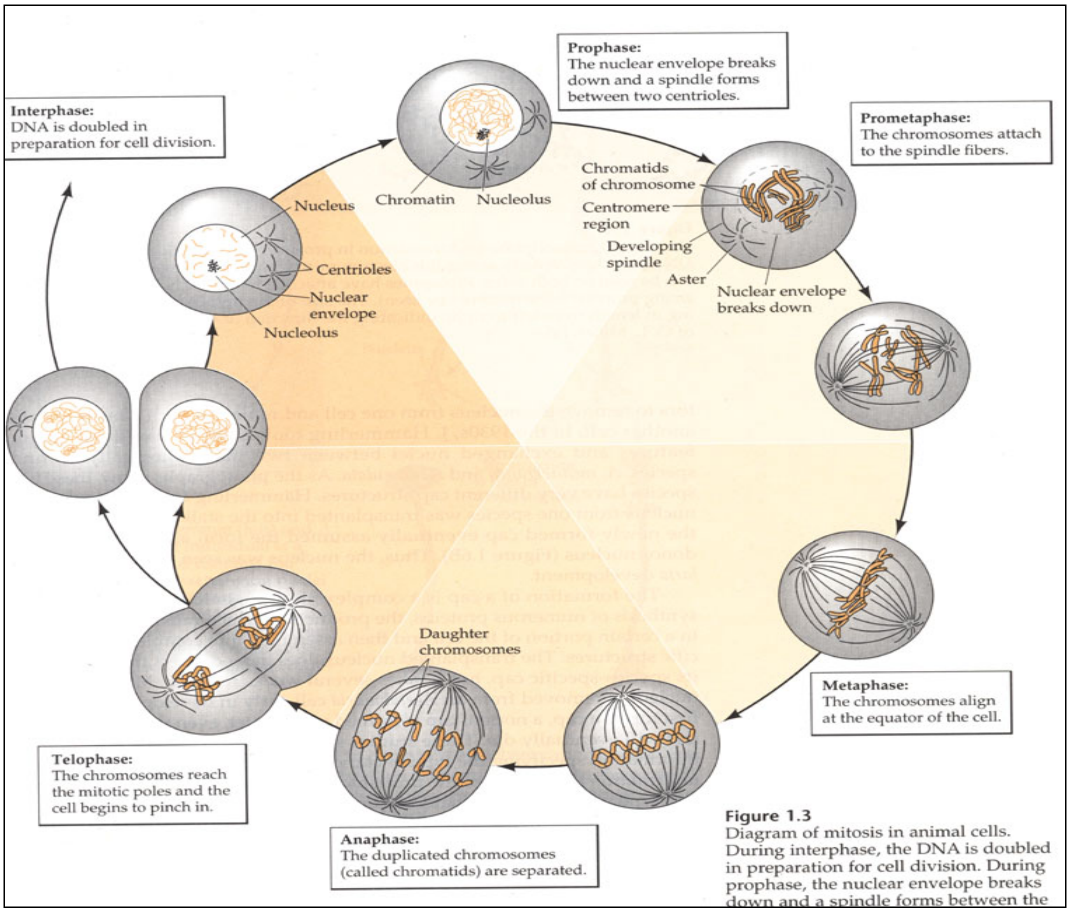


Figure 24: Cytokinesis

7.6.1.1 Significance of Mitosis

Mitosis is important for the maintenance of the chromosomal set; each cell formed receives chromosomes that are alike in composition and equal in number to the chromosomes of the parent cell.

Following are the occasions in the lives of organism where mitosis happens:

Development and growth

The number of cells within an organism increases by mitosis. This is the basis of the development of a multicellular body from a single cell i.e., zygote and also the basis of the growth of a multicellular body.

Cell replacement

In some parts of body, e.g. skin and digestive tract, cells are constantly sloughed off and replaced by new ones. New cells are formed by mitosis and so are exact copies of the cells being replaced. Similarly, RBCs have short life span and new RBCs are formed by mitosis.

Regeneration

Some organisms can regenerate their parts of bodies. The production of new cells is achieved by mitosis. For example; sea star regenerates its lost arm through mitosis.

Asexual reproduction

Some organisms produce genetically similar offspring through asexual reproduction. For example, the hydra reproduces asexually by budding. The cells at the surface of hydra undergo mitosis and form a mass called bud. Mitosis continues in the cells of bud and it grows into a new individual. The same division happens during asexual reproduction or vegetative propagation in plants.

7.6.2 Meiosis

Meiosis is a special type of cell division necessary for sexual reproduction. The cells produced by meiosis are gametes or spores. The animals' gametes are called sperm and egg cells.

In meiosis the chromosomes undergo a recombination producing a different genetic combination in each gamete. The outcome of meiosis is four (genetically unique) haploid cells.

Meiosis begins with one diploid cell containing two copies of each chromosome—one from the female organism and the other from male organism. Each of the resulting chromosomes in the gamete cells is a unique mixture of maternal and paternal DNA. This is how a variety of organisms are formed. Meiosis was discovered and described for the first time in sea urchin eggs in 1876 by the German biologist Oscar Hertwig.

Stages of Meiosis

Meiosis consists of two major phases of meiosis occur: meiosis I and meiosis II. During meiosis I, a single cell divides into two. During meiosis II, each of the two cells divide again.

Meiosis I

Let us take the example of meiosis in human beings. At the beginning of meiosis 1, a human cell contains 46 chromosomes, or 92 chromatids (the same number as during mitosis). Meiosis I has the following phases:

Interphase

As in mitosis the cell replicates its chromosomes. Each chromosome has two sister chromatids which are held together by a centromere.

Prophase I

Prophase I is also similar in some ways to prophase in mitosis. The daughter chromosomes i.e. chromatids shorten and thicken and become visible under a microscope. However, in meiosis two processes called “synapsis” and crossing over occur during prophase 1.

Synapsis is a process in which two homologous chromosomes come near each other. As you know each chromosome consists of two chromatids, the four chromatids aligned next to one another. The coming together of two chromatids is called synapsis and this combination of four chromatids is called a tetrad

After synapsis, segments of one chromatid in the tetrad pass to another chromatid in the tetrad. The exchange of chromosomal segments occurs in a complex and poorly understood manner. |This process is called Crossing over and it results in the formation of a new chromatid. After crossing the four chromatids of the tetrad are genetically different from the original four chromatids.

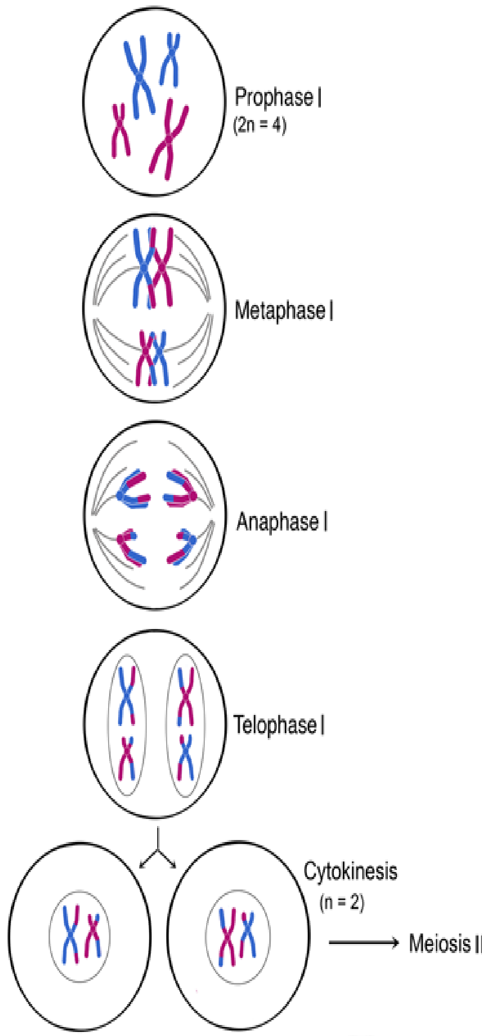


Figure 25: Meiosis

Metaphase I
At this stage the tetrads align on the equatorial plate (as in mitosis). The centromeres attach to spindle fibers, which extend from one poles of the cell to the other. One centromere attaches on one spindle fiber.

Anaphase I
At this stage of meiosis 1, the homologous chromosomes separate. One homologous chromosome (consisting of two chromatids) moves to one side of the cell, while the other homologous chromosome (consisting of two chromatids) moves to the other side of the cell. In this way one set of 23 chromosomes (each consisting of two chromatids) move to one pole, and the other set of 23 chromosomes (each consisting of two chromatids) move to the other pole of the cell. In this way the chromosome number of the resulting two cells is halved. For this reason the process is a reduction-division.

Telophase I
In telophase of meiosis I, the nucleus reorganizes, the chromosomes become chromatin, and a cytoplasmic division into two cells takes place. This process occurs differently in plant and animal cells, just as in mitosis. Each daughter cell (with 23 chromosomes each consisting of two chromatids) then enters interphase, during which there is no duplication of the DNA. The interphase period may be brief or very long, depending on the species of organism.

Meiosis II

Meiosis II is the second major stage of meiosis. It occurs in the same way as in mitosis. In meiosis II, a cell containing 46 chromatids undergoes division into two cells, each with 23 chromosomes. All the stages of this second phase of meiosis are exactly same as in mitosis.

During meiosis II, each cell containing 46 chromatids yields two cells, each with 23 chromosomes. Originally, there were two cells that underwent meiosis II; therefore, the result of meiosis II is four cells, each with 23 chromosomes. Each of the four cells is haploid; that is, each cell contains a single set of chromosomes.

The difference in the result of mitosis and meiosis is that 23 chromosomes in the four cells from meiosis are not identical because crossing over has taken place in prophase 1. The crossing over yields variation so that each of the four resulting cells from meiosis differs from the other three. Thus, meiosis provides a mechanism for producing variations in the chromosomes. Also, it accounts for the formation of four haploid cells from a single diploid cell.

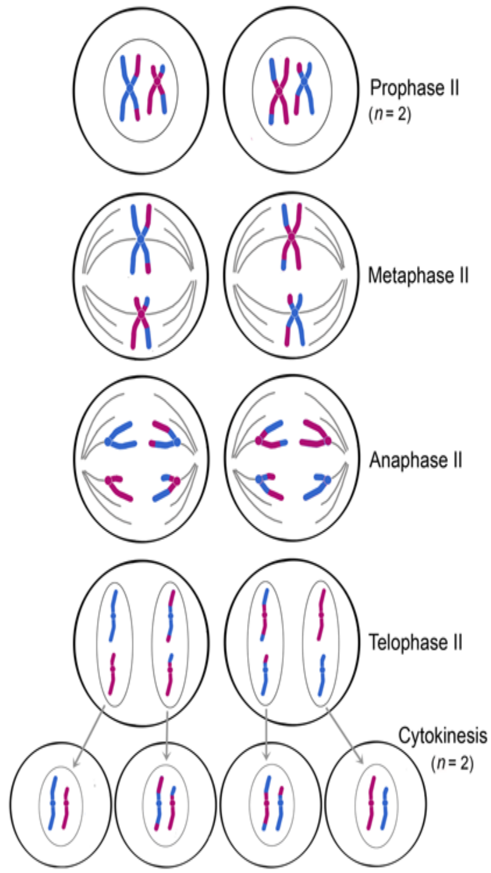


Figure 26: Meiosis

Key Points

1. Continuity of life is possible only through the process of reproduction. Every species can reproduce new individuals of its own kind.
2. Asexual reproduction requires only a single parental organism which gives rise to offspring by mitotic cell division. Offspring produced by mitosis are genetically similar to their parents.
3. Sexual reproduction usually involves two parents. A fertilized egg is produced through the union of two sex cells (sperms and egg) from each parent. The organisms produced by this process are genetically different from their parents.
4. Cell division is the process by which a parent cell divides into two or more daughter cells.
5. Mitosis is the process by which a eukaryotic cell separates the chromosomes in its cell nucleus into two identical sets, in two separate nuclei. Mitosis is important for the maintenance of the chromosomal set.
6. Meiosis is necessary for sexual reproduction. The cells produced by meiosis are gametes or spores.
7. The chromosomes in meiosis undergo a recombination producing a different genetic combination in each gamete.
8. Meiosis is divided into two stages, Meiosis I and Meiosis II.
9. Meiosis I separates homologous chromosomes, producing two haploid cells, so meiosis I is referred to as a reduction division.
10. Meiosis II is the second part of the meiotic process. The end result is production of four haploid cells from the two haploid cells produced in meiosis I.

Self Assessment Exercise 06

1. Choose the correct statement
    i. Which types of cells are produced through mitotic division?
        a) Skin cells b) Egg cells
        c) Sperm cells d) None of the above

    ii. Which of the following statement is true about mitotic division?
        a) It takes place when gametes are produced.
        b) It is completed in two phases
        c) Each daughter cell receives diploid number of chromosomes
        d) Each daughter cell receives haploid number of chromosomes

    iii. Meiosis is also called reduction division because Daughter cells …
        a) Have a smaller size than parent cell
        b) Lack some of the cell organelles
        c) Haploid number of chromosomes
        d) smaller nucleus than parent cell

iv. If the parent cell starts out with 24 chromosomes. If it divides by mitotic division what will be the number of chromosomes in daughter cells?

a) 48	b) 24
c) 12	d) 6

v. When synapse is formed during meiosis division? During …

a) Prophase 1	b) Metaphase 1
c) Anaphase 1	d) Telophase 1

vi. Synapse is formed between chromatids of …
a) All chromosomes
b) Any two chromosomes
c) Two similar chromosomes
d) Two dissimilar chromosomes

Q.2 Write down the answer of the following questions
i. Write names of different stages of mitosis in detail.
ii. What type of changes take place in a cell during interphase?
iii. What is a synapse?
iv. At which stage of meiosis chiasma forms?
v. What are homologous chromosomes?
vi. Explain different stages of Meiosis I.
v. What is difference between mitosis and meiosis? Explain briefly.

7.7 Cellular Organization

The body of multicellular organisms is not a haphazard collection of cells. The cells in a multicellular organism are specialized cells. It means that...

i. They do one particular job.
ii. Have a distinct shape according to their function.

There is a division of labour in the body of multicellular organisms, i.e. cells are specialized to perform specific functions. There are following levels of organization in the body of living organisms:

Cells ⟹ **Tissues** ⟹ **Organs** ⟹ **Systems**

Cell
As you have read in earlier sections cell is the basic unit of structure and function in the body of multicellular organisms.

Tissues
A collection of similar cells that group together to perform a specialized function is termed as tissue.

Organs
An organ is a structure that contains at least two different types of tissue which function together to perform a common function.

System
A system is a set of things working together as a part of as mechanism or an interconnecting network. In the body of multicellular organisms several organs work in conjunction as a system.

7.7.1 Cellular Organization in Human Body
There are four primary types of tissue in the human body: epithelial tissue, connective tissue, muscle tissue and nerve tissue.

1. Epithelial Tissue
In an epithelial tissue the cells are closely packed together to form continuous sheets just like the tiles in wall or floor. Epithelial surrounding different parts of the body to keep the body's organs separate, in place and protected. The outer layer of the skin, the inside of the mouth and stomach, and the tissue surrounding the body's organs are some examples of epithelial tissue are.

2. Connective Tissue
There are many types of connective tissue in the body. Connective tissue provides support and structure to the body. Most of the connective tissues contain fibrous strands

of the protein called collagen. Collagen adds strength to connective tissue. Some examples of connective tissue include the inner layers of skin, tendons, ligaments, cartilage, bone and fat tissue. Blood is also a form of connective tissue.

3. Muscle Tissue

All the muscles in the body are formed of muscle tissues. Muscle tissues can contract and expand back to their normal size. Muscles which are attached to the bones help in movement. You can see these muscles in your arms and legs. Bend your arm and watch the upper arm, it swells because the muscle in the upper arm has contracted that is how it has moved the bones of your fore arm. The muscles also form different organs like heart, stomach etc.

4. Nerve Tissue

Nerve tissues form brain and spinal Nerve tissue has the ability to generate and conduct electrical signals in the body. These electrical messages are managed by nerve tissue in the brain and transmitted down the spinal cord to the body.

ORGANS

There are many different organs in the body: the liver, kidneys, heart, eyes, ears, nose even your skin is an organ.

System

In human body and in most of the multicellular animals there are several systems e.g. Digestive system, respiratory system, excretory system, nervous system, skeletal system, muscular system and reproductive system. You will read about these systems in the next unit.

7.7.2 Plant Systems

Observe the flowering plants in your area. Do you notice what the two major parts of green plants are? As you can see there is stem growing above the ground bearing leaves and flowers and fruits. There is an underground part of these plants called root. Shoots and roots together make the two main “body systems:” in plants.

All of the functions necessary to keep the plant alive are performed in these two systems. These two body systems perform the following functions in plant:

- exchange of gases with its surroundings
- moving water and nutrients around internally
- reproducing

The root system generally grows underground. However there are certain plants which also have roots growing above the ground, Banyan tree, and money plant you can see roots hanging in the air. The root system performs the following major functions. It...

- Anchors the plant to the ground
- Absorbs water and minerals from the soil, and to store food.

There are two basic types of root system: primary root system and adventitious root system.

The primary root system consists of a main root and its branches. The primary root is the plant's first root which gives rise to lateral, or branch, roots. Adventitious roots are growing in an unusual position like on leaves or stems are called adventitious roots. Unusual places like leaves.

Figure 27: Adventitious roots of a banyan tree

The shoot system of flowering plants is composed of three parts namely: the leaf, the flower, and the stem.

The leaf is the food factory of green plants. Chloroplasts in a plant's leaves use carbon dioxide, water, and light energy to produce glucose and oxygen. This process of manufacturing glucose is called photosynthesis.

Flowers contain male or female reproductive structures. Male reproductive structures produce pollen grains. Female structures produce eggs. After eggs are fertilized by pollen, seeds are formed within a specialized structure called a fruit.

Stem supports the plant's leaves and flowers, and contains channels to transport the materials the plant needs.
The three major tissue systems of plants are:

- Dermal tissue
- Vascular tissue
- Ground tissue

The outmost layer of a plant is formed of dermal tissue system. The surface of the leaves, stem, and roots of a plant that we see consists of dermal tissue. The thin layer of cells that covers the surfaces of leaves, stems, and roots is epidermal tissue (epidermis).

In woody plants, the epidermal tissue is replaced by periderm tissue, which forms bark on stems and large roots.

Some cells of the dermal tissue system absorb water and minerals from the surrounding soil. Others produce a layer of wax to waterproof the surface of leaves. Still others contain chemical irritants for defence.

Plants have a network of tubes spread from the roots up the stalk to the leaves. It is called vascular tissue system. Water and nutrients absorbed by roots is transported by the vascular tissue system to the various parts of the plant, where they are needed for growth.

The vascular tissue which transports water and dissolved minerals from the roots to the rest of the plant is called Xylem. Water moves through the tubes in one direction.

Solutions of sugars produced during photosynthesis, as well as other dissolved nutrients and hormone are transported by Phloem**.** Phloem transports food materials both in downward as well as upward i.e. from photosynthesizing leaves to stem and upward from the root and stem to the leaves.

Third major tissue of plants is Ground tissue cells. They fill the spaces between the dermal and the vascular tissues. Depending upon their location in the plant they perform a number of functions. In the green parts of the plants ground tissues manufacture nutrients by photosynthesis.

In the stems, they provide storage and support and in the roots, they store carbohydrates.

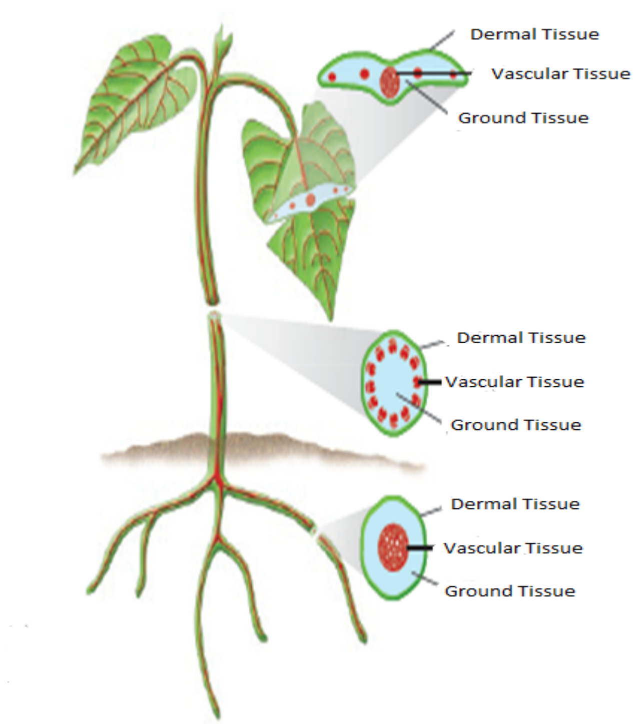


Figure 28: Position of Various Tissues in Green Plants

Key Points

1. The cells in the body of advanced multicellular organisms are organized in a systematic and hierarchical order into tissues, organs and systems.
2. There are four primary types of tissue in the human body: epithelial tissue, connective tissue, muscle tissue and nerve tissue.
3. Epithelial surrounding different parts of the body to keep the body's organs separate, in place and protected.
4. Connective tissue provides support and structure to the body.
5. Muscle tissues give shape to the body, form organs like heart and move the bones.
6. A system is a set of things working together as a part of as mechanism or an interconnecting network.
7. Human systems are composed of many organs each performing a specific function. There are nine major systems in the human body: skeletal, muscular, digestive, respiratory, excretory, circulatory, nervous, endocrine, and reproductive system.
8. There are two major systems in the body of green plants: shoot and root system.

Self Assessment Exercise 07

Q.1 Choose the correct statement.

i. The third level of cellular organization is tissue.
ii. Cells in a tissue perform different functions.
iii. Human body has three different types of tissues.
iv. Connective tissues connect the bones.
v. Inside of our stomach is lined by epithelial tissues.
vi. Our skin is a tissue.
vii. There are two types of plant tissue systems.
viii. Phloem tissues transport water from roots to the shoots and leaves.
ix. In xylem tissue materials are transported in only one direction.
x. Surface of green leaves is formed of ground tissues.
xi. Dermal tissues are absent in roots.
xii. Photosynthesis takes place in the cells of ground tissues.
xiii. In a plant nutrients are transported from leaves to roots and also from roots to leaves.
xiv. In plants water moves only from root to the stem and leaves and not in the opposite direction.
xv. In green plants food is stored in ground tissues.

Q.2 Answer the following questions:

i. Describe the functions of various tissues in plants.
ii. What are the different types of tissues in our body? Describe their functions.
iii. Explain the location of various tissues in green plants and describe their functions.
iv. What is the difference between primary and adventitious roots? Give examples of plants which have adventitious roots. Also explain the meanings of adventitious roots.

7.8 Genes at Work

Have you ever seriously considered how characteristics such as skin colour, height, hair colour etc are transferred from parents to offspring? Or how variations appear in the organisms of the same species and even children of the same parents? You know that all living organisms reproduce by cell division. You also know from your study of cell structure and division that each species has a specific number of chromosomes in their cells. Human beings have 46 chromosomes in their cells. In mitosis each chromosome divides into two chromatids so that the new cells inherit the same number of chromosomes. Chromosomes consist of a protein network and a long molecule of Deoxyribosenucleic acid (DNA) is coiled round the protein framework in a complicated way. It is the DNA part of chromosome which controls heredity characteristics. Heredity information is stored in DNA. The hereditary unit is called gene. A gene is a short length of DNA and so contains a section of genetic code. A gene consists of a unique sequence of DNA that provides the complete instruction to make a functional product called protein. Gene instructs each cell type such as , brain, liver to make specific sets of proteins and it is through this specificity that unique organism is developed.

Each cell in the human body contains about 25,000 to 35,000 genes, which carry information that determine their traits. Traits are characteristics you inherit from your parents. For example, if both the parents have green eyes, their children might inherit the trait of green eyes from them. The genes are not only present in humans — all animals and plants have genes, too.

Every cell of an organism contains a complete set of instruction for building the organism. This set of instruction is passed on to gamete (egg and sperm cells in animals and human beings) during meiosis. You know that during meiosis similar or homologous chromosomes pairs form synapse and exchange parts. In this exchange genes are also exchanged that is how variations occur.

7.8.1 Biotechnology

Biotechnology (sometimes shortened to "**biotech**") is the use of biological processes found in nature to make useful products, or "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use". Biotechnology is a field of applied biology.

You know that yeast which is a unicellular organism. They reproduce by budding. It is used to raise dough to make bread. During their growth process, the yeast cells produce substances called enzymes. So when the yeast is added to cake or bread dough, one enzyme acts on the flour and changes the starch in it into sugar. Another enzyme then takes over and changes the sugar into alcohol and a gas called carbon dioxide. This gas spreads through the dough in the form of bubbles. That is how dough rises when we add yeast to it. This is one example of using a naturally occurring biological process to make a product.

Use of Biotechnology

Biotechnology is used in medical, crop production and agriculture, non food (industrial) uses of crops and other products, and for environmental uses.

Medicine

Biotechnology used in medicine in such areas as:

- Drug production
- Pharmacogenomics
- Gene therapy
- Genetic testing (or genetic screening

Pharmacogenomics uses information about a person's genetic makeup, or genome, to choose the drugs and drug doses that are likely to work best for that particular person. This new field combines the science of how drugs work, called pharmacology, with the science of the human genome, called genomics.

Genetic Testing

Genetic testing involves the direct examination of the DNA molecule itself. A scientist scans a patient's DNA sample for mutated sequences.
Genetic testing is now used for:
Carrier screening, determining sex, Identity testing, Newborn screening, etc.

Gene Therapy

Gene therapy may be used for treating, or even curing, genetic and acquired diseases like cancer and AIDS by using normal genes to supplement or replace defective genes. It can be used to target somatic cells (i.e., those of the body) or gametes (i.e., egg and sperm) cells.

Cloning

Cloning involves the removal of the nucleus from one cell and its placement in an unfertilized egg cell whose nucleus has either been deactivated or removed.
There are two types of cloning:

Reproductive cloning. After a few divisions, the egg cell is placed into a uterus where it is allowed to develop into a fetus that is genetically identical to the donor of the original nucleus.
Therapeutic cloning. The egg is placed into a Petri dish where it develops into embryonic stem cells, which have shown potentials for treating several ailments.

Tissue Culture

Tissue culture is the growth of a tissue in an artificial liquid culture medium. This technique is used in plants. New plants obtained from parent plants, by using this technique, are called clonal plants. They have same traits as of their parents.

Animal Biotechnology

In animals, biotechnology techniques are being used to improve genetics and for pharmaceutical or industrial applications. Molecular biology techniques can help drive breeding programs by directing selection of superior animals. Animal cloning, through somatic cell nuclear transfer (SCNT), allows for genetic replication of selected animals. Genetic engineering, using recombinant DNA, alters the genetic makeup of the animal for selected purposes, including producing therapeutic proteins in cows and goats.

Bioengineering

Biotechnological engineering or biological engineering is a branch of engineering that focuses on biotechnologies and biological science. It includes different disciplines such as biochemical engineering, biomedical engineering, bio-process engineering, biosystem engineering and so on. In general it is an integrated approach of fundamental biological sciences and traditional engineering principles.

Key Points

1. The chromosomes and genes are made of DNA, which is short for deoxyribonucleic acid.
2. Biotechnology is a field of applied biology that involves the use of living organisms and bioprocesses in engineering, technology, medicine and other fields requiring by-products.
3. Biotechnology has applications in four major industrial areas, including health care (medical), crop production and agriculture, non food (industrial) uses of crops and other products, and environmental uses.
4. Cloning involves the removal of the nucleus from one cell and its placement in an unfertilized egg cell whose nucleus has either been deactivated or removed.
5. Biotechnological engineering or biological engineering is a branch of engineering that focuses on biotechnologies and biological science.
6. Tissue culture is the growth of a tissue in an artificial liquid culture medium. This technique is used in plants. New plants obtained from parent plants, by using this technique, are called clonal plants. They have same traits as of their parents.

Self assessment exercise 08

Q.1 Anwer the following questions:

1. Define biotechnology. Explain its use in different fields.
2. What is difference between a gene and a chromosome?

Answers to Self Assessment Exercises

Self Assessment Exercise 01
Q.1 b, 2.c, 3. c, 4. c,
Q.2 For question 5 read the relevant sections of the unit.

Self Assessment Exercise 02
Q.1 a, 2. C, 3. D, 4.a, 5.d,
Q.2 6 – 7 Read the relevant sections of the unit.

Answers of Assessment Exercise 03
Q.1 I. d, II.a, III.b, IV. a, V.a,

Answers of Assessment Exercise 04
Q.1 I. d, II.a, III. b, IV. b, V. d, VI. d, VII. d, VIII. b

Answers of Assessment Exercise 05
Q.1 C, 2. D, 3. B, 4. B, 5. B, For questions 6 -9 Read the relevant sections of the unit.

Answers of Assessment Exercise 06
Q.1 I.a, II. C, III. C, IV. B, V. A, VI. C
Q.2 For question 2,i –iv read the relevant sections of the unit

Answers of Assessment Exercise 07
Q1. V, vii, ix, xii, xiii, xv are correct statements.
Q.2 For question 2 – 5 read the relevant sections of the unit

Answers of Assessment Exercise 08
Q1 & 2 Read the relevant sections of the unit

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Unit–8

HUMAN BODY SYSTEMS

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CONTENTS

Introduction

Human beings are the most advanced and complex organisms on this planet earth. Just think how complex the body would be in which 100 trillion (a billion billion is a trillion) cells are working at different levels of organization in a harmony to carry out various functions of the body.

Cells have long been recognized as the basic units of function and structure. All the functions of our body right from respiration to reproduction are performed at cellular level. What we see is the outcome of functions at the cellular level. There are four levels of structural organization of human body namely; cellular level, tissue level, organ level and system level with increasing complexity. Groups of similar cells work as units to perform a task are called tissues. Several different tissues are organized as organs; at the highest level of organization are systems. System is defined as an assemblage or combination of things or parts forming a complex or unitary whole. We can define a human body system as an organization of varying number and kind of organs so arranged that together they perform a complex function of the body.

The major functions of human body include feeding, respiration, moving, feeling the changes in the environment and responding to them, excretion of the wastes produced in the body, transport of materials from one part of the body to the other, and reproduction of off springs. All these functions are performed under eleven different systems of the body.

In this unit you will study about the structure and function of these systems. The unit has been written with the assumption that most of you will have studied these systems in your school or college science course. However now that you are entering into teaching as profession it seems important that you not only refresh your knowledge of the subject but also start thinking as to how you will teach these topics to your students. We hope that you will find this unit interesting, informative and useful as a resource for teaching human systems at elementary level.

Objectives

After completing this unit, you should be able to:

1. Describe the structure of skeletal system and explain its functions.
2. Elaborate the main functions of the muscular system.
3. Describe various components of food and their sources and importance for the human body.
4. Describe the structure and function of digestive system.
5. Name the organs of respiratory system and their functions.
6. Explain the process of respiration.
7. Explain the role of circulatory system, its structure and functions of its organs.
8. Explain the structure of excretory system and functions of its organs.
9. Name different parts of nervous system and explain their structure and functions.
10. Describe reproductive system.

8.1 Muscular System

If you have seen human skeleton or its picture you can imagine the amount of muscles that cover our bones. The bones we see in the human skeleton hanging in most of the school science laboratories are not visible in our body though we can feel them. 40 – 50 percent of our body weight is due to muscles. So it is the muscles which give shape and beauty to our bodies. Is there any other role of the muscles? Do the muscles work as a system in our body? These are questions we shall be answering in this section. But before reading on just think if there is muscular system in our body how it works? What are the different functions of muscular system other than giving a shape to our body?

Muscular system is the system of all the muscles in the human body. This system makes the major portion of the weight of human body and consists of about 650 different muscles. These 650 muscles are attached to various bones and by contraction and relaxation these muscles produce the movements of the body.

Have you ever watched puppet show? How they move hands and legs of a puppet? In human beings muscles act as the strings of a puppet to move the bones. Stretch your arm and then bend it at the elbow. Carefully observe the upper arm while folding and unfolding your arm. In Fig. 1 the upper you can see a muscle becoming prominent as you fold your arm. Actually by contracting the muscle pulls the bone, it is attached to and in this way the arm is folded. What happens when you unfold the arm?

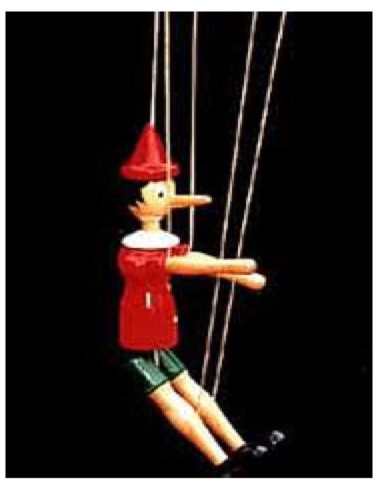

Fig.1: Muscles like strings of a puppet help to move the bones

Muscles can only pull, they cannot push. The muscles can only exert force on other structures when they are contracting. When the muscles have once contracted they cannot relax by exerting force on other structures to which they are attached. Instead, another muscle to help them come to their original size and this other thing is. It means that;

Muscles no matter where they exist in the body always occur in pairs and these pairs are known as antagonistic pairs of muscles because the muscles of a pair act opposite to one another and by acting opposite they actually help one another in their functions.

Muscle pair attached to our upper arms.
Notice in the diagram that as the upper muscle (called bicep) contracts, the lower or triceps relaxes back to its original length to allow the arm to bend at the elbow. The opposite the true when the arm is straightened back out.

The muscles which cause bending of a joint are called "flexor" muscles while those which straighten the joint are called "extensor" muscles. Identify flexor and extensor muscles in the diagram shown here.

Fig. 2:
SOURCE http://mdb06jp.webnode.com/anatomy-of-muscles/
http://www.google.com.pk/search?q=muscles+work+in+pairs&hl=en&biw=1366&bih=571&prmd=imvns&tbm=isch&tbo=u&source=univ&sa=X&ei=Xh4nUO66Ee7E4gTinoGwAg&ved=0CG0QsAQ

The muscles are of two major types: voluntary and involuntary muscles. Voluntary muscles are under the control of our will e.g. muscles of our arms and legs, cheeks. There are other muscles which contract and relax without our control and knowledge e.g. heart muscles. Heart is made of muscles which are all the time contracting and relaxing to keep the blood in circulation but their movement is not under our control. These and other similar muscles which are not under our control, like the muscles of stomach, intestines etc. are called involuntary muscles.

8.1.1 Types of Muscles
Muscular tissue is classified into three main groups on the basis of structures and functions. These are: skeletal muscles, smooth muscles and cardiac muscles.

1. **Skeletal Muscles**
   Skeletal muscles are attached to the bones by structures called tendons. You can see these tendons at the end of goat's leg muscles. These muscles are responsible for the movements of the body. They also make the moveable structures such as the lips, tongue and eyelids. The skeletal muscle fibers show alternate light and dark bands and for this reason, the skeletal muscle is also known as striated (or striped) muscle. Ends of skeletal muscles are drawn out into structures called tendons which attach the ends of muscles to the bones.

2. **Smooth Muscles**

Smooth muscles have no stripes, therefore they are also termed as smooth or non-striated muscles. They are involuntary muscles and are found in blood vessels, digestive tract and urinary bladder etc. The cells making these muscles are narrow at the ends and broad in the middle like a spindle and are arranged in bundles or in sheets. They contract slowly than the skeletal muscles but they can contract for a longer period of time without any signs of fatigue that is why our digestive track muscle can work for longer period without getting tired!

3. **Cardiac Muscles**

Cardiac muscles constitute the contractile tissue of the heart. These are striated like the skeletal muscles but are involuntary like smooth muscles. The cells are branched and signals of contraction are carried from cell to cell during the heart beat. Their action is involuntary, automatic and rhythmic.

8.1.2 Functions of Muscles

You have studied the types of muscles and the parts of the body they make. Can you think of important functions of muscles? Give shape and beauty to the body is one function the others are as follows:

1. **Protection of Organs**

If you feel your abdomen you would find that there are no bones in this part of the body. However there are some very important organs in this part for example, intestines. The muscles in the abdomen protect the vital organs located in the abdominal part.

2. **Pumping the Blood**

The contraction of the heart muscle is involuntary and primarily controlled by your heart's own electrical system, with and without influence from factors in the blood. Your heart is responsible for receiving blood back from your muscles, pumping it into your lungs, receiving the blood from the lungs then pumping it out into your arteries to supply your entire body.

3. **Digestion**

The involuntary contractions of smooth muscles of stomach churn the food this helps in mixing digestive juices secreted by stomach in this way they aid in digesting the food. Muscles of intestines contract and their contractions push the food along your digestive tract.

4. **Keep the Blood Flowing**

Walls of the blood vessels are made of smooth muscles. The heart contracts and pumps the blood into arteries. The arteries expand to accept the blood. The smooth muscles in the arteries contract to push the blood throughout the system of blood vessels spread in all parts of the body, ultimately pushing the blood from your arterioles into your capillaries to return back to the heart.

Activity 1

Take a clothespin and squeeze it as many times as possible in two minutes. Then rest for a minute and try again. You will notice that you cannot flex the clothespin as many times the second time around. What does it mean about the capacity of muscles to work? What type of muscles is involved in flexing the clothespin?

Feel your heart for 15 seconds and notice the rhythm, then jump back and forth over a line placed on the floor for 45 seconds. After jumping, feel the heart again. Notice the cardiac muscles working and explain the effect of activity on the cardiac muscles by writing down any changes you noticed in the heart's rhythm. Compare the working of heart muscles with the muscles of hand.

Key Points

1. Bulk of our body weight is due to muscles.
2. There are two types of muscles, skeletal muscles, smooth and cardiac muscles.
3. Skeletal muscles are attached to the bones.
4. Smooth muscles have no stripes. They are involuntary muscles and are found in blood vessels, digestive tract and urinary bladder.
5. Cardiac muscles constitute the heart. These are striated like the skeletal muscles but are involuntary like smooth muscles.
6. Muscles provide shape to our body. Muscles move our bones and thus give us mobility; they also help in digestion processes, keeps the blood flowing in the body as it is due to muscular structure that our heart can act as a pump.

Self Assessment Exercise 1

Q.1 Choose the correct statement.

a. Bones cannot be moved without muscles.
b. Muscles function in pairs.
c. A major function of muscles is production of red blood cells.
d. Cardiac muscles are involuntary striated muscles.
e. Skeletal muscles are smooth muscles.
f. Tendons are special kind of muscles.
g. Stomach is made of smooth muscles.
h. Blood flows in veins due to contraction and relaxing action of muscles of walls of veins.
i. Muscles of heart easily get tired.
j. Skeletal muscles can contract at a rapid pace than muscles of stomach.

Q.2 Answer the following questions.

i. What are the various types of muscles and what are their functions?

ii. What are the major difference between cardiac a, skeletal and smooth muscles?

8.2 Skeletal System

Bones, cartilage, tendons and ligaments are the parts which make the skeletal system of human body. There are 206 bones of various shapes and sizes in our body. The longest bone in our bodies is the thigh bone (**femur**). The smallest bone is inside the ear (stirrup bone). Each hand has 26 bones in it.

Cartilage is a specialized form of connective tissue Cartilage is flexible substance that is not as hard as bone. Cartilage forms the skeleton of mammalian embryos. However, the cartilage model for the skeleton is found only in the earlier stages of development. Late on as the embryo develops except in some parts the rest of the cartilage is replaced by bone. If you have ever noticed that when a baby is born front part of her head is very soft and mothers are very careful while handling the baby. Later hard bone is developed.

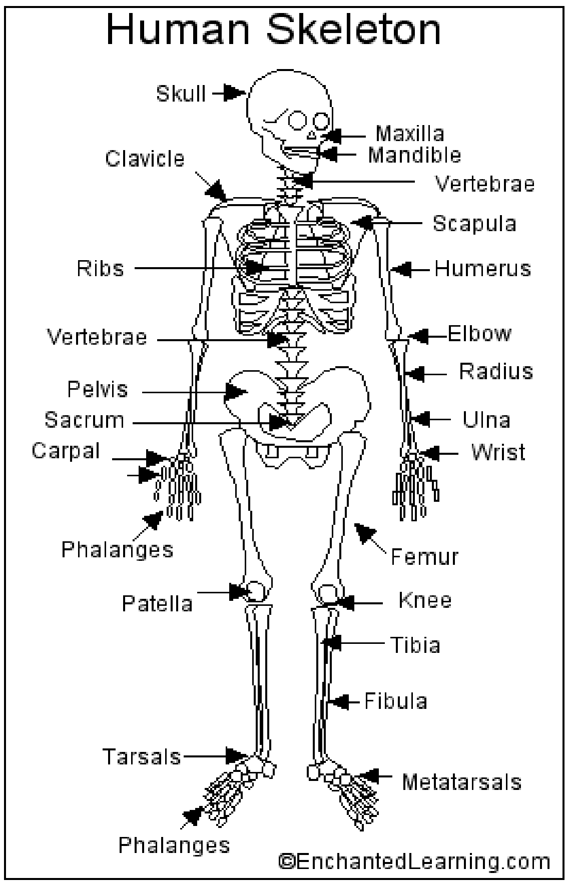

Fig 3: Human Skeleton

Source:
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8.2.1 General Plan of Skeletal System

Look at the diagram of the human skeleton. Perhaps you can notice that we can divide it into two main parts: a central part and parts attached to it. The central part comprises of skull, backbone, rib cage and breast bone. It is named as **"**axial skeleton", axial means central**.** We can also see the parts attached or appended to this central structure. These include shoulder bones (together named as pectoral girdle), arms, hip bones (pelvic girdle) and legs. Since these are attached or appended to the central system hence it is named "appendicular skeleton".

You can see that the skeleton is comprised of a variety of bones flat, round, long, large and small in. For example, the bones of skull and face are flat and are joined together make face and skull structure. Backbone or vertebral column comprise of 33 small bones called vertebra (plural vertebrae). All vertebrae have a hole in the middle and are placed in such a manner that there holes make a long canal. Inside this canal lies a very important and delicate part of nervous system called "spinal cord". Can you think of the reason why our backbone is made of 33 different bones? What difference it would have made if it were made of one long bone? The vertebral column supports the body and the skull; helps in standing upright; maintains the balance of the body. It also permits easy movement; helps in head and neck movements. It also allows the body to stretch, bend, lean and rotate. All this would not have been possible if it were made of one long bone.

There are long bones of our limbs. Limb bones and muscles help us to move. There are ribs. Observe how the rib bones form a cage like structure in which protects our vital organs i.e. heart and lungs.

Activity 2

Make a table like the one given below and fill each column with the name of the bones which fall under the category indicated at the top of the column. You can simply copy the names of bones consulting the diagram of skeletal system.

Small bones	Long bones	Flat bones

1. Bones

Bones are alive and like all other parts of the body, these are also made of cells. Bones are covered with hard, dead, mineral substances which give shape and strength to the bones. Bones are made of compounds of calcium like calcium carbonate and calcium phosphate. The amount of these compounds keeps on changing. When we do not eat balanced diet calcium and phosphate are removed from the bones and used by the body to meet its needs. If a person starves for some time his or her bones can lose about a third of its mineral content leaving the bones week and fragile. There is also a mechanism in our body to repair bones if they break or fractures. Bones are strong but light so that they can easily be moved with less energy. The light weight of long bones of e.g. limbs is due to the fact that they are hollow from inside. In the hollow region contains a tissue which makes red and white blood cells.

Activity 3

Take the limb bone of chicken. Place it in a beaker and cover it with dilute hydrochloric acid. Leave it for 24 hours. After 24 hours pour away the acid wash the bone and observe it. You will notice that the bone has become very soft and rubbery. It is because the layers of calcium and phosphate have dissolved in the acid and only the inner fibrous connective tissue is left. This shows that hardness of bones is due to the covering layer of compounds of calcium.

2. Joints

As you know there are hundreds of bones (over 207 bones are present in a new born baby) these are joined in different ways to make our skeleton. The region of joining of two or more bones is called ‘joint”. The bones forming the joint are held in place by a tough band of fibrous tissue called “ligament”. Where the surface of bones rubs each other a sheet of thin cartilage cover the bones to reduce friction and resultant abrasion. Presence of a lubricating fluid between certain bones, for example in knee joint, also helps to reduce the friction. Some joints are enclosed in a capsule like structure which contains a fluid called “synovial” fluid. This fluid reduces the friction between the bones. It is present in knee and shoulder joint.

You may have noticed that the degree of movement of bones of different parts of the body is different. For example, bones of limbs can be moved in many directions; you can bend your arm, raise it, and give it a circular movement. However, there are other bones which have a limited movement like your lower jaw. There are still others which are fixed e.g. skull bones; there are eight skull bones of which you can move only the lower jaw. The extent to which bones of any part of the body can be moved depends upon the type of joints between the bones of that part.

Depending upon the degree of movement of joints there are three types of joints:

1. Immovable joints e.g. joints between the bones of skull and face.
2. Slightly movable joints
3. Movable joints

Movable joints are of two major types:

1. Hinge joints
2. Ball and socket joints

3. Hinge Joints

Move your elbow, knuckles joints of fingers and knees. Observe their movement. Can you move them in more than one direction? No, they move only in one direction like the hinge of a door; that is why these are called hinge joints.

4. Ball and Socket Joints

Move your arms and observe the movement of your shoulder joint. Compare the movement with the movement of hinge joints. You will notice that Shoulder joint moves more freely. It is because the joint between the round end of bone of upper arm and cup shaped socket of the shoulder bone gives more flexibility to the joint. These joints are found in shoulder and hip joints. These joints are held in place with the help of ligaments.

Key Points

1. Bones, cartilage, tendons, and ligaments are the parts which make the skeletal system of human body.
2. Bones are made of cells and are alive. The hardness of bones is due to the outer covering of compounds of calcium.
3. There are more than 200 hundred bones in our body.
4. Bones are joined together to form the skeletal structure of our body.
5. The point at which two or more bones join is called joint.
6. Joints are of three main types: moveable, fixed and slightly movable.
7. Movable joints are of two major types: hinge joints which work like the hinges of a door and ball and socket joint in which ball like end of a bone fits into the cup shaped socket of the other bone. The former type of joints have limited movement while the later have more flexibility and can move in more than one plan.

Self Assessment Exercise 2

Q1. Choose correct answer.

i. What is the skeletal system?
   a. All the bones in the body
   d. All the muscles and tendons
   c. All the body's organs, both soft and hard tissue
   d. All the bones in the body and the tissues that connect them

ii. How many bones are there in the average person's body?
   a. 33
   b. 206
   c. 639
   d. It varies by the individual.

iii. Which of the following statement is INCORRECT?
   a. Bone is where most blood cells are made.
   b. Bone serves as a storehouse for various minerals.
   c. Bone is a dry and non-living supporting structure.
   d. Bone protects and supports the body and its organs.

iv. The place where two or more bones meet is called…
   a. Bone marrow
   b. Tendon
   c. Joint
   d. Ligament

v. Which of the following joint is found in your knee and elbow?
   a. Ball and socket
   b. Hinge

c. Pivot
d. None of these

vi. In which part of the bone blood cells are formed?
a. Joint
b. Ligament
c. Marrow
d. Tendons

vii. Immovable joints are found in…
a. Backbone
b. Wrist
c. Skull
d. Lower jaw

viii. Which of the following is true about hinge joints?
a. They are found in skull
b. They can move in all directions
c. They are immovable joints
d. They can move in one direction

ix. Which of the following types of joint is found in our shoulder?
a. Hinge
b. Ball and socket
c. Slightly movable
d. None of these

x. Our backbone is comprised of how many vertebrae?
a. 22
b. 33
c. 44
d. 55

Q2. Answer the following questions.
i. Describe the functions of skeletal system.
ii. What are the various types of joints? Also give examples of the joints.

8.3 Digestive System

We eat three to four meals a day. We eat to fulfill the physiological, social, psychological, and emotional needs of our body. Sometimes we eat because we are with friends and it is a social requirement. There are times when we are upset or depressed and we feel an urge to eat something. But basically we need to eat at regular intervals to fulfill the needs of our cells. As you know cells are basic units of structure and function in our body. They perform many functions and to perform their functions they need energy and materials. Our cells need food to:

1. Grow, repair, and maintain normal functions of cells;
2. Obtain energy ;
3. Develop resistance against disease.

Everything that we eat may not necessarily provide us with the materials our cells need. The food which provides the materials necessary for normal functioning of cells and to keep them alive is called nutrition. The components of food which are used by the cells for their functions and which are essential to keep them alive are called “nutrients”. The nutrients have been classified into seven major groups:

1. carbohydrates,
2. fats and oils,
3. dietary fiber,
4. minerals,
5. proteins,
6. vitamins, and
7. water

Some of these are needed in relatively large amounts these are called macronutrients while others are needed in smaller quantities and are given the name micronutrients. The macronutrients include carbohydrates, fats, fiber, proteins, and water. The micronutrients are minerals and vitamins.

Our body needs that we eat to break it into smaller, simpler and soluble substances to obtain nutrients from the food so that blood can transport these to the cells. The processes through which food is changed into smaller, simpler, soluble and diffusible substances are called digestion and take place in our digestive system. Prior to learning about digestive system it is essential that we know the nature of various food groups to have better understanding of need for a digestive system in the body and its functions.

8.3.1 Components of Food

Below and on the following pages we shall read about the nature of various food groups.

1. Carbohydrates

As the name indicates carbohydrates are made of carbon, hydrogen and oxygen atoms. There are two major types of carbohydrates in foods: simple and complex.

a. **Simple Carbohydrates**

These are also called simple sugars. Simple sugars are found in refined sugars, like the white sugar you use in tea or sweet dishes. Simple sugars are also found in foods, such as fruit and milk. It's better to get your simple sugars from food like fruit and milk instead of taking white sugar.

b. **Complex Carbohydrates**

These are also called starches. Starch is present in all types of grains like rice, wheat, corn, beans, and chickpeas and in vegetables e.g., potatoes, sweet potatoes.

Grain products, such as bread, crackers, pasta, and biscuits all are starchy foods. As with simple sugars, some complex carbohydrate foods are better choices than others. For example, unrefined grains, such as whole grain flour and brown rice, are better choice than refined grains like white flour and rice. Refined grains are processed and lack many nutrients and fiber. But unrefined grains still contain these vitamins and minerals. Unrefined grains also are rich in fiber, which helps your digestive system work well. Fiber helps you feel full, so you are less likely to overeat.

c. **How our Body Uses Carbohydrates**

Our body breaks down the carbohydrates into simple sugars, which are absorbed into the bloodstream. Carbohydrates have following functions in our body:

1. These are major source of energy;
2. These are important as body can store carbohydrates and use them when needed;
3. Carbohydrates help in normal functioning of the organs such as liver, brain heart and muscles.

d. **Proteins**

Proteins are essential nutrients for the human body. They are one of the building blocks of body tissue. Proteins are also used as fuel to get energy. Amino acids link together to form chains called polypeptide chains. The bond between amino acids is called peptide bond. Proteins are complex compounds. The body uses amino acids to prepare its own proteins. Proteins that we eat provide these amino acids. It is therefore essential that proteins are broken down in the stomach during digestion so that there amino acids can be used by the cells. Amino acids can be divided into three categories: essential amino acids, non-essential amino acids and conditional amino acids. Essential amino acids cannot be made by the body, and must be supplied by food. Non-essential amino acids are made by the body from essential amino acids or in the normal breakdown of proteins. Conditional amino acids are usually not essential, except in times of illness, stress or for someone challenged with a lifelong medical condition.

e. **Fats and Oils**

Fats and oils are important components of our food. We take fats and oils in the form of ghee, animal fat, butter, and seed oils. The difference between fat and oil is that oil is liquid at 20^oC while fat is solid at this temperature. Oils are also present in nuts like almond, peanuts, cashew nuts and many other dried nuts.

- Fats are a rich source of energy.
- Fat deposits in the body act as food reserves.
- Fat provides important protection for the vital internal organs such as heart, kidneys. Have you observed that kidneys of lamb have a fat layer around them it saves kidneys from shock and injury.
- Fat is a poor conductor of heat, fat layer under the skin acts as insulation, and prevents loss of body heat.
- Fats are important part of brain structure.
- Fats also provide the covering for nerves, and thereby allow nerves to carry the impulses.
- Fat are part of the structure of walls of cells, the cell membranes.
- Fats are necessary for the production of hormones to regulate and initiate body activities.
- Fat is absolutely necessary for milk production in nursing mothers, and is required during pregnancy for the proper development of the child.
- They are also important to store certain vitamins like vitamin A, D, E and K which are soluble in fats and insoluble in water.

Scientific name for fats and oils is "lipids".
Fat is used in the body in four main ways:

1. As a source of heat and energy;
2. As padding and insulation for the organs and nerves;
3. As a regulator for the fat soluble vitamins (A, D, E and K); and
4. As a source of the essential fatty acids.

f. Vitamins

Vitamins and minerals are essential nutrients. They perform hundreds of roles in the body. They help shore up bones, heal wounds, and bolster your immune system. They also convert food into energy, and repair cellular damage.

Vitamins are vital (i.e. essential) to the body hence the name "vitamins" has been given. They work within the body like the machine oil that keeps all the parts of the body functioning. They are used at the cellular level and help in a variety of physiological processes, from development to metabolism to enable repairs that maintain health.

i. Types of Vitamins

Vitamins are of two types: fat soluble and water soluble. The fat soluble vitamins are absorbed into the lymph with fat. They are stored in the body, so if you take in more than you need, they accumulate in the body. Unnecessary accumulation of vitamins in the body can become toxic. The water soluble vitamins are simply absorbed in the blood, and if you consume more than the body needs the excess is excreted in the urine.

ii. Oil Soluble Vitamins

Vitamins A, D, E and K. are oil soluble. They have specific functions in the body. Vitamin A is necessary for eyes to maintain their light-sensitivity. It is also essential for bone growth and to maintain the mucosal lining of internal organs as well as the skin. Vitamin D, maintains levels of calcium and phosphorous in the blood and they are required for the growth and rebuilding of bones. Vitamin E is an antioxidant and Vitamin K must be available for blood to clot.

iii. Water Soluble Vitamins

Vitamin B and C are water soluble vitamins. Vitamin B is actually a group of vitamins. Each B vitamin is a co-enzyme which functions by associating with an enzyme. Hence the B vitamins must be present for enzymes to carry out their functions in the body. Enzymes are found in every cell and they are the key to physiological reactions in the body that break down and build up compounds that are required for us to live.

g. Dietary Fiber

Dietary fiber is the part of the plants we eat that we cannot fully digest. Therefore, it passes relatively intact through your stomach, small intestine, and colon and out of your body. You may think that if it is not used in the body then perhaps it is not useful for the body. It is not used by the body to get energy or materials for growth and repair but it has several important roles in maintaining our health.

Dietary fiber consists of non-digestible carbohydrates and a substance lignin that are present in plants. For example oat and wheat bran are made of lignin and cellulose. Vegetables such as okra also contain cellulose. Dietary fiber is found mainly in fruits, vegetables, whole grains and legumes. It prevents or relieves constipation. Fiber is of two types: insoluble fiber and soluble fiber.

i. Insoluble Fiber

This type of fiber helps in the movement of material through your digestive system thus increases stool bulk. It is of benefit to those who have constipation or irregular stools. Whole-wheat flour, wheat bran, nuts and many vegetables are good sources of insoluble fiber.

ii. Soluble Fiber

This type of fiber dissolves in water and forms a gel-like material. It helps to lower blood cholesterol and glucose levels. Hence it prevents diabetes. Soluble fiber is found in oats, peas, beans, apples, citrus fruits, carrots, and barley.

iii. **Functions of Dietary Fiber in the Body**

- **Normalizes Bowel Movements**
  Dietary fiber increases the weight and size of stool and softens it. A bulky stool is easier to pass. Hence prevents constipation. Fiber may also help to solidify the stool by absorbing excess water.
- **Lowers Blood Cholesterol Levels**
  Fiber found in beans, oats, flaxseed and oat bran may help lower blood cholesterol levels. Studies have shown that increased fiber in the diet can reduce blood pressure.
- **Helps Control Blood Sugar Levels**
  Fiber can slow the absorption of sugar, which for people with diabetes can help improve blood sugar levels. A diet which includes insoluble fiber is helpful in reducing the risk of developing diabetes.
- **Aids in Weight Loss**
  When we eat high-fiber foods are low in calories hence helps to control weight.

h. **Water**

Water makes up more than half of your body weight. We can't survive for more than a few days without water. Why? Our body has lots of important jobs and it needs water to do many of them. For instance, all cells of our body need oxygen. Blood carries oxygen to all the cells of our body. A major component of blood's composition is water which keeps it flowing in our arteries and veins. So water helps in transport of materials in our body. We need water to digest our food. Excretion of waste materials from the body is also possible because of water in our body. And you know that water is the main ingredient in perspiration, in urine through which waste materials are excreted. Cells depend on water to function normally.

Your body doesn't get water not only from drinking water but also from fruits, vegetables, and milk. All fluid drinks contain water.

Water is essential for following body functions:

1. Transport of materials from one part of the body to the other.
2. Digestion
3. Excretion
4. Regulation of body temperature
5. Functions of cells

8.3.2 Structure of Digestive System

The human digestive system is a complex system comprising of organs and glands that processes food. In order to use the food we eat, our body has to break it down into smaller molecules that can be transported to cells and used to make materials and to get energy. The digestive system is essentially a long, twisting tube that runs from the mouth to the anus, plus a few other organs (like the liver and pancreas) that produce or store digestive chemicals.

Our digestive system converts the food into diffusible, soluble and usable form. It also excrete the materials produced as a result of digestion.

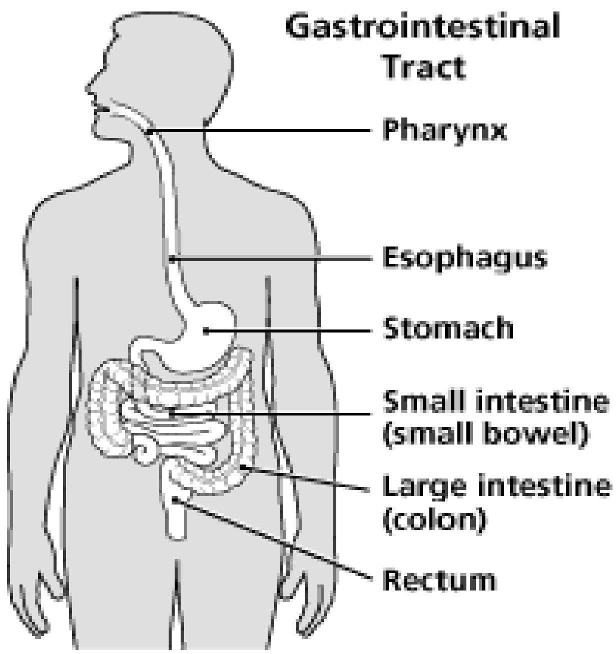


Fig 4: Digestive System

Source:
http://my.clevelandclinic.org/anatomy/digestive_system/hic_the_structure_and_function_of_the_digestive_system.aspx

i. Oral Cavity

Oral cavity i.e. mouth is the first part of the digestive tract. You have learned that digestion is the chemical and physical breakdown of food. Chewing physically breaks down the food into smaller pieces. During chewing process saliva is mixed with the food. Saliva is a sticky fluid which binds food particles together into a soft mass. Salivary glands secrete saliva. Look at the diagram of digestive system. You can see three pairs of salivary glands contain enzymes secreted by six salivary glands. These enzymes convert starch into sugar. Take a piece of bread chew it for a minute feel the change in its taste. You will notice that as you chew its taste becomes sweet. Bread has starch in it when we chew it saliva containing enzymes mixes with it and change the starch into sugar.

ii. Esophagus

Oral cavity opens into a tube called esophagus. Esophagus is located in your throat and extends from throat to chest where it joins the stomach. Esophagus lies behind the wind pipe. Grinding action of teeth and movement of tongue the saliva in the food and it is rolled into a soft and moist ball like mass called bolus. Tongue pushes the bolus into esophagus. As soon as food enters the esophagus muscles in the walls of esophagus start contracting and this action pushes the bolus to the end of esophagus where it enters into stomach. To understand the movement of esophagus; think of how you squeeze out tooth paste from the tube.

Do you know why sometimes when you eat or drink something you choke?

You know that esophagus lies behind the windpipe. When we swallow bolus a soft cartilage around the opening of windpipe closes and passage to windpipe is closed and bolus slips over this cartilage and enters esophagus. But when we eat or drink carelessly i.e. we talk or breath from mouth with full mouth pieces of food enters the windpipe and we are choked. That is the reason we are told not to talk with food in our mouth.

iii. Stomach

Stomach is attached to the end of the esophagus. It is sack like organ. Its shape is like the letter J. It is located on left side of abdomen. The opening between esophagus and stomach is guarded by a valve. This valve is called cardiac sphincter. It permits the passage of food only in one direction i.e. from esophagus into stomach. At the lower end of stomach where it is connected with the small intestine there is also a valve called pyloric sphincter. Stomach has strong muscular walls. Stomach has three functions:

1. it stores the food
2. break down the food into a liquid like mixture called chyme
3. transport chime to the small intestine

The stomach is like a mixing, churning and mashing machine which breaks the food into smaller and smaller pieces. The contraction of strong muscles in the walls of the stomach churns the food and mixes the secretions of stomach called gastric (gas-trik) juices into food. Walls of stomach secrete an enzyme and hydrochloric acid. In the stomach proteins are partially digested. In addition to breaking down food, gastric juices also help kill bacteria that might be in the eaten food.

iv. Small Intestine

The small intestine is a 22-foot long muscular tube. It is made up of three segments — the duodenum, jejunum, and ileum. The duodenum is largely responsible for the continuous breaking-down process, while the jejunum and ileum are mainly responsible for absorption of nutrients into the bloodstream.

v. Duodenum

It is the first part of small intestine. It is about 10 inch long. The secretions from the liver and pancreas are and from the walls of duodenum are mixed in the food. These secretions have following functions:

1. The secretion from liver called bile acts on fat and convert it into simpler substances.

2. Pancreatic juice contains three enzymes: trypsin, amylase and which breaksdown food using enzymes released by the pancreas and bile from the liver. Peristalsis also is at work in this organ, moving food through and mixing it with digestive secretions from the pancreas and liver.

   Contents of the small intestine start out semi-solid, and end in a liquid form after passing through the organ. Water, bile, enzymes, and mucous contribute to the change in consistency. Once the nutrients have been absorbed and the leftover-food residue liquid has passed through the small intestine, it then moves on to the large intestine, or colon.

vi. Pancreas

The pancreas is located deep in the abdomen between the stomach and the spine. It lies partially behind the stomach. The pancreas secretes digestive enzymes into the duodenum, the first segment of the small intestine. These enzymes break down protein, fats, and carbohydrates. The pancreas also makes insulin, secreting it directly into the bloodstream. Insulin is the chief hormone for metabolizing sugar.

vii. Liver

The liver is a major vital organ. Bile is a secretion of liver. The gallbladder is a small organ that lies beneath liver. It stores bile produced by the liver. Liver in part, stores nutrients, detoxifies the blood and regulates blood glucose levels.

Liver produces bile which is greenish in color. Bile helps in digestion of fats and oils. Bile salts break the fat molecules into tiny oil droplets. Pancreatic juices and juices from the walls of duodenum act on the smaller droplets more effectively and digest the fats completely.

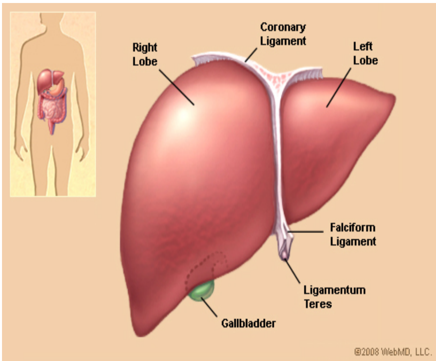


Fig 5: Liver is a vital organ of the body

viii. Jejunum

The combination of food, bile, enzymes and mucus passes into the jejunum after exiting the duodenum. The inner lining of the jejunum and the later section the ileum are lined with villi, small fingers containing capillaries that increase the surface area that can absorb nutrients. The villi in the jejunum absorb simple sugars, amino acids and many vitamins.

ix. Ileum

Last 3.5cm of small intestine is ileum. It is concerned with absorption of food. There are circular folds in the inner wall of ileum. These folds have numerous fingers like projections called villi (single, villus). The villi increase the surface area of the inner walls so that maximum nutrients could be absorbed. Look at diagram of internal structure of a villus given below. You can see that it is richly supplied with hair like thin blood capillaries and there is also a vessel of lymphatic system called lacteal. The walls of villus are made of a single layer of cell. The digested materials are absorbed from the small intestine via hepatic portal vein. Hepatic portal vein takes it to the liver for filtering, removal of poisonous materials called toxins and further processing of nutrients. The digested materials also contain Fatty acids and glycerol. These are absorbed into the lacteal which is the lymphatic vessel present in villi. Lymphatic vessel carries these materials to main lymphatic duct, from where they enter in blood stream.

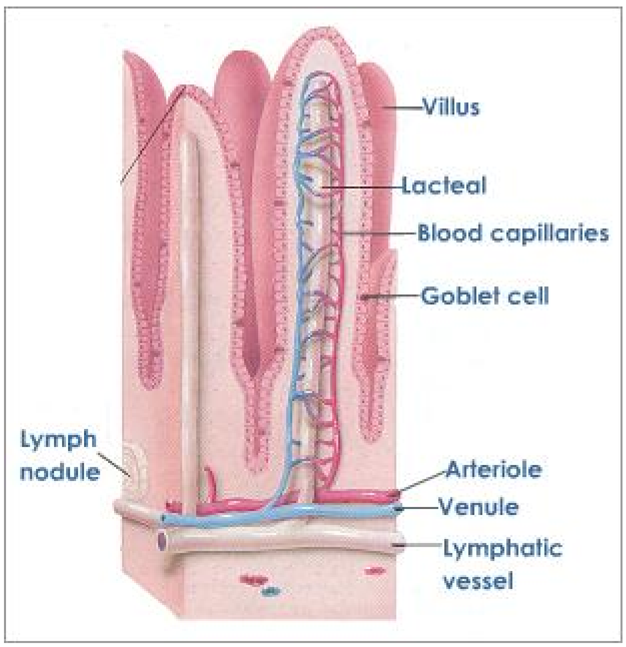


Fig 6: Structure of villus

x. Colon (large intestine)

The colon is a 6-foot long muscular tube. The large intestine is made up of three parts, colon, cecum and rectum. The major part of the large intestine is Colon. The large intestine is a highly specialized organ that is responsible for processing waste so that emptying the bowels is easy and convenient.

xi. Cecum

The undigested waste materials are transported to the first pouch like part of the large intestine which is called cecum. Cecum is located in the lower right region of the abdomen. There is a valve at the joining point of ilium and cecumm. It is called iliocecal valve. If you observe the diagram of the large intestine you will Appendix contains lymphoid tissues. Sometimes it becomes infected and swells this condition is called appendicitis.

xii. Colon

Colon has four parts, an ascending part on the right side of the abdomen, a transverse part and a descending part and the sigmoid colon, which connects to the rectum. Stool, or waste left over from the digestive process, is passed through the colon by means of peristalsis, first in a liquid state and ultimately in a solid form. As stool passes through the colon, water is removed. Stool is stored in the sigmoid (S-shaped) colon until a "mass movement" empties it into the rectum once or twice a day. It normally takes about 36 hours for stool to get through the colon. The stool itself is mostly food debris and bacteria.

xiii. Rectum

The rectum (Latin for "straight") is an 8-inch chamber that connects the colon to the anus. Rectum stores feces. When anything (gas or stool) comes into the rectum, sensors send a message to the brain. The brain then decides if the rectal contents can be released or not. If they can, the valves or sphincters relax and the rectum contracts, disposing its contents. If the contents cannot be disposed, the sphincter contracts and the rectum accommodates so that the sensation temporarily goes away.

xiv. Anus

The last part of the digestive is tract anus. It is a 2-inch long canal. It has two anal sphincters (internal and external) which allow control of stool.

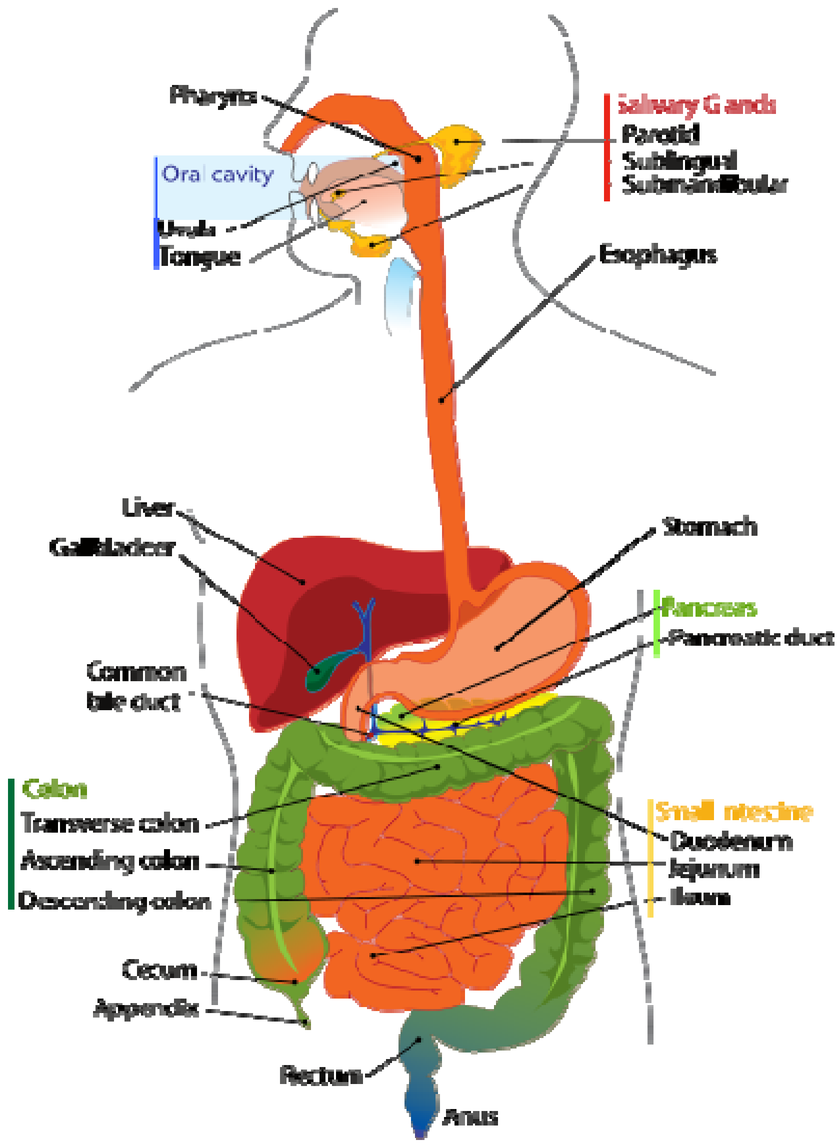


Fig 7: Digestive System

SOURCE: http://en.wikipedia.org/wiki/File:Digestive_system_diagram_en.svg

Key Points

1. Digestion is breaking down of large complex food molecules into smaller and simpler substances.
2. During digestion food is broken down into smaller simpler substances mechanically as well chemically.
3. The system under which digestion and absorption of nutrients in the blood takes place is called digestive system. The digestive system consists of a long tube called alimentary canal. Alimentary canal is composed of oral cavity, esophagus, stomach, small intestine and large intestine. Most of the digestion occurs in small intestine.
4. The food we eat has been grouped into proteins, carbohydrates, fats and oils, vitamins, minerals, dietary fiber and water.
5. Oral cavity is the first part of digestive system.
6. Secretions of salivary glands contain enzymes which partially digest the starch. From oral cavity food is pushed to esophagus through peristalsis.
7. Esophagus connects oral cavity with stomach. It is located in the chest.
8. Muscular walls of esophagus contract and move the food forwards into stomach. These special kinds of movements are called “peristaltic” movements.
9. Stomach is a “J” shaped organ with strong muscular movements. It produces HCL and gastric juice. Grinding, mixing and churning action of stomach walls convert the food into a chime.
10. Small intestine has three parts, duodenum, jejunum and ileum. Most of the digestion occurs in the first two parts. Ileum and jejunum have muscular walls which are folded and have small finger like projections called villi. From villi food is absorbed into blood stream.
11. Undigested part of food enters into large intestine. Here water is absorbed and waste materials are converted into a comparatively solid mass called feces.
12. Feces are stored in rectum until the defecation Liver is not an organ but gland which helps in lipid digestion. The colour of feces is due to the bile pigment.

Self Assessment Exercise 3

Q.1 Select the correct answer.

i. In which of the following part of digestive system starch is partially converted into sugar?
   a) mouth
   b) esophagus
   c) stomach
   d) duodenum

ii. A long tube that carries food from the mouth to the stomach.
   a) jejunum
   b) esophagus
   c) ileum
   d) duodenum

iii. Which part stores the liver's digestive juices until they are needed by the intestines?
   a) pancreas
   b) gall bladder
   c) villi
   d) appendix

iv. Which organ produces bile?
   a) liver
   b) pancreas
   c) gallbladder

v. In which part of the digestive system water is absorbed?
   a) small intestine
   b) large intestine
   c) mouth
   d) esophagus

vi. The proteins are broken down into
   a) amino acids
   b) fatty acids
   c) simple sugars
   d) none of the above

vii. Which type of digestion happens in the mouth?
   a) Chemical
   b) Mechanical
   c) a and b Both
   d) None

viii. Bile acts on which of the food component?
   a) Starch
   b) Proteins
   c) Fats
   d) Vitamins

ix. Which of the following statements describe functions of the large intestine?
   a) Absorb useful amino acids and fatty acids
   b) Digest cellulose and starch
   c) Chemically and mechanically digest food
   d) Absorb vitamins and minerals; remove water, reservoir for solid wastes

x. Villi are finger like structures in the alimentary canal. In which part of the alimentary canal you will find them?
   a) Duodenum
   b) Ilium
   c) Ascending colon
   d) Descending colon

xi. The final portion of the small intestine is the
   a) Ileum.
   b) Duodenum.
   c) Jejunum.
   d) Colon.

Q.2 Fill in the blanks.

i. A long folded tube in the abdomen which absorbs nutrients is called_________.
ii. A part of your throat that acts like a gateway sending air into the lungs and food down into the stomach is called___________.
iii. The place where waste is stored before it leaves the body is __________.
iv. The part of the food that is not digested ___________.
v. Name of the movement of elementary canal which pushes food forward _______________.
vi. After being swallowed, food goes to this place where it is mixed with acid _______________.
vii. The part of digestive system in which conversion of starch to sugar starts _______________.
viii. The part of elementary canal where water is absorbed _____________.
ix. Jejunum is part of ____________________.
x. The finger like structures which absorb nutrient are called _____________.

Q.3 Answer the following questions.

i. Describe the structure and functions of various parts of digestive system.
ii. What are the various components of food and what are their functions?

8.4 Human Circulatory System

Circulatory system is one of the most important systems of human body. In our body, as you know there are different systems which perform different functions. For example, food is digested in the digestive system the nutrients produced as a result of digestion needs to be carried to all parts of the body. Similarly the waste materials produced in different parts of the body are to be transported to the organs or systems which excrete these waste products. So there is a need of system which can transport materials from one part of the body to the other. The blood circulatory system transports the materials from one part of the body to the other. As you know for transport of materials there is a need of channels of transport and the vehicle to carry the materials from one part to the other. In the circulatory system blood is the vehicle which carries materials. The network of vessels of different sizes provides the route or channel. The heart pumps the blood to keep it in circulation.

8.4.1. Blood

Our blood is the medium of transport in the body. Approximately 8% of an adult's body weight is made up of blood. Females have around 4-5 liters, while males have around 5-6 liters. This difference is mainly due to the differences in body size between men and women.

Blood is considered a connective tissue for two basic reasons: (1) it has the same origin as the other connective tissue types and secondly, blood connects the body systems together. It brings oxygen, nutrients, hormones and other signaling molecules, and removes the wastes.

Blood has two components, liquid part called plasma and formed elements (cells) suspended in it. The fluid portion i.e. plasma makes up 55% of the total volume of whole blood. Formed elements makes up 45% of the total volume of whole blood.

The plasma is a straw-colored liquid composed primarily of water. All the important nutrients, the hormones, and the clotting proteins as well as the waste products are transported in the plasma. Red blood cells and white blood cells are also suspended in the plasma.

i. Plasma

Plasma is mostly water in which proteins, salts, metabolites and waste are dissolved. In about 90-92% is water and 8-10% dissolved salts. Plasma also contains the digested food, nitrogenous waste and hormones, and respiratory gases i.e. oxygen and carbon dioxide.

ii. Blood Cells

There are three types of cells.

a. Red blood cells.(Erythrocytes) containing hemoglobin for transportation of oxygen
b. White blood cells. (Leukocytes) serving as defense cells
c. Platelets. (thrombocytes) having function of blood coagulation.

The detail of each of the blood cell is as follows:

a. Red Blood Cells (RBC)

Red blood corpuscles are also known as RBCs or erythrocytes. They constitute 45% of blood by volume. RBCs contain pigment hemoglobin that gives blood its red color. In the functions of bones you have learnt that RBCs are produced in the bone marrow. On average our body contain up to 5000,000 cells per mm3. RBCs have a life cycle of 100-120 days. Mature RBCs are biconcave. They are flexible and do not have nucleus and other organelles. The principle function of RBCs is to deliver oxygen to different tissues of the body. Although they do carry a little carbon dioxide sometimes, however most of this unwanted gas is transported by the plasma.

Hemoglobin reacts with oxygen and makes an unstable substance, oxyhemoglobin. When the blood circulates among the cells of the body oxyhemoglobin breaks down into oxygen and hemoglobin. Oxygen diffuses into cells and is utilized by the cells.

b. White Blood Cells

White blood corpuscles (WBCs) are known as leukocytes. They make for 1% by volume of total blood. White blood cells contain nucleus. They are larger in size than RBC's. Our body contains about 7500 WBCs per mm3. They play role in body's defense by engulf small particles. Like RBCs they are also produced in the bone marrow and have various functions in the body. Leukocytes are classified as granulocytes and agranulocytes. Granulocytes cells are further classified into three groups: neutrophils, basophils and eosinophils. Agranulocytes cells are also of three types: lymphocytes, monocytes and macrophages. The count of leukocytes in blood is an important factor for normal functioning of the body.

Lymphocytes are essential for defence of body against diseases; these are components of the defence system of the body called immune system. Neutrophils and monocytes function primarily as phagocytes; a word which means "cell eater". They attack and engulf other cells especially invading microorganisms e.g. bacteria. About 30 percent of the white blood cells are lymphocytes, about 60 percent are neutrophils, and about 8 percent are monocytes. The remaining white blood cells are eosinophils and basophils. Their functions are uncertain; however, basophils are believed to function in allergic responses. Leukocytes provide protection to the body from foreign particles and infectious diseases.

c. Platelets

They are not cells, but are fragments of large cells of bone marrow. They do not have any nucleus and any pigment. There are 250,000 mm^3 platelets per cubic millimeter of blood. They help in blood clotting. In dengue fever, there is a sharp decrease in the number of platelets in blood, because of this, patients bleed from the nose, gums, and under the skin.

Activity 4

Collect a blood reports from a laboratory or clinic and read the information given. Note down what type of information is provided. Does it give you the idea of composition of the blood and the normal range of different types of cells in the blood?

Blood has following functions:

1. Transport of oxygen from the lungs and around the body; and CO_2 from the body cells to the lungs where it is excreted.
2. Transport of nutrients such as glucose and amino acids from the digestive system to the cells in our bodies.
3. Transport of waste products such as lactic acid away from the muscles when it's produced by anaerobic respiration; and urea from the liver to the kidneys and bladder.
4. Circulation of blood in the body keeps your core body temperature at a steady $37^{o}C$.
5. White blood cells help kill pathogens and microbes hence provide defence.
6. Blood platelets and fibrin help to clot wounds.

8.4.2. Blood Vessels

A vessel is defined as a hollow utensil: a cup, a bucket, a tube. Blood vessels, then, are hollow utensils for carrying blood. They make network throughout your body. If all of the blood vessels of an average child are laid out in one line, the line would be more than 60,000 miles long! An adult's vessels if joined would expand to 100,000 miles. Blood vessels are of three types:

a. Arteries.
b. Veins.
c. Capillaries.

The detail of each blood vessel is as follows:

a. Arteries

Arteries are the blood vessels that carry blood away from heart. The walls of an artery are composed of three layers: a single celled inner membrane which is surrounded by a layer of muscle fibers which is also covered by a layer of fibrous material. With the contraction of heart the blood is forced out into the arteries under high pressure. Due to pressure of blood the arteries stretch. The strong walls of the arteries bear that pressure easily. When arteries enter body organs, they divide into smaller vessels known as arterioles. Arterioles enter tissue and divide into thin hair like vessels called capillaries.

b. Capillaries

Capillaries are the smallest blood vessels present in tissues. These are formed by the divisions of arterioles. Walls of capillaries are composed of only a single layer of cells thus are very thin and permeable that is exchange of materials such as water and dissolved substances can take place through the capillaries.

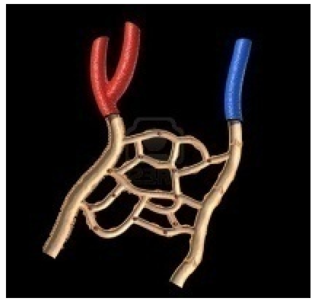


Fig 8: Capillaries

c. **Veins**

The blood vessels that carry blood towards heart are veins. They carry deoxygenated blood. They are composed of same three layers as arteries. In a tissue, capillaries join to form small venules, which join to form veins. Most veins have flaps called valves that prevent the back flow of blood.

8.4.3. Heart

The heart is a muscular organ responsible for pumping blood through blood vessels. The rhythmic beating of the heart is the result of contraction and relaxation of muscles of heart i.e. cardiac muscles. Cardiac muscles contract and relax rhythmically, which are called beats. The heart beats about 60 – 70 times per minute in a resting adult human. Exercise may cause an increase in the heart beat to 150 times or more depending upon how strenuous the exercise is. If you calculate the number of times heart beats in a day you would be amazed to find that on average in a normal healthy person the heart beats over 100,000 times a day and it pumps 14000 liters of blood!

Our heart is normally about the size of our fist. It is located behind and slightly to the left of your breastbone, also called the sternum. The heart is enclosed in a sac known as pericardium. There is a fluid, known as pericardial fluid, between pericardium and heat walls. Human heart consists of four chambers. The upper thin walled chambers are called left and right atria (singular atrium) and the lower thick walled chamber are called left and right ventricles. Left ventricle is the largest and strongest chamber in the heart.

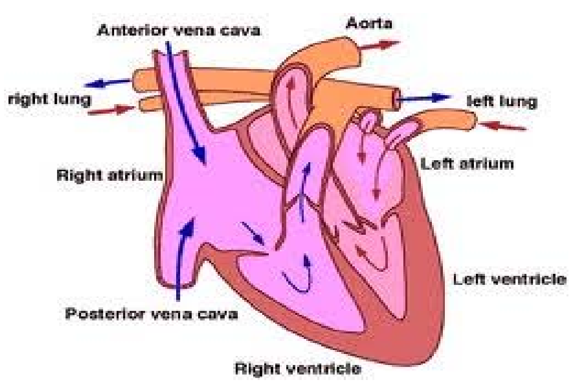


Figure 9: Internal structure of the heart

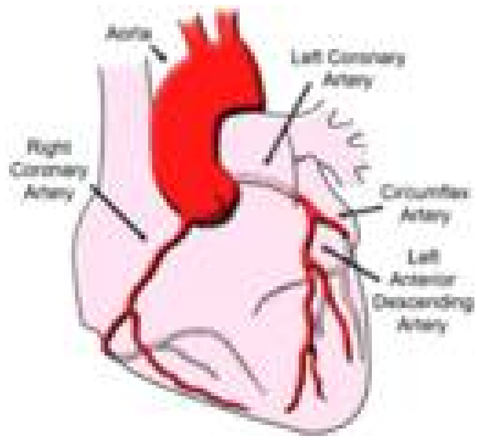


Figure 10: Human heart

- **Double Pump**
  Human heart works as a double pump. It receives deoxygenated blood from body and pumps it to lungs. At the same time, it receives oxygenated blood from lungs and pumps it to all body. Inside heart chambers, the deoxygenated and oxygenated bloods are kept separated. Double pump of our heart is carried out by two processes i.e. pulmonary circulation and systemic circulation.

8.4.4 Pulmonary Circulation

Blood circulates in our body following a certain path in the body. There are two circuits in the circulatory system of higher animals through which blood circulates. Pulmonary circulation and systemic circulation. The blood moves through pulmonary circulation and then continues on through systemic circulation. The path way on which deoxygenated blood is carried from heart to lungs and in return oxygenated blood is carried from lungs to heart is called pulmonary circulation. In pulmonary circulation the deoxygenated blood enters from the vena cava (Vena cava is the large vein which brings deoxygenated blood from the body to heart) into right atrium and from the right atrium to the right ventricle. There is a valve between right atrium and ventricle which prevents the blood from flowing back into the right atrium. Pulmonary artery carries the blood from the right ventricle to the lungs. In the lungs gaseous exchange takes place. Carbon dioxide is released into lungs and oxygen enters the blood. Oxygenated blood is carried via pulmonary vein to the heart. Pulmonary vein brings oxygenated blood from the lungs into the left atrium. When the left ventricle is full it contracts and blood is forced into the main artery of the body called Aorta. There is a valve between Aorta and left ventricle which prevents blood from flowing back into ventricle. In the diagram of circulatory system trace the path of blood from heart to lungs and back to heart.

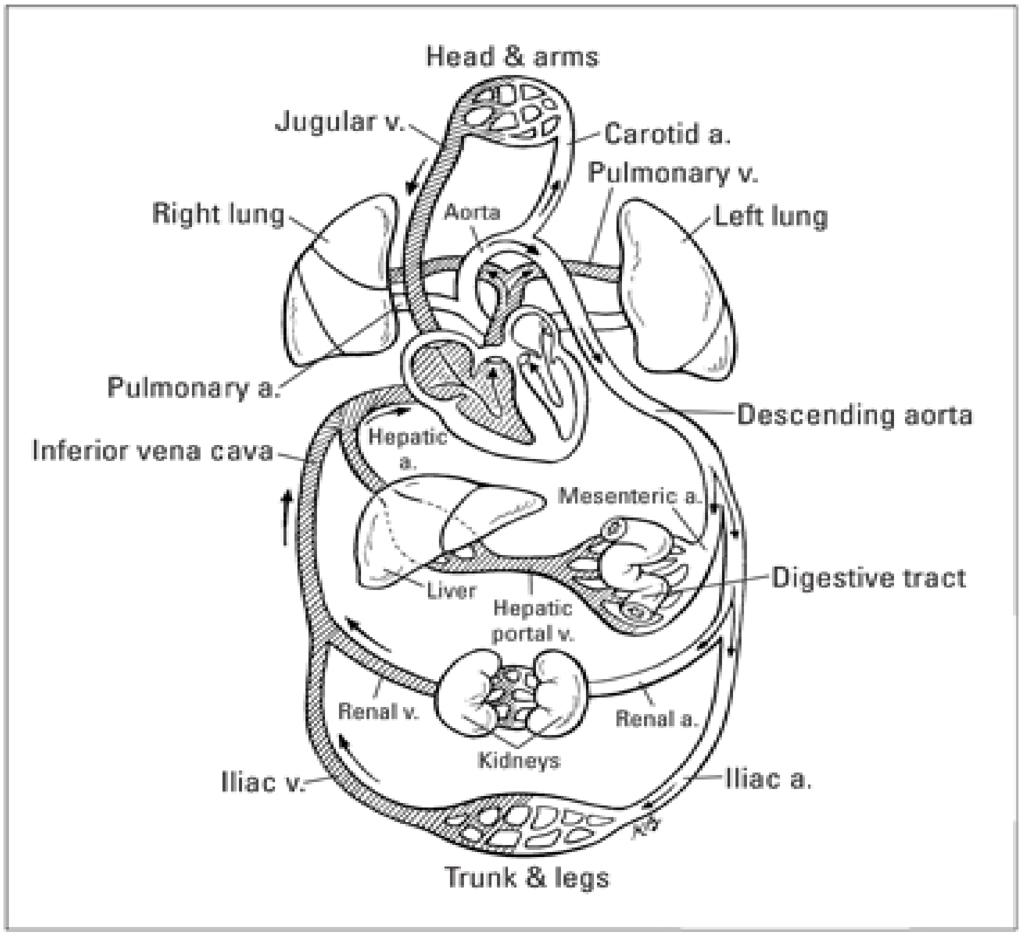


Fig 11: Path of blood through the Human Body

Source: http://www.dummies.com/how-to/content/the-path-of-blood-through-the-human-body.html

8.4.5 Systemic Circulation

The path way on which oxygenated blood is carried from heart to body and in return deoxygenated blood is carried from body tissues to heart is called systemic circulation. Systemic circulation is, distance-wise, much longer than pulmonary circulation, transporting blood to every part of the body.

8.4.6 Heart Beat

The relaxation of heart chambers fills them with blood and contraction of chambers pumps blood out of them. The alternating relaxations and contractions make up the cardiac cycle and one complete cardiac cycle makes one heart beat. Complete cardiac cycle consists of the following steps;

- Atria and ventricle relax and blood is filled in atria. This period is called cardiac diastole.
- Immediately after their filling, both atria contract and pump blood towards ventricles. This period in cardiac cycle is called arterial systole. Now both body and lungs period of ventricular contraction is called ventricular systole.

You can count your heart beat rate or pulse rate by putting slight pressure on any artery in the body. When you will slightly press an artery you will feel its pulsation. You may have noticed or even experienced doctor feeling the pulse rate by putting finger pressure on a specific point of your wrist. Besides wrist you can feel an artery at other locations e.g. side of the neck groin or side of the feet.

Activity 5

Visit a nearby clinic and request them to check your blood pressure and heart beat rate. Find out what is your systolic pressure. What is you diastolic pressure? Which one is higher?

Activity 6

Feel your pulse by putting the fingers on an artery as shown in the figure.

Fig 13: Pulse

Source: http://en.wikipedia.org/wiki/Pulse

Quickly climb the stairs or run and then take your pulse rate. What is the difference in the pulse rate taken before and after running? What does it indicate about your heart beat?

Key Points

1. Circulatory systems composed of blood, blood vessels and heart.
2. Blood is a tissue and it is composed of a liquid part, plasma and suspended elements called blood cells. Blood cells are of three types i.e. RBC's, WBC's and Platelets.
3. Circulatory system comprised of heart and blood vessels
4. There are three types of blood vessels. Arteries, veins and capillaries.
5. Arteries carry blood away from heart.
6. Veins carry blood towards the heart.
7. Capillaries serve as a link between arteries and veins. They actually supply blood to the tissues.
8. The heart is composed of four chambers. Right and left upper chambers called atria (singular atrium) and right and left lower chambers ventricle.
9. The blood circulates through two circuits: pulmonary and systemic circulation.
10. In pulmonary circulation deoxygenated blood is carried from heart to lungs and oxygenated blood is carried from lungs to heart.
11. The second blood circuit is the one through which oxygenated blood is carried from heart to body and deoxygenated blood is carried from body tissues to heart. The blood circulation in this circuit is called systemic circulation.
12. The heart works all the time. It contracts and relax rhythmically without getting tired. The alternating relaxations and contractions make up the cardiac cycle and one complete cardiac cycle makes one heart beat.

Self Assessment Exercise 4

Q.1 Answer the following questions:

- i. Why blood is considered a connective tissue?
- ii. What type of muscles are cardiovascular muscles? How are they different from smooth muscles?
- iii. What is the composition of blood?
- iv. What is the role of different types of cells in the blood?
- v. Enlist the functions of blood.
- vi. Describe the structure of the heart.
- vii. Differentiate between systemic and pulmonary circulation?
- viii. What are the different types of blood vessels in our body?

Q.2 Choose the correct answer.

- i. Which type of blood vessels carries blood away from the heart?
  - a. Arteries
  - b. Veins
  - c. Capillaries and veins
  - d. Venules

ii. What is the main job of the red corpuscles in the blood? It …
   a. helps in clotting of blood
   b. carries carbon dioxide
   c. carries oxygen
   d. kills microbes

iii. Which of the following is correct sequence of blood circulation?
   a) Left atrium –left ventricle – lungs - right atrium – right ventricle
   b) right atrium – right ventricle - lungs - left atrium – left ventricle
   c) left atrium – left ventricle _ right atrium – right ventricle – lungs -body
   d) Left Atrium – lungs – left ventricle – body – right atrium – right ventricle

Q.3 Fill in the Blanks

a. Plasma contains ________ percent of water.
b. Red blood cells contain a pigment called ________.
c. Among the four chambers of heart ______has strongest walls.
d. The heart is enclosed in a membrane called_____
e. The blood cells which are thinner at the center than their edges are ________.
f. The red blood cells have a life span of ______ days.
g. Hemoglobin has ________ which makes a bond with _______.
h. Red blood cells are produced in _________.

8.5 Respiratory System

As you know oxygen is vital for each cell of the body. You are also aware that all living beings including man get their oxygen from the atmosphere. It is the respiratory system which makes atomospheric oxygen available for blood to carry it to the cells of the body. How this atmospheric oxygen is made. The respiratory system consists of a pair of lungs with associated structure like nose, pharynx, larynx, trachea, bronchi and bronchioles.

i. Nose

Nasal cavity or nose has two nostrils; air enters through the nostrils into nasal cavity. The nostrils are lined with hairs. The nasal cavities located above the oral cavity and behind the nose are covered with epithelial tissues. Due to presence of hair dust is trapped in nose preventing it to move to the nasal cavity. Mucous is also present in the nose.

ii. Pharynx

The next part of our respiratory system is pharynx. The inner compartment of the nasal cavity opens into the pharynx (throat). The pharynx is a muscular passage way which extends from behind the nasal cavities to the opening of esophagus and larynx. The air goes from the pharynx into larynx.

iii. Larynx

The upper most part of our air tube (trachea) is called larynx. The larynx is made of cartilage. Two fibrous bands called vocal cords are located in it. Sound is produced when vocal cords are vibrated. Larynx is also called sound box. The air enters into the larynx through a small opening which is called glottis. The opening is guarded by a muscular flap called epiglottis.

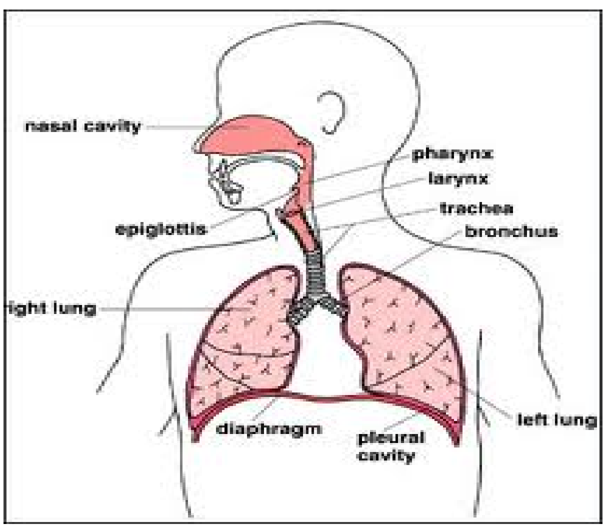


Figure 14: Respiratory System
http://www.umm.edu/respiratory/anatomy.htm

iv. Trachea

Air tube is called trachea, it is about 12 cm long cylindrical tube which lies in front of esophagus. If you move a finger along your front part of your neck you will feel hard ridge like structure. These are "C" shaped cartilaginous bones placed at regular intervals in the wall of the trachea. These rings prevent the collapsing of the tube and keep the air passage wide open all the time. Trachea is also lined with ciliated mucous epithelium. Cilia prevent any foreign particles from entering air passage. Epithelial cells also secrete mucus. If a foreign particle enters trachea it is trapped in the mucus and involuntary coughing starts which pushes the particle in the upward direction and out of the system.

v. Bronchi

The trachea on entering the chest divides into two smaller tubes which are called bronchi, which are similar in structure to the trachea but are smaller in diameter and they have in their walls small irregular cartilaginous plates. Each bronchus enters into the lungs of its own side. The right bronchus branches into left bronchus divide into two secondary bronchi which serve the 3 right and 2 left lobes of the lungs respectively.

vi. Bronchioles

The secondary bronchi divide into and smaller branches until they end in thousands of passage way called respiratory bronchioles. The bronchioles have not cartilaginous plates in their walls.

vii. Alveoli

The walls of the respiratory bronchioles have clusters of tiny branches (like grapes) that along with the respiratory bronchioles are the sites of gaseous exchange, these are called alveoli. They are numerous in number. Each lung has 3 hundred million alveoli.

viii. The Lungs

The masses of alveoli constitute our lungs and their lobes. Our lungs are present in chest box made of ribs and the muscles between the ribs called intercostal muscles. A dome shaped muscular diaphragm makes the floor of the chest box. The lungs are enclosed in a double layered membrane called pleural membrane.

ix. Mechanism of Breathing

Breathing has two phases:

a. Inhalation
b. Exhalation

8.5.1 Inhalation

During inspiration the dome shaped diaphragm contracts flattening somewhat and thereby lowering the floor of the thoracic cavity. The external intercostals muscles contract and the rib cage is raised. A combined action of these two events expands the thoracic cavity which in turn expands the lungs. As a result of it the air pressure within the lungs decreases. Thus air from the environment outside the body is pulled into lungs to equalize the pressure of both sides.

i. Exhalation

In exhalation the external intercostals muscles relax and the internal intercostals muscles contract as a result of which ribcage lowers down. The diaphragm relaxes and assumes a dome like shapes. The combined action of these two events reduces the volume of lungs which results in an increase in the air pressure in lungs. The air is thus forced out.

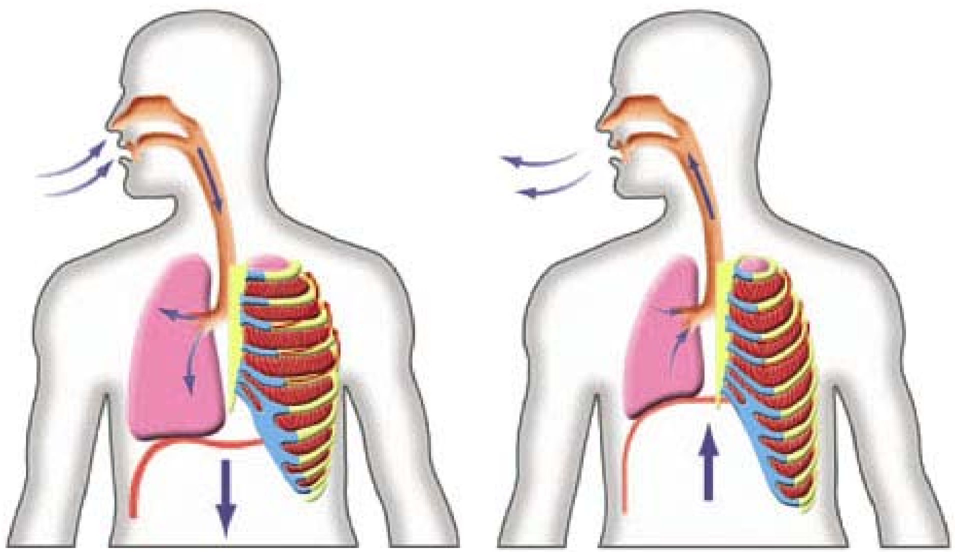


Figure 15: Respiration consists of two phases inhalation and exhalation
http://www.clipart.dk.co.uk/1228/subject/Biology/Inhalation_and_exhalation

Activity 7

Take a pair of goat's lungs along with trachea. Observe the color and texture of lungs. Blow air in the trachea and observe the difference in lung size.

Key Points

1. Respiratory system is composed of nose, pharynx, larynx, trachea, bronchi, bronchioles, alveoli and lungs.
2. Air enters the respiratory system through nose, the dust particles in the air are trapped in the nose. From nose the airs moves towards the pharynx, which acts as a passage way. Larynx contains a vocals cord which helps in production of sound, so it is called as voice box / sound box.
3. Air tube is also called trachea. Its walls have "C" shaped cartilaginous rings which keep it from collapsing. The walls of trachea are made of epithelial cells which have hair like cilia. Presence of mucous and cilia prevent the dust particles from entering into the respiratory system. Trachea divides into two branches called bronchi, which enter each lung where they divide into many branches called bronchioles.
4. The bronchioles form tiny grape like structures called alveoli. These are number of alveoli so they join to form clusters. These clusters make the lungs.
5. The process of breathing replenishes the lungs with fresh air, and allows blood to be continually supplied with oxygen. Breathing is controlled by various muscles in the chest (including the diaphragm) which cause the lungs to expand and contract, which in turn causes us to inhale and exhale.

Self Assessment Exercise 5

Q.1 Answer the following questions.

1. What are the main functions of respiratory system?
2. Which part of the respiratory system has the mechanism of trapping germs and dust?
3. We are often told not to breathe through mouth. Why it is not advisable to breathe through mouth?
4. In which part of the respiratory system exchange of gases takes place and how?
5. Keeping in view the role of blood and respiratory system can you explain how the two systems are related?
6. What is the name of membrane which keeps the lungs' surface moist and save them from friction against chest box?

Q.2 Choose the correct answer.

i. Which of the following statement is true about lungs?
   a. They are made of strong voluntary muscle fibres.
   b. They are made of involuntary muscle fibres.
   c. Lungs have no muscle fibres in their structure.
   d. The membrane around the lungs is called pericardium.

ii. Trachea subdivides into branches called:
   a. Bronchioles
   b. Capillaries
   c. Alveoli
   d. Bronchi

iii. The vessel carrying the oxygenated blood from the lungs to the heart is called__________
   a. Superior vena cava
   b. Aorta
   c. Pulmonary vein
   d. Hepatic portal vein

iv. During inhaling
   a. Diaphragm and intercostals muscles are relaxed
   b. Diaphragm is relaxed but intercostals muscles are contracted
   c. Both the diaphragm and intercostals muscles are contracted
   d. Diaphragm is contracted but intercostals muscles are relaxed

v. Respiratory bronchioles are formed by subdivision of______
   a. Bronchi
   b. Bronchioles
   c. Capillaries
   d. Alveoli

8.6 Excretory System

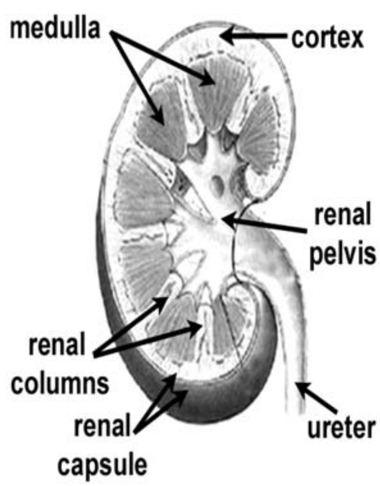
As our body breaks down the materials to convert them into usable substances or manufacture new materials like proteins waste materials are also produced in this process which needs to be removed from our system as they are poisonous. The process of removal of wastes is called excretion. The word excretion means the removal of waste substances from the body. Several organs of our body excrete waste materials e.g. kidneys, sweat glands, lung, and rectum. The primary organs of excretions, however, are the kidney. As you know, carbon dioxide and water vapor are removed by the lungs; solid wastes are removed by the rectum. Wastes, such as urea, uric acid, various salts, and other nitrogenous wastes, are removed by the kidneys and sweat glands.

8.6.1 Structure of Excretory System

Urinary system also called excretory system, comprise of: a pair of kidneys, uretor, and bladder.

i. Kidneys

You may have observed the kidneys of a buffalo or a goat, they are bean shaped organs (See the diagram). Our kidneys are similar in shape. The average kidney is of the same size as the mouse of your computer! Kidneys are the major organs of excretion. They are located on either side of the backbone at about the level of the stomach and liver. The right kidney lays slightly lower than the left kidney. The concave side of the kidney faces the vertebral column. The depression in the outer of this surface is called hilus. It provides a place for the renal artery, renal vein and nerves to enter and leave the kidney.



Fug 16: Structure of a Kidney

The longitudinal section of a human kidney shows that it mainly consists of two regions, the outer dark red region is called cortex. The inner pale red region is called medulla.

Medulla consists of several cone shaped areas called pyramids. The pyramids project into space present in centre of concave surface of kidney called renal pelvis.

As you know from the previous sections, blood is the means of carrying materials from one part of the body to the other, it also carries waste materials. Blood enters the kidneys through **renal arteries** and leaves through **renal veins.** Tubes called **ureters** carry waste products from the kidneys to the **urinary bladder** for storage or for release.

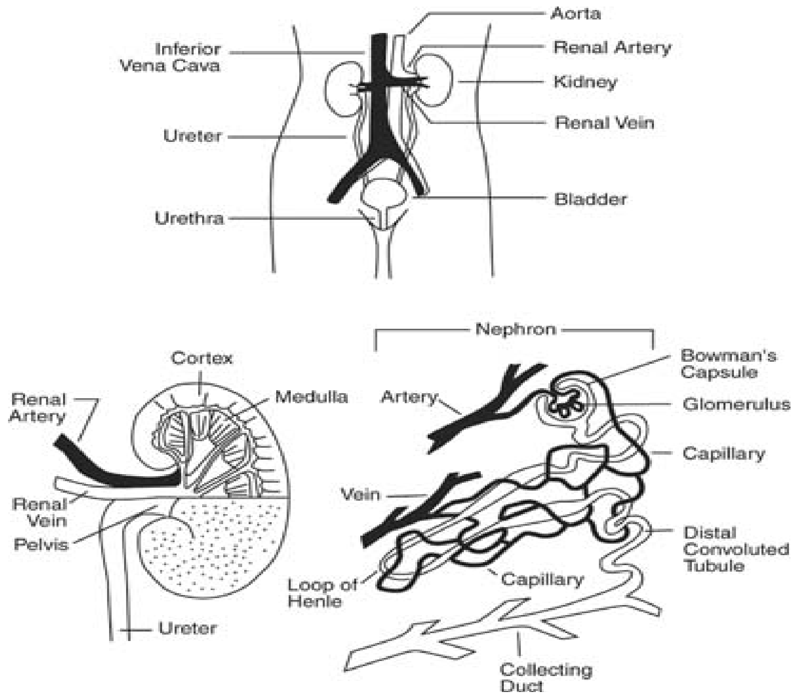


Fig 17: Excretory System

The waste product of the kidneys is urine. Urine is a watery solution. It contains waste products such as: salts, organic and nitrogen compounds. Uric acid and urea are the two major nitrogenous compounds formed as a result of metabolic activities in the body. These are poisonous compounds and should be regularly excreted from the system. Uric acid results from nucleic acid decomposition, and urea results from amino acid breakdown in the liver.

ii. Nephron

The functional and structural unit of the kidney is the nephron. The nephron produces urine and is the primary unit of homeostasis in the body. It is a long tubule with a series of associated blood vessels. The upper end of the tubule has an enlarged cuplike shape called the Bowman's capsule. Below the Bowman's capsule, the tubule coils to form the *proximal tubule*, and then it is turns like a hair pin taking the shape of a loop called the *loop of Henle*. After the loop of Henle, the tubule coils once more as the *distal tubule*. Distal tubule enters the *collecting* *duct*.which also receives urine from other distal tubules. Within the Bowman's capsule is a coiled ball of capillaries known as a glomerulus. Blood from the renal artery enters the glomerulus with a great pressure. Due to the force of the blood pressure plasma passes through the walls of the glomerulus and pass through the walls of the Bowman's capsule, and flows into the proximal tubule. Red blood cells and large proteins remain in the blood. When plasma enters the proximal tubule, it passes through the coils, where usable materials and water are re-absorbed. Salts, glucose, amino acids, and other useful compounds flow back through tubular cells into the blood by active transport. Osmosis and the activity of hormones assist the movement. The blood fluid then flows through the loop of Henle into the distal tubule. Once more, salts, water, and other useful materials flow back into the bloodstream. Homeostasis is achieved by this process: A selected amount of hydrogen, ammonium, sodium, chloride, and other ions maintain the delicate salt balance in the body.

The fluid moving from the distal tubules into the collecting duct contains materials not needed by the body. This fluid is called urine. Urea, uric acid, salts, and other metabolic waste products are the main components of urine. The urine flows through the ureters towards the urinary bladder. When the bladder is full, the urine flows through the urethra to the exterior.

iii. Urinary Bladder and Ureters

A tube from kidney originates called ureter from renal pelvis. Both of the ureters open in urinary bladder.

iv. Urethra

The urinary bladder opens to outside through a duct known as urethra.

From renal pelvis of both the kidney ureters originate which opens into urinary bladders Urinary bladders have an opening called urethra.

8.6.2 FUNCTION OF KIDNEY

The main function of our kidney is urine formation which takes place in three steps.

1. Filtration.
2. Reabsorption.
3. Secretion.

1. FILTERATION

In the first step, the pressure filteration takes place in the renal corpuscle. Due to the blood pressure in the glomerulus's the part of the blood (without red blood cells and plasma proteins) is filtered into the Bowman's capsule and is called bowman's fiterate. It mainly consists of salts, glucose, urea and uric acid dissolved in water. From glomerulus's it moves down into the renal tubule.

2. REABSORPTION

In the second step the process of selective reabsorption takes place by the network of capillaries, which surrounds the tubule .Firstly all the glucose with much of water is reabsorbed. Some of the salts are sent back into the blood.

3. SECRETION

In the third step the necessary salts with urea and uric acid with excess water travel down to the pelvis of the kidney, from where it moves to the bladder through the ureters.

Key Points

1. Excretory or urinary system consists of pair of kidney, ureters, urinary bladder and urethra. The kidney is a bean shaped organ mainly consisting of two regions.
2. The function of our kidney is urine formation. Urine is formed in three steps.
3. In first step when blood entered the kidney, the undigested material is filtered. Blood returns back and the filterate stay in the kidney.
4. In the second step material is reabsorbed or filtered again so that if there are some useful materials in the filterate must sent back to the blood.
5. In the last step all of material in the kidneys is moved down to the urinary bladder through ureters.
6. Our kidney consists of large number of nephrons. They are composed of cluster of capillaries. They are composed of clusters of capillaries called glomerulus's, which is covered by a cup shapes structure called Bowman's capsule.
7. Nephrons renal tubule is long surrounded by a network of capillaries .One of its portion forms a u-shaped structure called loop of henle. The last portion of nephrons opens into collecting duct.

Self Assessment Exercise 6

Q.1 Fill in the Blanks.

i. The depression in the centre of the kidney is called________________.
ii. The outer dark region of the kidney is called______________.
iii. Urine formation takes place in ____steps.
iv. Glomerulus's is surrounded by _________.

Q.2 Choose the correct option.

i. All of the following belong to the urinary system EXCEPT the
   a. urethra.
   b. ureter.
   c. bladder.
   d. colon.

ii. The part of the kidney that cleans blood is called….
   a. glomerulus.
   b. nephron.
   c. corpuscle.
   d. calyx.

iii. The structure that connects a kidney to the urinary bladder is the
   a. ureter.
   b. urethra.
   c. renal pelvis.
   d. collecting duct.

Q.3 Answer the following questions.

i. Describe the process of urine formation.
ii. Describe the structure and function of nephron.

8.7 Nervous System

In the previous sections, various systems of human body and their functions have been described separately as if each system and its organs work independently and have no connection. In fact each system performs its own function but all the systems and processes are closely linked and dependent on each other. For example, digestion of food in the digestive system will be of no use if the digested materials are not absorbed by the blood and distributed to all parts of the body. We all have the experience increase in breathing rate and heart beat during physical exercise. It is because the body needs more glucose and oxygen to get the energy and it is possible only when our respiratory and blood circulation system have some coordination. Without coordination, the bodily activities would be thrown into chaos and disorder. The activities of the organs and systems are not only related to each other but also respond to the changes in external environment and adjust and modify their pattern, for example when it is very hot excessive sweating starts. Coordination is brought about by two systems, nervous system and endocrine system. The former comprise of an elaborate network of specialized tissues which transmit messages from one part of the body to the other while the later consists of a number of glands in the body which secrete certain chemicals which circulate in the body via bloodstream and stimulate certain organs when they reach them.

8.7.1 Nervous system

Like the whole body the basic structural and functional unit of the nervous system is also cell. Specialized cells constitute the nervous tissue. These cells are called nerve cells or neurons.

They are highly specialized cells adapted for carrying messages from one part of the body to the other. Look at the diagram of neuron. As you can see it has a body called soma which contains nucleus and cytoplasm. From the cell body branch a number of filaments called dendrites. Often one of these filaments is very long and is called axon if it carries impulses away from cell body and Dendron if it carries impulses towards cell body. Generally these branches are called nerve fibres. In our neurons the nerve fibres are covered by a sheet of fatty material called myelin sheath. In human nervous system the bodies or soma of the neurons are confined to the brain or spinal cord and the nerve fibres are extended to the organ they supply.

The thousands of nerve cells are organized into a nervous system. The cell bodies are grouped largely into the central nervous system i.e. the brain and the spinal cord and the nerve fibres are arranged in bunches to form nerves. The nerves from spinal cord leave between the adjacent vertebrae. These nerves supply to diaphragm, skin muscles of neck and arms, thoracic region, abdomen and legs. Each nerve contains nerve fibres which carry the impulse away from the spinal cord and also fibres which carry the impulse towards spinal cord.

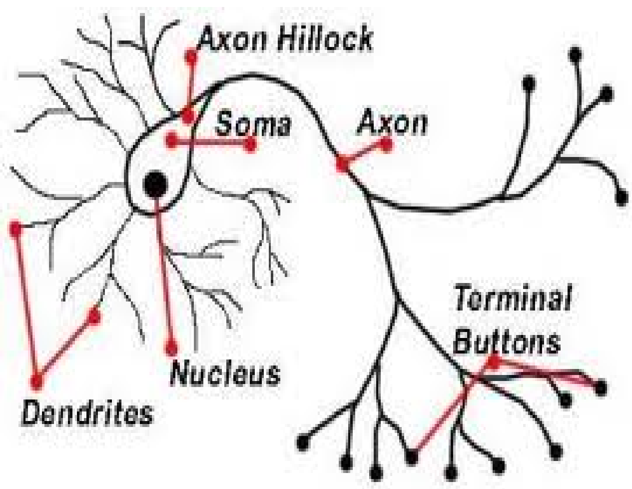


Figure 18: Structure of neuron

There are three kinds of neurons:

- Sensory neurons
  They carry impulses from receptors (e.g. skin, eyes,ears) from receptors to central nervous system.
- Motor neurons
  The forms central nervous system and are responsible for analyzing the massages and issuing the order.
- Associate neurons
  They carry impulses from central nervous system to the effecters.

8.7.2 Brain

Our brain is enclosed in a bony shell called skull, and three membranes called meninges. It has three parts: Dura mater closest to the skull, the middle Arachnoid mater, the Pia mater closest to the brain. The inner layer covers the brain, and is supplied with blood vessels. It brings oxygen and nutrition to the brain and protects it. Between the inner and middle layer a fluid is present called cerebrospinal fluid .The outer layer is tough and fibrous, which provides support to the brain.

Our brain is composed of three parts:

- Forebrain
- Mid brain
- Hind brain

i. FOREBRAIN

Forebrain has three parts: the cerebrum, thalamus, and hypothalamus.

The Cerebrum

The cerebrum or cortex is the largest part of the human brain. It is associated with higher brain function such as thought and action. It is divided into four sections, called "lobes": the frontal lobe, parietal lobe, occipital lobe, and temporal lobe.

Frontal Lobe is associated with reasoning, planning, parts of speech, movement, emotions, and problem solving. Parietal Lobe is associated with movement, orientation, recognition, perception of stimuli. Occipital Lobe- associated with visual processing and temporal lobe is associated with perception and recognition of auditory stimuli, memory, and speech. The cerebral cortex is highly wrinkled. It resembles the walnut in its appearance. The wrinkles increase the surface area of the brain so that it can accommodate more neurons.

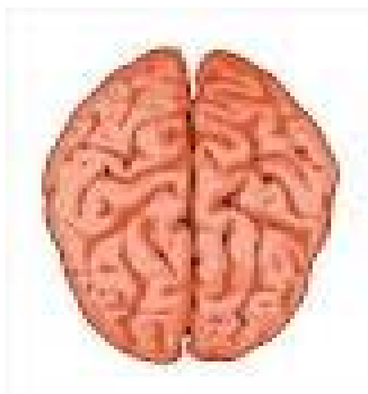


Fig 19: Cerebrum

A deep furrow divides the cerebrum into two halves, known as the left and right hemispheres (see the diagram). The two hemispheres look mostly symmetrical yet it has been shown that each side functions slightly different than the other. Sometimes the right hemisphere is associated with creativity and the left hemispheres is associated with logical abilities. The corpus callosum is a bundle of axons which connects these two hemispheres. The bodies of nerve cells make up the gray surface of the cerebrum. The white nerve fibers carry signals between the nerve cells and other parts of the brain and body.

Fore brain contains centers of control of smell, touch, sight, hearing, speech, voluntary actions such as walking and memory, logical thinking and intelligence.

THALAMUS

The thalamus is a large mass of grey matter buried under the cerebral cortex. It has two lobes. It also plays a role in sensory perception and regulation of motor functions. The thalamus connects areas of the cerebral cortex that are involved in sensory perception and movement with other parts of the brain and spinal cord that also have a role in sensation and movement. The thalamus also controls sleep and awake states of consciousness.

HYPOTHALAMUS

It is a small part of the forebrain. However it is very important part as it controls body temperature, sleep, hunger, and keeps the water balance in the body.

ii. MIDBRAIN

The midbrain is the part of the brain located underneath the middle of the forebrain. It acts as a master coordinator for all the messages going in and out of the brain to the spinal cord.

iii. THE HINDBRAIN

The hindbrain lies underneath the back end of the cerebrum. It consists of three parts: cerebellum, pons, and medulla. The cerebellum looks like a smaller version of the cerebrum and is therefore also called the "little brain". It is responsible for balance, movement, and coordination.

The pons and the medulla, along with the midbrain, are often called the brainstem. The brainstem takes in, sends out, and coordinates all of the brain's messages. It also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking.

iv. SPINAL CORD

Spinal cord is a thick dorsal neural track extending from the brain stem to the lower back. Our spinal cord is completely enclosed by vertebrae of the vertebral column just as brain is enclosed by the bones of the skull. There are 13 Pairs of spinal nerves arising from the spinal cord. Spinal cord is concerned with reflex action and also serves as pathway of information from and to the brain.

8.7.3 SENSORY ORGANS

Sense organs keep our mind informed about the external environment. There are five kinds of sensory organs present in our body.

- Organs of sight(eyes)
- Organs of hearing(ear)
- Organ of smell(nose)
- Organ of taste(tongue)
- Organs of touch(skin)

Sight

Sight probably tells us more about the world than any other sense. Light entering the eye forms an upside-down image on the retina. The retina transforms the light into nerve signals for the brain. The brain then turns the image right-side up and tells us what we are seeing.

Hearing

Every sound we hear is the result of sound waves entering our ears and causing our eardrums to vibrate. These vibrations are then transferred along the tiny bones of the middle ear and converted into nerve signals. The cortex then processes these signals, telling us what we are hearing.

Taste

The tongue contains small groups of sensory cells called taste buds that react to chemicals in foods. Taste buds react to sweet, sour, salty, and bitter. Messages are sent from the taste buds to the areas in the cortex responsible for processing taste.

Smell

You smell different odors through your nose. Our nose is built to smell, moisten, and filter the air we breathe. After passing through the nasal cavity, the air passes through a thick layer of mucous to the olfactory bulb. There the smells are recognized because each smell molecule fits into a nerve cell like a lock and key. Then the cells send signals along the olfactory nerve to the brain. The brain can distinguish between more than 10,000 different smells. With that kind of sensitivity, it's no wonder research suggests that smells are very closely linked to our memories.

Touch

The skin contains more than 4 million sensory receptors that gather information related to touch, pressure, temperature, and pain and send it to the brain for processing and reaction.

Key Points

1. The basic unit of structure and function of nervous system is neuron. Neuron is specialized cell for conduction of messages from receptors to brain and from brain to the effectors. They are composed three parts:
    - Cell body
    - Dendrites
    - Axons

2. Brain is the most complex organ of the body. Brain helps in the coordination of our body functions. Our brain is composed of three parts hindbrain, midbrain, and forebrain. The largest part of the brain is cerebrum.
3. Brain is involved in control and balance of the body. It also controls many involuntary actions our body e.g. heart beat, breathing blood pressure etc. spinal cord is also an integral part of our brain, it serves as a link between brain and sensory organs
4. Spinal cord is a thick dorsal neural track extending from the brain stem to the lower back. Our spinal cord is completely enclosed by vertebrae of the vertebral column just as brain is enclosed by the bones of the skull.
5. Sense organs keep our mind informed about the external environment. There are five kinds of sensory organs present in our body.

Self Assessment Exercise 7

Q.1 Choose the correct answer.

I. The part of the brain in charge of thinking and memory.
   a. cerebrum
   b. cerebellum
   c. medulla oblongata

II. This part of the brain controls coordination and balance.
   a. cerebrum
   b. cerebellum
   c. medulla oblongata

III. The cell body of a neuron is called…...
   a. dendrite
   b. axon
   c. soma

IV. The central nervous system enclosed in bone consists of:
   a. brain and spinal cord
   b. sensory and motor nerves

c. the peripheral nervous system
d. none of the above

V. Sensory nerves carry nerve impulses from the senses to the:
   a. brain
   b. motor nerves
   c. muscles

VI. Motor nerves carry nerve impulses to the muscles from the:
   a. senses
   b. brain
   c. sensory nerves

VII. The part of the brain responsible for vital functions such as heartbeat and breathing is the:
   a. medulla oblongata or hindbrain
   b. cerebellum or midbrain
   c. cerebrum or forebrain

VIII. The senses felt by the skin are:
   a. touch, pressure, heat, cold and pain
   b. touch, heat and cold only
   c. sight, smell, hearing and taste

Q.2 Answer the following questions:

i. Describe the structure and function of different parts of the brain.
ii. What is the basic unit of structure and function of nervous system?
iii. Write brief notes on five senses.

8.8 Reproductive System

Death is the ultimate destiny of all living beings, but the life continues as living things are capable of reproducing their own kind. Reproduction is another characteristic feature of living things which makes them different from non living things.

Like all other functions there is a system in the body which carries out the process of reproduction. It is the "Reproductive System". It is also comprised of a number of organs which work in a coordinated and systematic way to carry out their function. In this section you will study about human reproductive system.

You know that in some plants we can grow new plants from a part of the plant e.g. you can grow a potatoes plant by sowing potatoes' eye. This is a type of reproduction called asexual reproduction. You are also aware that in many plants we sow seeds to grow new plants and seeds are produced in flowers. Seeds are formed by union of special cells produced in male and female parts of the flower. These special cells are called gametes. Male gamete unites with the female gamete and the process is called fertilization. After fertilization the fertilized cell divides again and again to form many cells which form the seed. The type of reproduction in which male and female gametes take part is called sexual reproduction.

Asexual reproduction is the production of new individual that does not involve fusion of male and female gametes i.e. fertilization. Sexual reproduction is production of new individual by fusion of male and female gametes i.e. fertilization.

In the human reproductive process, like all mammals, two kinds of sex cells, or gametes, are involved: the male gamete, or sperm, and the female gamete, the egg or ovum. The gametes meet in the female's reproductive system to create a new individual. Both the male and female reproductive systems are essential for reproduction.

Humans, like other organisms, pass certain characteristics of themselves to the next generation through their genes, the special carriers of human traits. The genes parents pass along to their offspring are what make kids similar to others in their family, but they're also what make each child unique. These genes come from the father's sperm and the mother's egg, which are produced by the male and female reproductive systems.

8.8.1 Male Reproductive System

Male reproductive system consists of: a pair of testes, glands, sperm ducts, urethra and external genetalia.

Male gametes called sperms are produced in male reproductive organs called testes. Sperms produced in the testes are carried by a duct called sperm duct which opens into a tube called urethra. Numerous sperms are produced throughout the life of male organism after puberty. Sperm cells are unbelievably tiny. Four to five hundred million sperm cells will fit on one teaspoon. When viewed under a powerful microscope you can see that sperm cells are shaped like a tadpole. The testicles can produce millions of sperm cells each day. Sperm cells are the father's contribution to making a baby. When a sperm cell from the father joins with an egg cell from the mother a new life begins.

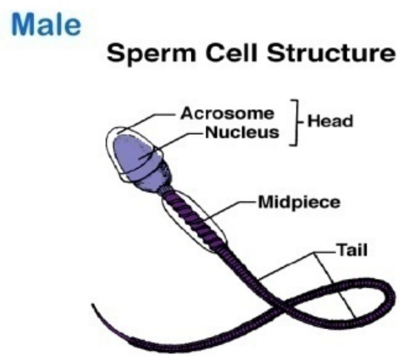


Fig 20: Male sperm cell structure

8.8.2 Female Reproductive System

Female reproductive system consists of ovaries, oviduct, uterus and the external genitalia. A pair of ovaries lies in the body cavity of the female. Female gametes are called eggs. Each ovary is connected to the uterus by a tube called an oviduct or fallopian tube. The egg tube is lined with cilia, which are tiny hairs on cells. Every month, an egg develops and becomes mature, and is released from an ovary. The cilia waft the egg along inside the egg tube and into the uterus. The baby or fetus develops in the uterus.

8.8.8.3 Fertilization

When male and female gametes unite to form a zygote, it is called as fertilization. The fertilization takes place in female body. The fertilized egg (zygote) develops in female body. A placenta is developed between the mother and foetal (body) tissues for exchange of gases and nutrients. The foetal development takes nine months. After nine month a new baby is born.

Key Points

1. The process of producing new organisms is called reproduction.
2. In human beings male and female both the parents takes part in reproduction.
3. Male contributes the sperms and from female eggs are contributed. They unite to form zygote. The zygote develops into a new organism.

Self Assessment Exercise 8

1. Fill in the Blanks

i. Male gametes are called ________________.
ii. Female gametes are called ___________________.
iii. Male gametes are formed in___________________.
iv. Female gametes are formed in _________________.
v. When egg and sperm unite _____________is formed.

Answers of Self Assessment Exercises

Self Assessment Exercise 1

Q1. a. correct, b. correct, c. wrong d. correct, e. wrong f. wrong, g. correct, h. correct, i. wrong j. correct
Q2. read the relevant section

Self Assessment Exercise 2

Q1. i. a, ii.b, iii. C, iv. C, v. b, vi. C, vii. C, viii. D, ix. B, x. b
Q2. For question i and ii read the relevant section.

Self Assessment Exercise 3

Q1. i. A, ii. B, iii. B, iv .a, v. B, vi. A, vii. C, viii. C, ix. D. x. B, xi. A
Q2. 1. Small intestine ii. Pharynx, iii. Rectum, iv. Feces v. Peristalsis, vi. Stomach, vii. Mouth, viii. Large intestine, ix. Small intestine, x. Villi
Q3. For question i and ii read the relevant section of the unit.

Self Assessment Exercise 4

Q1. For questions i to viii read the relevant section of the unit.
Q2. i.a ii. c iii. b
Q3.

a. 90%
b. Hemoglobin.
c. Left ventricle.
d. Pericardium.
e. Erythrocytes
f. 120
g. Iron, Oxygen
h. Bone marrow

Self Assessment Exercise 5

Q1. For question i to vi read the relevant section of the unit
Q2. i. c, ii. d, iii. c, iv. a, v. b

Self Assessment Exercise 6

Q1.

i. Hilus.
ii. Cortex
iii. Three steps.
iv. Bowman`s capsule.

Q2. I. d, II. b, III. A
Q3. Read the relevant section

Answers of Assessment Exercise 7

Q1.

I. a, II. b, III. C, IV. a, V. a, VI. B, VII. A

Q2. For answers to questions i, ii and iii read the relevant section

Answers of Assessment Exercise 8

i. Sperms
ii. Egg
iii. Zygote.

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Unit–9

MAN AND HIS ENVIRONMENT

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Reviewed by: Dr. Qudsia Rifat

CONTENTS

Introduction

Environment and environmental problems such as pollution, rapidly depleting natural resources, climatic changes and many other problems related to the environment are topics of hot debate in today's society. Everybody seems to be seriously concerned about environmental problems. Life of man and all other living beings is said to be at stake due to environmental deterioration. It is interesting to note that we, human beings are said to be the culprits causing all these problems.

Have you ever seriously considered what is environment? What is pollution and what are its causes? Why are natural resources diminishing? How are these problems related to environment? What is meant by sustainability of environment? What is the role of man in creating these problems? What type of human activities are the cause of environmental change and deterioration? And most importantly why the survival of man and other living beings on this planet is at stake?

In this unit, we have tried to answer these and many other questions related to environment; environmental problems, effect of environmental problems on human life in particular and life in general and role of man in deterioration of his environment.
We hope that you will find this unit, interesting and informative.

Objectives

After studying this unit, you will be able to:

- explain what is environment and what are its components.
- define ecosystem and enumerate its component.
- explain energy flow in ecosystem.
- explain the types of ecosystems.
- describe the cycles in ecosystem.
- define pollution and describe its various forms.
- explain the concept of conservation of environment.

9.1 Environment & its Components

It is said that earth is the only known planet which sustains life. So any discussion of human environment is related to earth. Life exists everywhere on this earth; it is present in water, in soil and even in the air. It is therefore important that prior to any discussion on human environment we learn about earth and its system.

Scientists have classified the different areas of earth into four inter-connected "geo-spheres:" (geo means earth and sphere means space, field or area). These four spheres include:

- Atmosphere
- Hydrosphere
- Lithosphere
- Biosphere

The terms used for these spheres have been derived from the Greek words. Litho means stone, "atmo" means air while hydro is for water and as you may know 'bio" means life. Life can exist in any of these four spheres. All these spheres are interconnected and make earth's system. A system has different components or parts which are interconnected and work together in the form of a complex.

The major areas of earth include: Atmosphere, Hydrosphere, Lithosphere and Biosphere. These are connected and work together as a system.

In any system the parts are so closely interconnected that any change or disturbance in one part affects the working of the other parts. Like any other system these four components of the earth's system are also interlinked in such a manner that a change in one sphere often affect other spheres. Consider for example, hydrosphere, it contains living organisms. Any change in hydrosphere will affect the biosphere. Similarly any change in atmosphere or air surrounding the earth will affect the hydrosphere.

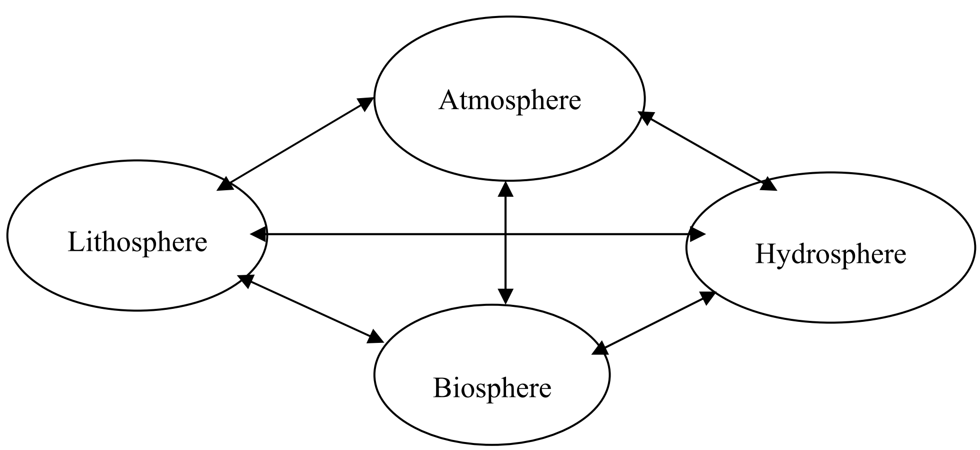


Figure 1: Earth's spheres are interconnected in the form of a system

1. Atmosphere

The atmosphere is actually a layer of air which surrounds the whole earth. Most of the earth's atmosphere is near its surface; hence it is most dense near the earth's surface. It consists of many gases like oxygen, carbon dioxide and nitrogen. Seventy nine percent of atmosphere is Nitrogen, and about 21 percent is oxygen, the rest of it is composed of carbon dioxide and other gases. You must remember that this is natural undisturbed composition of earth's atmosphere and any disturbance in it will affect the other spheres particularly biosphere.

2. Hydrosphere

Hydrosphere includes all the water mass on or near the earth. This includes oceans, rivers, streams, lakes, ponds, moisture in the air, ground water (water in soil and beneath the earth surface) glaciers, and the snow cover ice caps on the mountains. Hydrosphere is about seventy percent (70 %) of the earth's surface. Oceans make ninety-seven percent of the earth's water the remaining three percent is fresh water.

3. Lithosphere

Is the solid, rocky cover or crust of the earth and the whole earth is covered by it. It is composed of minerals. In lithosphere weathering of rocks produces soil and minerals for plants. Soil contains decayed organic material (Humus) which is a source of nutrients for plants. Humans are found from the decay of dead plants and animals.

The lithosphere is the solid, rocky crust covering entire planet. This crust is inorganic and is composed of. It covers the entire surface of the earth from the top of Mount Everest to the bottom of the Mariana Trench.

It is the dark or black carbon containing residue in the soil resulting from the decomposition of vegetative tissues of plants originally growing in soil.

4. Biosphere

Biosphere is that part of the lithosphere, hydrosphere and atmosphere in which life can exist. It means that wherever there will be life there will be air, water and hard part of the earth that is lithosphere. Living things or biosphere interacts with the components of the other three spheres: Lithosphere, hydrosphere, and atmosphere. As a result of interaction between living beings and other components of biosphere changes may occur in the earth's system. Human interventions in the environment have changed and are continuously changing the natural earth system.

Biosphere is capable of sustaining and supporting life. Life on this earth exists from three meters below the earth's surface to thirty meters above it and also in the upper 200 meters of the oceans and seas. Biosphere of the earth evolved about three billion years ago.

9.1.1 Ecosystem and Its Components

The word environment has been derived from the French word "environ" meaning "encircle" so with reference to life on this planet, all the things encircling human beings and other living things are called environment. Since biosphere is part of lithosphere and atmosphere, therefore everything in earth's spheres which surround living beings makes environment. These include physical, chemical and biological factors. To describe it in more inclusive terms, "environment is the sum of all elements, factors and conditions which may have an impact on the development or survival of living and non living things or organism".

All the needs of and requirements of every living organism are met/fulfilled from their environment. Therefore the knowledge of environment is important for the existence and survival of every living organism.

Environment means everything which exists around us and which can influence us in any way. It includes components of lithosphere, hydrosphere and biosphere.

If you look around, you will realize that there are factors and elements in the environment which are naturally present For example, forests, rivers, oceans soil, air, sun and its energy, wildlife, weather and man himself. There are also a number of things which man has added in the environment for his comfort For example, buildings, gardens, factories, industries, alternate energy resources such as electric light, machines, cultivated crops and new varieties of plants etc.

We can say that environment may be natural or artificial. When we refer to the environmental problems we mean natural environment. Unfortunately, improper and unwise interventions in the natural environment have caused its deterioration and disturbance in the earth's systems.

As we know human being are the most important and the most intelligent creatures that almighty Allah has created. Over the past two centuries there has been an unprecedented growth and development in science and technology. Man has not only extended his reach to the vastness of the universe to the depths of the oceans but has also molded and modified natural environment to best suit his needs and requirements. Industrialization and development of new communication technologies have brought a revolution in life style. Unfortunately all this development of human societies has caused more harm than benefit to the natural environment. Besides human activities, exponential increase in human population is also one of the major causes of environmental deterioration. Overpopulation causes deterioration of the natural environment in a number of ways. As the human population increases in size waste products accumulate and natural system of disposal of waste is disturbed.

There is a complex relationship between population size and environmental change. Increasing population affects environment in a number of ways. Population is continuously increasing however there is no increase in the available land nor is there any increase in the natural resources such as land, drinking water, and forests. Decrease in the land available for farming affect the food production. Similarly, population growth increases the demand for drinking water. It has been estimated that between 1900 and

1995 water consumption has increased six fold which is more than double the rate of population growth.

Developments in technology have affected the energy use which has serious consequences for the quality of environment. With the technological development the consumption of energy resources such as oil, natural gas, and coal has increased. Due to industrialization the use of natural energy resources has increased along with parallel increase in addition of harmful gases and other industrial wastes in the environment. Addition of harmful gases in the environment is adversely affecting the atmosphere of the earth. You might have read or heard about global warming. The term “global warming” refers to the observed and projected increases in the average temperature of Earth's atmosphere and oceans. According to scientists, during the 20th century, the Earth's average temperature has increased by about 0.6° Celsius (1.1° Fahrenheit).

Consumption of natural resources also plays an important role in straining the environment. Due to overpopulation and unwise use and waste of natural resources, for example, waters and energy, our present human race and our future generation is running short of natural resources which are crucial for survival of life on this earth. As you may have concluded from this discussion, the quality of environment has badly deteriorated over the past century. “Environmental quality is a set of properties and characteristics of the environment, either generalized or local, as they impinge on human beings and other organisms. It is a measure of the condition of an environment relative to the requirements of one or more species and or to any human need or purpose”.

Environmental quality means the set of natural environmental conditions without interference of human activities.

Thus the environmental quality has been degraded by the following main factors.

- Rapid increase in human population
- Industrialization and advancement in technology
- Increase in waste products

If the aforementioned factors were not controlled, the living organism like plants, animals etc. would be unable to adapt to polluted environment therefore, it is the need of the hour to give proper consideration and keep care of environmental resources which cannot be reproduced or regenerated easily if once utilized. The supply of non-renewable resources is running short for example, fossil fuels which include coal petroleum, natural gas etc. Various minerals and metals are also included in non-renewable resources. Modern man is using these resources very rapidly and these resources may be depleted very soon. Now it is a dire need of the have to take practical steps to save our natural resources. We should realize the future time when all of its natural resources will be utilized and the survival of this human population will be endangered.

From the previous section you have learned that Earth's environment is composed of two major types of factors or elements: living factors i.e. animals and plants and non-living factors which include air, water, soil, energy etc. These are called biotic and a -biotic factors respectively. You also know that living things draw all their basic needs from the environment. A-biotic factors such as air, water, soil all play a very important role in sustaining life. Living and non-living factors of the environment constantly interact with each other forming a complex system which is termed as ecosystem. The term ecosystem was first introduced by Roy Clapham in 1930 and according to him "the sum total of physical and biological components of an environment makes the ecosystem".

"A unit area in which living and non living organisms interacts and influence upon each other is called an Ecosystem".

This unit area could be a pond, a stream, or a forest. It means that on this Earth a number of ecosystems exist. Combination of many ecosystems on earth forms the global ecosystem which is called "Ecosphere". A particular ecosystem of a region is also called as biome. Before studying about the ecosystem in detail, we should study some basic concepts regarding ecosystems.

1. Population

You are familiar with the term "population. Generally we use the term to mean a group of people living in an area, For example, population of Pakistan. When used with reference to ecosystem it means group of organisms of same kind which live in a specific place and reproduce their own kind. A group of organisms of same kind which can interbreed and reproduce fertile offspring is called a "species "So we can define population as:

A population is a group of individuals of the same species living together in a specific set of environment.

A population comprises all the individuals of a given species in a specific area or region at a certain time.

2. Community

The term community is used in more than one meaning. When used in sociological terms with reference to human beings, it means "group of interacting people, living in the same space and time. However, in biological terms, a community means a group of interacting living organisms sharing a populated environment. It means that unlike population a community includes individuals of different species living in a common place.

3. Biosphere

In the previous section you have read about the biosphere that it is the space on earth occupied by living organisms. It could be a part of lithosphere, atmosphere and hydrosphere.

Thus biosphere includes all form of life on the earth e.g. plants, animals and micro organisms etc. Biosphere is supported by nonliving environment. Every organism within the biosphere affects the life of other organism directly or indirectly, e.g. man cannot continue to live without the green plants which are a source of food and other basic needs of man. The green plants also depend on bacteria which convert dead bodies of plants and animals into inorganic form so that plants can absorb them and manufacture their food. Biosphere is a system comprising of many interacting components. This interaction is in the form of exchange of materials between living and non living components of the environment. The materials added to the environment are again used by the living things. Waste materials excreted by the living organisms e.g. carbon dioxide, urea etc. and dead organisms become a part of the non-living environment. There is a constant exchange of materials between living and nonliving environment. This exchange of materials between biotic and abiotic factors creates a balance in the natural environment. The harmful materials do not exceed a certain level and there is also a constant supply of materials needed by the living organisms due to natural systems of recycling of materials in the environment. Thus biosphere is a system of natural checks and balances.

Unfortunately man through his activities is destroying the natural balance of the environment. So there is a dire need to develop some strategies to save the quality of environment in biosphere.

4. Habitat

Different types of animals and plants occupy particular spaces in the environment. For example, termites live in soil or wood, similarly fish lives in water. There are different kinds of fish some live in sea, others are found in fresh water while there are some which are found in rivers. So we can say that organisms live in particular places with particular set of environmental conditions, these places are termed as “habitat”. Like many scientific terms, “habitat” is a Latin word meaning "it inhabits”. It means:

“An environmental area that is inhabited by a particular species of animal, plant or other type or organism” or it is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population.

SOURCE: http://en.wikipedia.org/wiki/Habitat

Several populations may share a habitat. For example,, in a small pond several aquatic populations may live in the same water at the same time. An aquarium is a good example of a shared habitat. Habitat is named after a specific characteristic of habitat or any other particular character. Examples of habitats include stream habitat, fresh water habitat, and marine habitat. In the above mentioned examples stream, fresh water ponds and marine water are prominent features that is why habitats have been named after them. The size of the habitat depends on the kind of organism livings there, e.g. the habitat of a frog may be a shady place near the bank of a pond. Likewise the habitat of pine trees may be pine forests spread on a vast area.

5. Biomes

Biomes are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment" (Campbell).

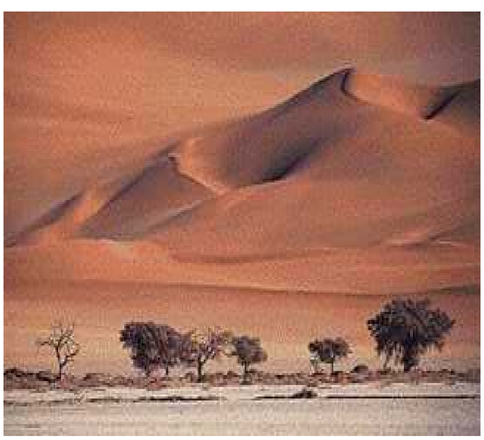
A biome is a large geographical area of distinctive plant and animal groups, which are adapted to that particular environment. The climate and geography of a region determines what type of biome can exist in that region. Major biomes include deserts, forests, grasslands, tundra, and several types of aquatic environments. Each biome consists of many ecosystems whose communities have adapted to the small differences in climate and the environment inside the biome.

6. Ecosystem

Living organism depends on each other and also influences living as well as non living components of the environment within a specific habitat. For example, green plants manufacture food by the process of photosynthesis which animals cannot do. So the animals depend on green plants for their food. Likewise plants depend on soil for the absorption of minerals. Moreover green plants obtain gases from the atmosphere through stomata. Living organisms also interact with their physical environment for example, light, temperature and water. This interaction of organism with their environment is called as ecological system or ecosystem.

A natural unit area, in which living and non living organisms interact and influence each other, is called on ecosystem.

Ecosystems can be as small as a puddle or as large as the Earth itself.



Desert is a large ecosystem

Lotus lake in Islamabad is a small ecosystem

Fig.1 Two different ecosystems

Ecosystem has the following properties and characteristics:
Ecosystems always maintain a balance. Whenever there is any change, ecosystems have the ability to adjust themselves in new ecological conditions to some extent.

Different types of cycles operate in ecosystem such as carbon-Hydrogen-Oxygen cycle, phosphorous and Nitrogen cycle etc.

There is an energy flow in ecosystems whose source is sun. Solar energy maintains life in ecosystems. Ecosystems are self running systems.

Factors of Ecosystem

Like other systems, ecosystem is also composed of interconnected factors. Functions of various factors of ecosystem are dependent on each other and influence each other. Basically ecosystems are composed of two kinds of components (i) Abiotic component and (ii) Biotic component.

Abiotic (A means = none and biotic means living) All the non-living factors that directly or indirectly influence the existence of living organisms in an ecosystem are the abiotic factors. Abiotic components include factors such as light, temperature, water, atmosphere, soil, topography and inorganic nutrients. These abiotic factors are very important for sustaining and maintaining life on this planet.

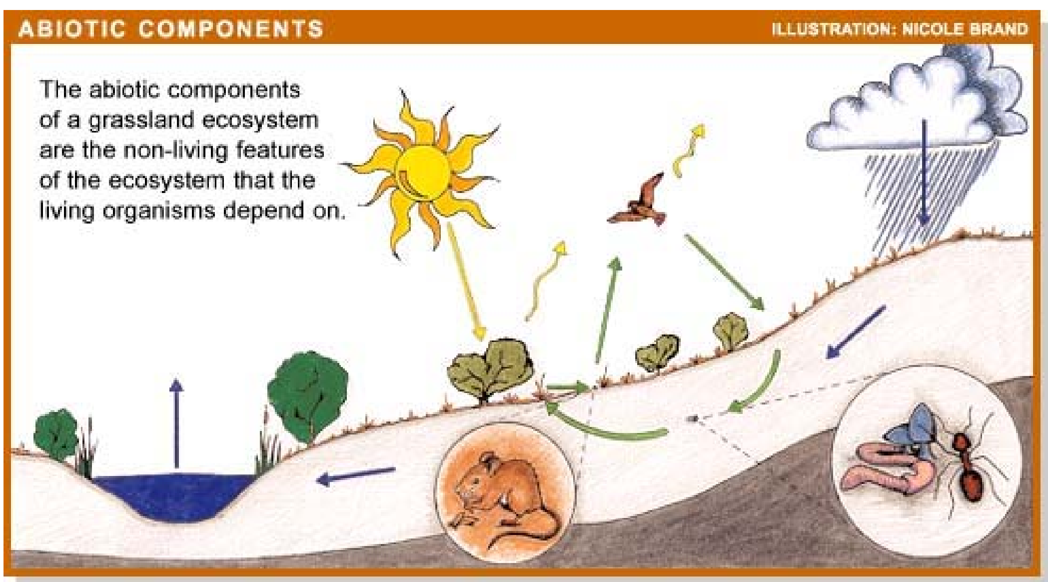


Fig. 2 Abiotic Factors

Biotic or biological components of ecosystem consist of all living part of ecosystem like plants, animals and decomposers. The examples of natural ecosystem are ponds, lakes, oceans, and forests etc. there may be artificial ecosystems e.g. cities, towns etc.

Abiotic	Biotic
Light, Temperature, Water, Atmosphere and wind, Fire, Soil, Gravity, Topography, Inorganic nutrients	Producers (Green Plants, Consumers(Animals & non-green plants, decomposers (Bacteria and Fungi)

Table 9.1 Factors of ecosystem

9.1.2 Abiotic (physical) Components of Ecosystem

Abiotic components of ecosystem play vital roles in the establishment of an ecosystem. A brief description of these abiotic components is as follow:

1. Light

The visible part of solar radiation is called light. Light is very important for existence of life in biosphere. It is the primary source of energy for all kinds of ecosystems on earth. We can safely say that "No life without light". Plants use light to convert Co_2 and H_2O into glucose. So the light energy is converted into green plants food. The rest of the living organisms in the biosphere directly or indirectly consume green plants as food for energy.

To understand why sun's light energy is essential to sustain ecosystems, carefully study the figure and try to follow the flow of energy in the ecosystem. From the sun, energy is captured by plants to prepare their food. Animals eat green plants. These animals are in turn are food for meat eaters or carnivores. When plants and animals die, organisms like crows, vulture, beetles, and microorganisms like bacteria, consume the dead bodies.

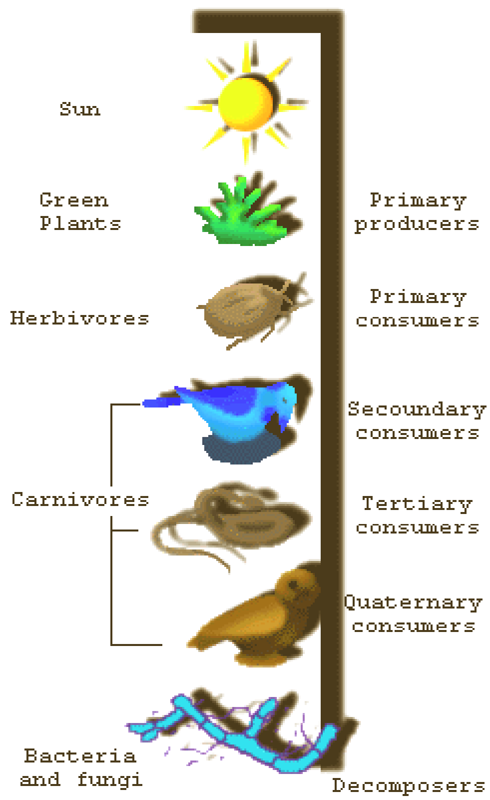


Fig.3 Flow of energy in ecosystem

This is how energy transfers from its primary source that is sun to all life in the ecosystem.

Three characteristics of light affect the ecosystem: i) quality of light, ii) intensity of light, and duration of light.

i. Quality of Light

Light comes from sun to earth in the form of rays. The visible light has seven colors, whose wavelength ranges from 390 nm to 760 nm. Blue and red light is important for plants to perform photosynthesis.

Activity 1

Take a prism. Place a white paper in front of prism place, the prism parallel to the sunrays, so that light may pass through it. Observe different colours of light formed on white paper. Enlist your observations in a notebook and share discuss with your tutor.

ii. Intensity of Light

Second is the "intensity of light", which directly affect the living organism. For example, chlorophyll does not develop fully in plants growing in shady places. That is why leaves become pale in absence of light.

Intensity of light that is how strong the light is affects the living organisms, particularly the plants which use light energy to manufacture their food. You may have noticed that when the leaves of the plants are placed under shade for a long period their leaves turn pale or yellow. The green substance or chlorophyll, present in the green parts of the plant, needs sunlight to develop. When there is less light it does not develop fully therefore the leaves turn yellow. As you may know in shady places light intensity is less than in the open areas.

iii. Duration of light

The duration for which plants and animals are exposed to sunlight also affects plants as well as many animals. You are aware that in summer, days are longer hence sunlight is available for longer period than in the winters. The production of flowers, fruits new leaves and growth all are dependent on relative day lengths, likewise hibernation or winter sleep in cold blooded animals (e.g. snakes), migration of birds from one place to the other and reproduction etc. all depend on duration for which sunlight is available which in turn is dependent upon relative day lengths.

If you are interested in birds you might have heard or noticed that many new birds start arriving in Pakistan in October and November and stay with us till March when the weather is mild. These are migratory birds which migrate to Pakistan to escape harsh cold in Russia and China. Sometimes they travel more than 4,500 kilometers from their original habitat. Cranes, ducks-mallards, common pochards, common teal, northern pintail, northern shoveler, cormorant, snipes, stints, plovers, gulls and score of other birds fly to Pakistan every winter. Bears go to sleep during winters

Fig. 4Effect of duration of light on different animals

Activity 2

Observe the birds in your area during winter and summer and make notes of the types of birds you see during different seasons. Find out if there are some birds which visit your area only during a particular season. You can also ask the farmers and gardeners of your area about their observations in this regard.

2. Temperature

The measurement of intensity of heat is called temperature. Different scales are used for the measurement of temperature. Celsius or centigrade and Fahrenheit scales are the most commonly used scales. Temperature affects the growth and distribution of organisms in ecosystems. Most of the living organisms in the biosphere carry out their physiological activities within a temperature range of $0C^o$ to $50C^o$. The optimum temperature range for life is $15C^o$-$35C^o$. Organism have various adaptations to overcome extremes of temperature. For example,, the deserts plants have very long roots that reach deep into the ground for underground supplies of water. Most other plants have evolved large root systems that lie close to the ground surface. Roots are then close to the water when it rains and can absorb the moisture in the soil surface before it evaporates under the desert sun. Their leaves have small area to reduce evaporation of water i.e. transpiration. Most plants stop growing at temperature below $6C^o$. Similarly rate of metabolism in animals decreases at low temperature and animals become lazy and slow.

3. Water

Water is essential for life in any ecosystem. Life is impossible without water. It is found in abundance in aquatic ecosystem while very little water is present in deserts and on mountain tops. Water is also present in the atmosphere in a very limited amount. Water circulates in the biosphere by three processes i.e. rainfall, evaporation and transpiration. Water possesses some very unique properties due to which it is one of the most important life - supporting bio-molecule. First of all it is best solvent; it provides a fluid material for various reactions to occur.

4. Atmosphere and Wind

Atmosphere or air is a gaseous envelope surrounding our earth. Air or atmosphere in motion is called wind. Atmosphere and wind are very important in maintaining life in the ecosystems. The important gases in the atmosphere are nitrogen, oxygen, carbon dioxide and water vapors. The relative concentrations of these gases have been given in table 9.2.

Gases	Percentage in atmosphere
Nitrogen	78-79%
Oxygen	21%
Argon	0.934%
Carbon Dioxide	0.03-0.04%
Other gases	0.003%

Table 9.2: The concentrations of various gases in the atmosphere.

Another important constituent of atmosphere is water vapors. Water vapors are released into atmosphere by transpiration in plants and evaporation. The amount of water vapors in the atmosphere determines the amount of rainfall in different ecosystems.

5. Fire

We often hear about the fire outbreaks in natural forests. Forest fire is regarded as a natural ecological factor of the environment. Fire affects include physical, chemical, and biological impacts on ecosystem resources and the environment. The effects of fire on abiotic factors include changes in air and water quality, soil properties etc. It also effect biotic factors i.e. plants and animals. It can alter vegetation which in turn will affect wildlife. The particular effect of fire on any one of these components (e.g., the fire severity) is not fixed, but will vary according to site characteristics and fire behaviour. For example, the effects of a fire burning under the same conditions may be very different on soils of different textures. Likewise, the effects of fires burning under different fuel and weather conditions can be very different on similar soils.

There are three requirements for fire.

i. Presence of dry organic matter.
ii. Dry environmental condition and
iii. Source of fire

Source may be natural lightning or man- made fires are also frequent, especially in grasslands fires are made to eliminate dry organic matter. Fire in an ecosystem has unpredictable results. However it is not always fatal. It is an important regulatory and decomposing agent. Fire eliminates certain unwanted species of plants and favoring survival of others. Following are the role of fire in an ecosystem:

In dry and hot regions the dead parts of the plants are too dry for decomposers to act on them. If these plants catch fire the nutrients are released and become part of the soil. The gases which result from burning are added to air thus it increases productivity by increasing fertility of the soil.

Fire promotes life cycle of many plants. For example, the seeds of some species of pine are only released out of their cones by fires. In this way it is the fire which starts their life cycle.

Some time fire results in selective destruction, destroying some species while leaving the others. If the fire destroys unwanted weeds and leave the beneficial then it helps in natural management of the forest.

Periodic and controlled fire has good effects on animals and plants. It plays a significant role in shaping the distribution and composition of much of plants and animals. Many species develop specific mechanisms to survive periodic fire; some even depend on it for critical life stages. It also causes migration of some animals.

6. Gravity

Gravity is an ecological factor which remains unchanged throughout the biosphere. Gravity can be defined as under:

Gravity is a force with which earth attracts different objects towards its centre.

We often think that gravity is the force with which earth attracts everything towards its center but, actually it is the force of attraction which exists between any two bodies. It is proportional to their masses. We are all familiar that gravitation is the agent that gives weight to objects with mass and causes them to fall to the ground when dropped. It is due to this force of attraction that dispersed matter fuses, and fused matter stays fused. The existence of the Earth, the Sun, and most of the macroscopic objects in the universe is due to the force of gravity. Hence you can imagine that it is a very important abiotic factor of the ecosystem.

Both animals and plants are affected by gravity and respond to this force in different ways. Response of plants to gravity is termed as geotropism. For example, the gravity affects the growth of roots and shoots. Roots grow towards gravity, so are said to be positively geotropic. The shoots grow away from gravity hence are negatively geotropic. The force of gravity pulls everything to overcome this pull or force objects need energy. Plants and animals have developed certain adaptations for gravity. In plants shoots grow upward i.e. away from the gravity. In order to supply water to its upright branches and stem plants have to transport water against the gravity. To solve this problem a special system of vessels have evolved in plants to conduct water and minerals from soil to arial parts of plants, it is called xylem tissue. Roots are positively geotropic and shoots are negatively geotropic.

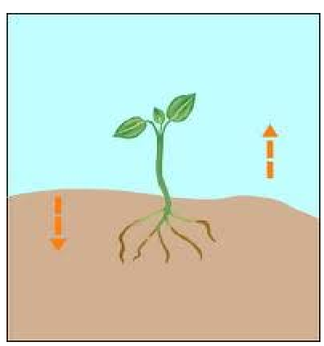


Fig.5: Geotropism in plants

Birds have forelimbs modified into wings to fly against gravity while vertebrates have vertebral column as an adaptation. It helps them to rise above the ground which is a movement against the gravity.

7. Topography

Topography is the study of surface, shape and features of the Earth and other observable heavenly objects including planets, moons, and asteroids. It is also the description of such surface shapes and features (especially their depiction in maps). The surface of the earth is not uniform at all places. In certain parts mountains are present, while there are low level sites in some other parts. Topography i.e. the features of earth surface, has indirect influence on the organisms. It affects the other abiotic factors such as climate, temperature etc. which in turn affect biotic components of the ecosystem. For example, with the increase in altitude the temperature decreases, wind velocity and intensity of sun rays increase at high altitude. These conditions enhance the atmospheric moisture and result in increased amount of rain fall. Steepness of slopes affects drainage and stability of soil. Soil is instable on steeper slopes, so stable plants communities do not develop. It means the erosion is greater on steeper slopes. Less steep slopes support more communities of organisms.

8. Soil

Soil is the uppermost layer of earth's crust. Factors such as water, ice, snow; wind and gravity break and disintegrate the rocks into soil.

Weathering is a set of physical, chemical and biological processes that change the physical and chemical state of rocks and soil at or near the earth's surface. Rock and soil is altered physically by disintegrating and chemically by decomposing.

The importance of soil in the ecosystem can be judged by the fact that all terrestrial plants and animals live on soil. All plants which have economic value grow on soil. Soil particles consist of sand, silt and clay. Loam is regarded as the best soil for plant growth. Loam is soil which has equal amounts of humus and soil particles.

Soil is formed through disintegrated of rocks. Soil is formed when factors such as water, chemicals, cold, and heat act on rocks over a long period of time and disintegrate them into soil. However this process is very slow and takes a very long time. There are two types of layers of the soil:

i. Top soil and ii. Subsoil.

i. Top Soil

Top soil is the surface soil which contains humus. Humus is organic matter formed from decay of dead plants and animal. It contains nutrients which are required for the plant growth.

ii. Sub Soil

It is located below the top soil. It is much thicker as compared to the top soil. It plays the following roles in maintaining life on biosphere; all plants whether trees, shrubs or herbs are rooted in the soil.

Soil provides water and mineral to plants. It provides oxygen to roots of plants and other animals living in the soil. Soil supports the life of a number of soil organisms like bacteria, fungi, algae, lichens, and a number of animals.

You can imagine how any deterioration in the quality of soil will affect the organisms, including man, for which soil is a habitat and a source of food.

9. Inorganic Nutrients

These includes various mineral nutrients like Calcium, Magnesium, Phosphorous, potassium, sulfur, and molecules like water, carbon dioxide etc. Usually these are present in solutions form in aquatic ecosystems. But in terrestrial ecosystem they are found stored in rocks. From rocks they are released slowly by weathering of rocks. Their presence or absence affects the efficiency of ecosystem greatly.

9.1.3 Biotic (Biological) Components of Ecosystem

Biotic components i.e. living organisms have different roles in the ecosystem and on the basis of their roles they have been classified into three groups:

1. Producers
2. Consumers
3. Decomposers

The detail of each classified group is as follows:

1. Producers

In any ecosystem sun is the main source of energy. Green plants use this energy to prepare their food thus convert the sun's energy into food energy. The green plants prepare food by CO_2 and water in the presence of sunlight this process is called photosynthesis. Green plants perform the function of production of food which is used by all other living organisms directly or indirectly. Therefore, green plants are called producers. Another term used for green plants is "autotrophs", (auto=self, troph=food) i.e. organisms which prepare their own food.

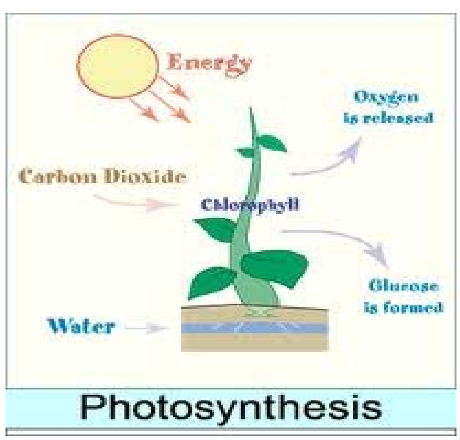


Fig. 6: Photosynthesis

Aquatic plants usually float on the surface of water or are present submerged in water. But terrestrial plants are usually rooted in the soil. Aquatic unicellular plants which float on the surface of water are called as phytoplankton (phyto= plant, plankton= swimming). The carbohydrates which are prepared by green plants are mostly used in their growth and respiration. The leftover food is used by other living organisms.

2. Consumers

The term consumers mean all those non green plants and animals which obtain food from green plants i.e. they only consume food they do not make it. Animals, fungi and some parasitic plants are consumers which lack chlorophyll in their cells and hence cannot prepare their food by photosynthesis. All the consumers are heterotrophy. (Hetero= other, troph= food) i.e. they obtain their food from others). There are various kinds of consumers depending upon the method of getting food.

i. Primary Consumers

They are also called as herbivores, because they utilize the plant parts directly e.g. cattle, rabbits etc. major consumers in terrestrial habitat are insects, rodents, (rats, squirrels). Cattle (goat, sheep, cow, buffalo), while in the aquatic habitat these are small crustaceans (a type of arthropods) mollusks and some fishes.

ii. Secondary Consumers

They are also known as carnivores. The secondary consumers use the flesh of herbivores as their food. Examples are dog, lion, tiger etc.

iii. Omnivores

Some animals use both plants and animals as their food. These are called as omnivores. For example, human beings, crow etc.

iv. Parasites

The organisms which derive their food from other living plants and animals are called parasites. Likewise scavengers which feed on dead animals are also regarded as consumers e.g. vultures, mushrooms etc. are few examples.

3. Decomposers

Decompose to breakdown complex compounds into simple substances. The Organism which break down or decompose the complex organic compounds of dead plants and animals into simple substances are called decomposers. The decomposers derive energy from the process of breakdown of complex organic compounds.

The inorganic substances produced by decomposition are again utilized by green plants during photosynthesis and other biochemical process. Thus the cycling of materials continues in the ecosystems chief decomposers in the ecosystem are bacteria and fungi. The action of decomposers is vital because if it did not occur, all the nutrients would remain blocked in dead bodies and no life would be produced. Temperature has marked influence on the rate of decomposition. In colder climate the rate is slower while in hot climate the rate is very rapid.

Key Points

1. Environment means everything which exists around us and which can influence us in any way. It includes components of lithosphere, hydrosphere and biosphere.
2. Environmental quality means the set of natural environmental conditions without interference of human activities.
3. A unit area in which living and non living organisms interacts and influence upon each other is called an Ecosystem.
4. A population is a group of individuals of the same species living together in a specific set of environment.
5. Scientists have classified the different areas of earth into four inter-connected geo-spheres: Atmosphere, lithosphere, Hydrosphere and Biosphere.
6. The atmosphere is a layer of air which surrounds the whole earth.
7. Hydrosphere includes all the water mass on or near the earth.
8. Lithosphere is the solid, rocky cover or crust of the earth.
9. Biosphere is that part of the lithosphere, hydrosphere and atmosphere in which life can exist.
10. "Habitat" is a Latin word meaning it inhabits.
11. A community means a group of interacting living organisms sharing a populated environment.
12. Ecosystems are composed of two kinds of components (i) Abiotic component and (ii) Biotic component.
13. All the non-living factors that directly or indirectly influence the existence of living organisms in an ecosystem are the aboitic factors.
14. Biotic or biological components of ecosystem consist of all living part of ecosystem like plants, animals and decomposers.
15. Abiotic factors include, air, water, soil, fire, light, gravity, and topography.
16. Biotic factors include all living organisms.
17. Quality, intensity, and duration of light affect both plant and animal life.
18. Forest fire is a natural ecological factor of the environment. It affects all other factors of ecosystem i.e. physical, chemical, and biological factors as well as resources and the environment in general.
19. Temperature affects the growth and distribution of organisms in ecosystems. Most of the living organisms in the biosphere carry out their physiological activities within a temperature range of $0C^{o}$ to $50C^{o}$. The optimum temperature range for life is $15C^{o}$-$35C^{o}$.

Self Assessment Exercise 9.1

1. Define Environment.
2. What is meant by environmental quality?
3. Do you know what factor has caused degradation of environmental quality?
4. What is the difference between renewable and non-renewable environmental resources?
5. Enlist some of the important renewable environmental resources.
6. Enlist the major components of earth's system.
7. Describe biosphere.
8. Define habitat.
9. What is the criterion of naming a habitat?
10. Which factor or factors determine the size of habitat?
11. Define ecosystem.
12. What are the major basic components of ecosystem?
13. What is the range of wavelength of visible light?
14. What is the range of temperature for organism in which they can service?
15. Which factor produces sudden change in ecosystem?
16. What is the importance of soil in terrestrial ecosystem?
17. Which soil is the best for plant growth?
18. Give examples of the following:
    a. Herbivores b. Decomposers c. Omnivores
19. What is the effect of temperature on decomposition?
20. Define phytoplankton.
21. What is the importance of decomposition in ecosystem?
22. Define autotrophs and heterotrophs.

9.2 Energy Flow in Ecosystem

For the biosphere sun is the ultimate source of energy for all type of reactions taking place in the ecosystem. Animals in any ecosystem cannot utilize solar energy as green plant does. The reason for this fact is that the green plant possesses necessary apparatus chloroplast for the capture of light in the form of Glucose. The chlorophyll and related pigments are responsible for entrapping light energy by which green plants manufacture their food. Thus light energy is converted into chemical energy.

Then this chemical energy of food is transferred from plant to animals. Because this transfer of energy follows a straight path i.e. from green plants to animal and finally to decomposers which derive some chemical energy by decomposing dead organic matter of plants and animals. So this flow of energy is strictly unidirectional. Up to 2% of total solar radiation is absorbed by green plants and is converted into chemical energy of food. Some part of this food is utilized by green plants themselves in their respiration. During respiration energy is released which is mostly stored in the cells in the form of ATP while some part of this energy is lost as heat.

When this food is transferred to animals it is again degraded in the cells during respiration. In this process energy is also released but overall amount of energy available to animals is less as compared to plants. The reason for this is that most part of the energy is lost during transfer from plants to animals. The flow of energy can be explained on this basis of two laws of thermo dynamics. According to first law of conservation of energy, energy can neither be created nor destroyed but it can be converted from one form to the other. As already discussed light energy is captured by green plants and converted into food energy through photosynthesis. Most of the solar energy i.e. 98% is not used by green plants and thus goes waste, only 25% of absorbed solar energy is used in photosynthesis. The food synthesized by green plants during photosynthesis is called as gross production. Some part of the gross production is used in respiration to get energy. Food energy stored in green plants after utilization in respiration is called as net production. Net production comprises 40% of the total gross production. Thus gross production can be presented as flows.

Gross Production = Net production + Respiration
Net production = Gross production – Respiration

When herbivores eat green plants food energy saved in the form of net production is transferred to herbivores then it is transferred to carnivores and so on.

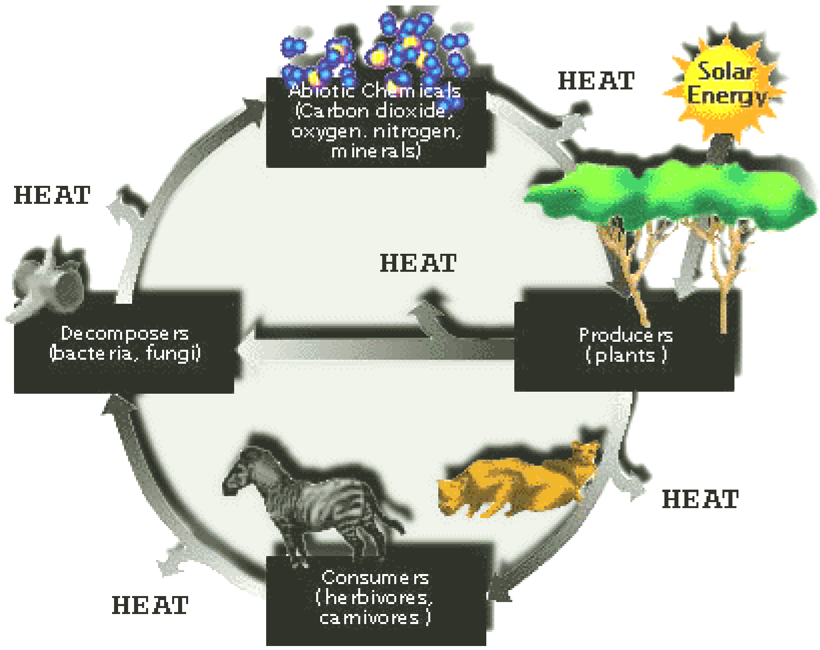


Fig.7: Energy Flow in Ecosystem

http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/ecosystem/ecosystem.html

There is a gradual decrease of energy at every transfer from one organism to the other because at each stage organism will use some of the food for growth, movement, and reproduction. It means that amount of available energy decreases at every energy transfer. Thus net production is the form of energy available to all heterotrophic plants and animals, by which they prepare biomass of their bodies.

Biomass' is the amount of living or organic matter present in an organism. In an ecosystem biomass refers to the total amount of living matter present in the organisms at each trophic level. All the living matter present in living plant and animals is known biomass.

The energy loss at each transfer from one organism to the other is according to second law of thermodynamics which states that "there can be no transformation of energy unless there is some loss of energy in the form of heat energy".

The total food energy obtained by herbivores will be gross production at herbivores' level. Some part of this food energy is used by herbivores in their respiration to perform life activities. Food energy stored in herbivores other than used in respiration is called as net production at herbivore level. Only about 10 percent of net plant production comprises the net herbivore production. When energy transferred to carnivores there is further decrease in available energy.

9.2.1 Food Chains and Food Webs

As you know from previous sections, biotic components of the ecosystem include: producers, consumers and decomposers. Producers capture sun's energy and make their food, consumers use green plants and other organisms as their food, decomposers live on dead bodies of plants and animals. In this way a chain of energy flow is established. It is called food chain. Food chain can be defined as.

The series of organisms through which food energy moves with repeated stage of eating and being eaten is called as food chain.

The food chain is the route through which energy in the form of food is transferred from producers to herbivores, then to carnivores and finally to decomposers. The pattern of energy flow can be outline as flows:

Producers ⟹ Herbivores ⟹ Carnivores ⟹ Decomposers

Food chains may be of following types:

1. **Parasitic Food Chain**
   In this food chain energy flows from hosts to parasites many types of bacteria, fungi, protozoan, nematodes and some flowering plants are parasites.

2. **Saprophytic Food Chain**
   Saprophytes are the organisms that feed on dead organic matter. For example, mushrooms. In this type of food chain energy flows from dead organic matter to decomposers, like bacteria and fungi.

3. **Grazing Food Chain**
   This type of food chain is found in land conditions and food energy is transferred from green plants to large animals, including man in aquatic environment it may consist of algae ⟶ water fleas ⟶ small fishes ⟶ large fishes ⟶ man in grassland. This food chain may be as follows:

In the above mentioned examples arrows indicate the direction of flow of food energy.

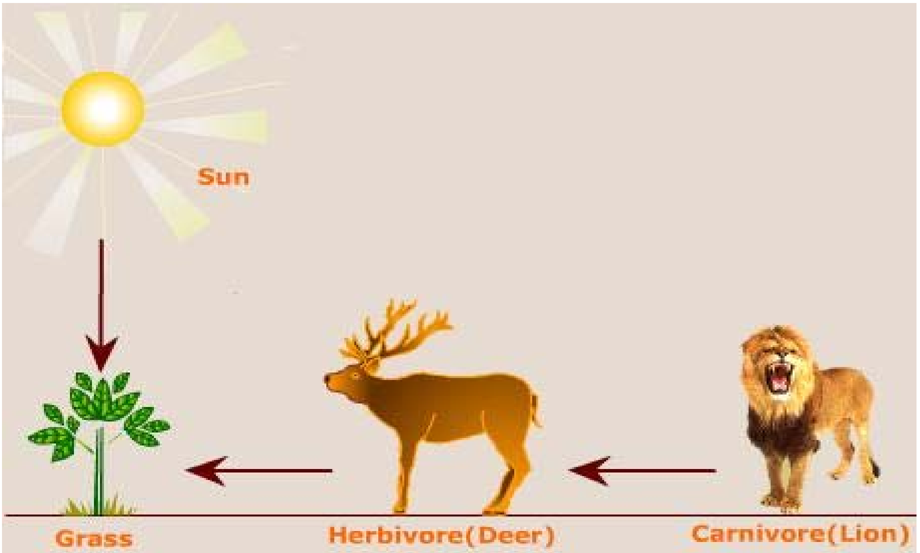


Fig. 8: Grazing Food chain

A simple food chain. Arrows indicate flow of energy from sun to green plants, to herbivore and then to carnivores.

Trophic Levels in a Food Chain

In the above description of food chains you may have noticed that in each food chain there are a number of levels of energy transfer. For example, the first level is of green plants which capture the sun's energy, then second level is of organisms which eat green plants i.e. herbivores, at the third level are meat eaters or carnivores i.e. the organisms which derive their energy from herbivores.

In a natural community each level in the food chain is called as trophic level

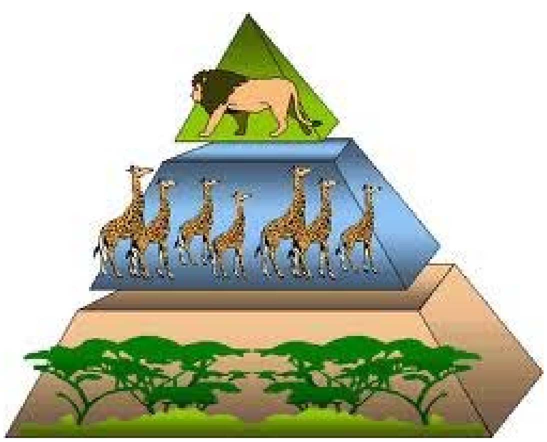


Fig. 9: Trophic levels in a food chain

The green plants constitute the first trophic level called as producer level. Herbivores are second trophic level or primary consumer level. Carnivores that eat herbivores are at the third trophic level or secondary consumer level. Thus there may be more than one trophic level in a food chain.

Look at the above diagram of the trophic levels. Green plant is at the first trophic level their number is very large as compared to the organisms at the upper levels hence the trophic levels are presented in the form of a pyramid. A trophic pyramid or energy pyramid is a graphical representation designed to show the biomass or biomass productivity at each trophic level in a given ecosystem. Another type of ecological pyramid is used to refer to show the production of biomass at different trophic levels it is called productivity pyramid.

Food web

As you may have realized food chain represent a single path of energy transfer. The communities in n ecological system are self sustaining systems in which the energy flows through a number of interconnected food chains thus form a complex or network of energy flow. This complex or network is called food web. The food web is defined as.

A complex relationship formed by interconnecting and overlapping food chains in an ecosystem is called food web.

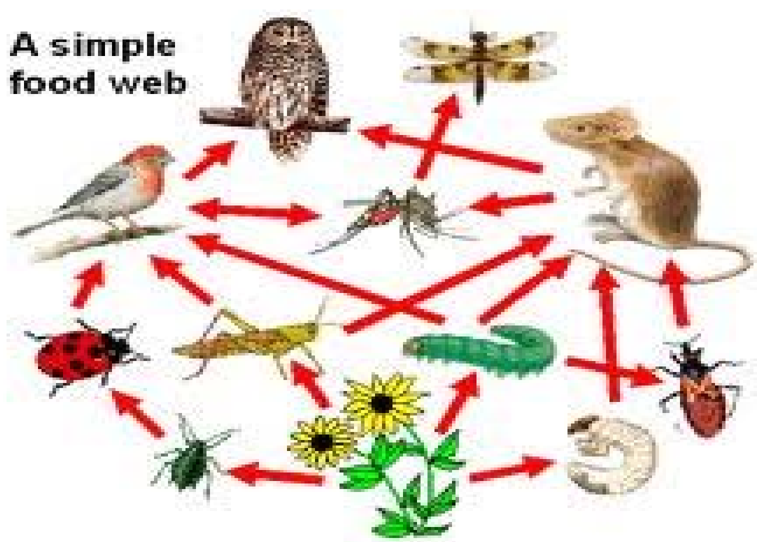


Fig.10: A simple Food Web

In complex communities there may be many alternate sources of food for herbivores and carnivores. The alternate sources of food in any ecosystem represent stability of an ecosystem. If there are more alternative food sources, the ecosystem will be more stable.

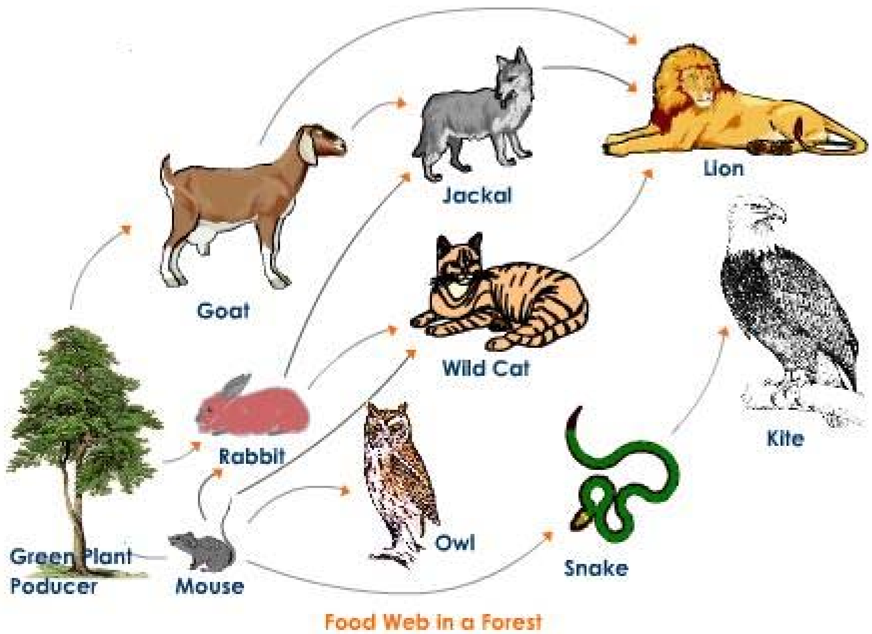


Fig. 11: Food web in forest

Key points

1. For all type of reactions taking place in the ecosystem, sun is the ultimate source of energy.
2. Food energy stored in green plants after utilization in respiration is called as net production.
3. The series of organisms through which food energy moves with repeated stage of eating and being eaten is called as food chain.
4. In a natural community each level in the food chain is called as trophic level.
5. A complex relationship formed by interconnecting and overlapping food chains in an ecosystem is called food web.
6. Biomass' is the amount of living or organic matter present in an organism. In an ecosystem biomass refers to the total amount of living matter present in the organisms at each trophic level. All the living matter present in living plant and animals is known biomass.
7. In a natural community each level in the food chain is called as trophic level.
8. A complex relationship formed by interconnecting and overlapping food chains in an ecosystem is called food web.

Self Assessment Exercise 9.2

Q.1 Answer the following questions:

i. What is meant by a food chain?

ii. How much solar radiation is absorbed by green plants?

iii. What is a food web?

Q.2 Complete the sentences with appropriate word or words.

a. A level of energy transfer in an ecosystem is called__________.

b. The organisms which consume dead organisms to obtain energy are called______.

c. The role of bacteria in the food chain is to__________________________.

d. When many food chains are interconnected they form a ____________.

e. If we consider the pyramid of trophic levels the green plants are at the____ of the pyramid.

f. Biomass is the ___________ in an ecosystem.

9.3 Types of Ecosystem

Ecosystem can be divided into two types:

1. Aquatic Ecosystem and
2. Terrestrial or Land Ecosystem

Here is the detail of each ecosystem:

1. Aquatic Ecosystem

Aquatic or water based ecosystem can further be classified into two categories:

i. Fresh water ecosystem
ii. Marine ecosystem

i. Freshwater Ecosystem

Freshwater ecosystem can further be divided into:

a. Standing water ecosystem
b. Running water ecosystem

The detail of fresh water categories is as follows:

a. Standing Water Ecosystem

Ecosystems of standing water include ponds and lakes. On the basis of depth of various parts of the lake or pond it is divided into three parts or zone: i) Littoral Zone, ii) Limnotic Zone, and iii) Profundal Zone

Different types of plants and animals are found in each type of the zone.

b. Running Water Ecosystem

Running water ecosystem is of two types:

- Fast or rapid flowing water
- Slow flowing water or pool

The bottom of running water is very important in determining the kind of organisms present there. There are some difference between the standing and running water bodies which are as follow.

- The water currents vary greatly in their velocity in various parts of some stream at different times. Standing water bodies have very few water currents.
- The stream is more closely associated with the surrounding land because in case of streams land water junction is larger than that of standing waters.
- Water in stream is usually shallow and has large exposed surface and is in constant motion as compared to ponds.

These three factors result in uniform distribution and abundant supply of oxygen. The stream or a canal makes a good example of rapids. The number and kinds of plants and animals in a stream, depends on the rapidity of waves in streams because organisms have to adjust themselves in rapidly flowing water. They have few adaptations in their bodies to remain at fixed positioning streams for examples plants are usually rooted in soil of bank while their stems are present in water. Few examples of plants are members of green algae like cladophora, diatoms, etc, stream animals are mostly present at the bottom. The producers and consumers of streams are very specific and support very few consumer communities. Due to shallowness the temperature of water stream shows wider fluctuations as compared to ponds. Moreover there is high oxygen concentration in streams that is why stream animals have a very narrow range of oxygen tolerance. Stream communities are also sensitive to water pollution. The examples of animals in streams are sponges, arthropods, mollusks. In pools or slow running water, various plants and animal are adapted to fix their positions due to running water Nekton and Burrowing animals are good examples of pool animals.

Activity 3

Visit to a bank of a pond or stream observe various types of plants and animals found there record your observations regarding their place and types in your note book and discuss with your tutor.

ii. Marine Ecosystem

An ocean serves as a very vast reservoir of life. Like ponds or lakes oceans have been divided into various zones depending upon availability of light, amount of nutrients, oxygen, temperature and depth. Each zone has its characteristic plants and animals.

Some animals are exclusively found in the sea for example, an interesting animal called chaetognath is found only in the sea. It has a very transparent body; these are commonly called sea worms. Echindermata is also a phylum of sea animals. Its name has been derived from a Greek word. “Echino” which means spiny and “derm” mean skin. Most but not all, of these animals have spiny skins. Animals such as star fish, sea star, and sea Urchins are some of the animals found in the sea. They have no left or right and like a cake cut into equal sized pieces, their body has many identical pieces which are joined, see the diagram of star fish. Usually echinoderms have five arms or rays, but there are some exceptions. Over 6,000 species of echinoderms have been found in the sea.

Marine animals belong to all phyla except amphibians, centipedes, millipedes and onchophora while ctenohora, chaetognaths, and brachiopods are exclusively found in oceans. The number of these animals is greater near water surface and their number decreases with increasing depth.

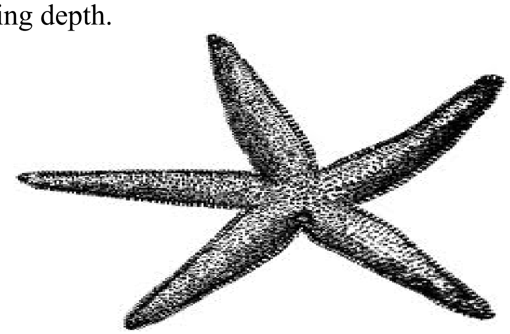


Fig.12: Star Fish: a type of echinoderm
Source: Starfish clip art, http://www.clker.com/clipart-13906.html

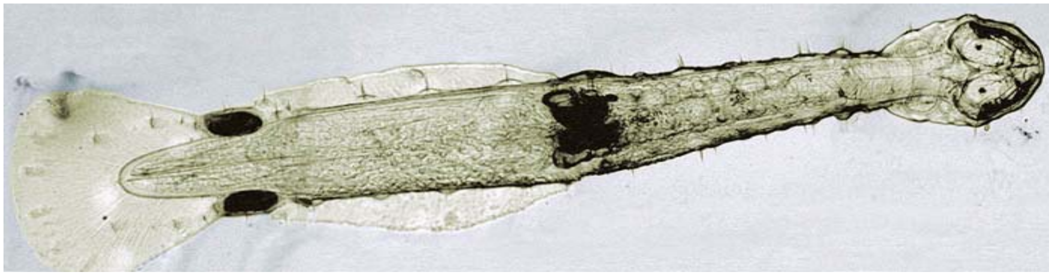


Fig. 13: The chaetognath

Source: Cavanihac,Jean-Marie. (1999). The chaetognath, a strange creature. France

http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/artjan00/chaet.html

2. Terrestrial or Land Ecosystem

The following are some of the major types of land ecosystem. These are also called as "Biomes" because these are affected by the local climate.

i. Forest Ecosystem
ii. Grassland Ecosystem
iii. Savanna Ecosystem
iv. Desert Ecosystem
v. Tundra Ecosystem

The detail of each terrestrial or land ecosystem.

i. Forest Ecosystem

The forest ecosystem can further be divided into following categories.

a. Tropical rain forest
b. Temperate deciduous forest
c. Coniferous forest

Here is the detail of each forest:

a. Tropical Rain Forest

The regions of the Earth surrounding the Equator are called tropics. The Equator is an imaginary line on the Earth's surface which divides the Earth into the Northern Hemisphere and Southern Hemisphere. It is at equal distance from the North Pole and South Pole. The tropical areas receive abundant rainfall therefore the forests are very thick and dense and are called tropical rain forests. Tropical rain forests have following features or characteristics.

- **Climate**

  These forests receive abundant rainfall, all the year round. The average annual rainfall exceeds 2000 mm. Temperature in general remains high which remains up to 40^0C during day time. Forests are very dense due to abundant water supply.

- **Location**

  On the world map these forests are spread between the tropics of cancer (it is the part on the globe which lies towards north above the equator) and tropic of Capricorn (it is the part on the globe which lies towards south below the equator). These forests are present in the countries like Indonesia, Malaysia, and Africa (around river Congo). In South America, tropical rain forests are present in basin of River Amazon (Brazil). The richness of vegetation can be estimated from the fact that in some parts of Brazilian rain forest, there are as many as 300 species of plants in 2sq-km area.

At many places forests are so thick that no one can enter. Light cannot reach the forest floor hence the plants even during the summer time so plants grow taller and taller to get light.

Activity 4

Get a globe and locate equator, tropics of cancer and Capricorn on it. Then note down what countries are located in these areas.

- **Producers and Consumers**

The plants of top storey or canopy are extremely dense. The canopy is the portion of a plant community or crop which is above the ground formed by plant crowns.

With reference to forests, the term canopy also refers to the upper layer or habitat zone, formed by mature tree crowns and including other biological organisms.
Due to very little light reaching the forest floor shade loving plants i.e. the plants which grow well under shade are in abundance in these forests. These plants are called sciophytes. Moreover there are many epiphytes in these forests. Epiphytes are the plants which grow on the surface of other plants.

The examples of epiphytes are some ferns, Lichens, certain mosses and orchids. There are many types of animals too e.g. tree frogs, pheasant, monkey, lemurs snakes, birds insects, rodents, deers and peccaries etc. Mostly animals live on trees and thus are called as arboreal animals.

Nutrient cycling is very rapid in these forests, because bacteria and fungi decompose the organic matter very rapidly. The productivity of the tropical forests is very high.

Productivity is the amount of carbohydrates prepared by green plants through the process of photosynthesis.

b. Temperate Deciduous Forests

The features of temperate deciduous forests are as follows:

- **Climate**

  Temperate deciduous forests are found in areas with abundant evenly distributed rainfall and moderate temperature. The average rain fall is about 750 to 1500mm. There is a distinct difference between summers and winters. Most areas of this forest have been affected by the activities of human beings.

- **Location**

  These forests are located in eastern North America, Europe, parts of Japan, China, Australia and Southern parts of South America.

- **Producers and Consumers**

  The number and quality of vegetation in temperate deciduous forest depends upon amount of rainfall which is variable in different parts of the world. Temperate conditions prevail in Shogran and Neelam Valley of Azad Kashmir in Pakistan. Common plants are pines and sanober.

c. Coniferous Forest

The prominent feature of these forests is the presence of plants belonging to gymnosperm group “conifers” (name given due to presence of cones as reproductive structures). There are two types of these forests.

i. Coniferous alpine forest
ii. Coniferous boreal forest

- **Location**

  These forests are found in North America and Eurasia just south of the tundra.

- **Climate**

  Temperature in these forests remains low throughout the year. The temperature may be as low as $10^{0}C$. The winter is long and severe with a constant cover of snow. The growing season is very brief as compared to temperate deciduous forest and lasts for 3-4 months

In Pakistan these forest are present in northern mountainous regions like upper reaches of Kaghan, Jaba valley in Swat, Dir and Chilas. As mentioned earlier there are two types of coniferous forest i.e. coniferous boreal forests and coniferous alpine forests.

Coniferous forest found at high altitudes (high mountains) are called coniferous alpine forest and those found at high latitudes are called as coniferous boreal forest.

- **Producers and Consumers**
  Major producers of this forest include deodar, cheer etc. Animals include snow leopards, black bears, Morcopolo sheep, and flying squirrels etc.

ii. Grassland Ecosystem

Grasslands are found at those places in the world where average annual rainfall is in the range of 250-270mm. Such amount of rainfall is insufficient for plant growth. More often there is severe drought in grasslands.

- **Location**
  Grasslands are found in temperate climates in the interiors of continents. Grasslands have been variously named in different regions of the world for example, prairies in North America, Pampas in Argentina, steppes in Russia, and veld in South Africa True grasslands do not have any kind of tree in them. However tropical grasslands have some patches of trees and are known as savanna. In Pakistan, grasslands are found in the northern mountain range such as lower chitral, part of Gilgit and Kashmir, Waziristan and north Kallat. Here rains are heavier than normal grasslands.

- **Climate**
  Grasslands occur in areas of scanty rainfall usually 250-270mm on the average annually such amount of rainfall cannot support the growth of trees. Often there are severe droughts. Grasslands are the areas of stress because there is no shade and protection for the animals from sun and winds. In the absence of shade grasslands are subjected to greater variations of temperature, moisture, winds, intensity of sunlight etc.

- **Producers and Consumers**
  Mainly various species of grasses are present in typical grassland. Tall grasses may range 5 - 8 feet in height but depending upon the amount of rainfall smaller species do not exceed more than 6 inches in height.

Grassland support communities of herbivores only. Large mammals like bison, antelope, Zebras, wild horses are common. Small burrowing birds like prairie chickens, meadow larks and some reptiles are also found. The burrows act as refuges during periods of intense heat and from attacks of predators. Predators of grassland include foxes, badgers and rodent eating hawks. Tigers and lions are found in grasslands of S. Africa. The soil of grassland is very rich in humus because of the rapid growth of grasses and decay of plants. In grasslands wheat and maize crops can be gown well.

iii. Savanna Ecosystem

Thus savannas are formed as a result of climatic conditions, but a few are formed by the destruction of tropical rain forests especially in African countries.

In savanna ecosystem there is a great variety of trees. Acacias are the most common plants of savanna ecosystems. Most common animals are large grazing mammals like zebras and large carnivores as lion and tigers.

Productivity of savanna ecosystem is less than tropical rain forests. Water is a limiting factor especially in the production of savanna ecosystem. Man has greatly affected savanna through fire, hunting and agricultural activities.

iv. Desert Ecosystem

Desserts are those areas where average annual rainfall is less than 250 mm. The other characteristic features of desert ecosystem are as follows:

- **Climate**

  The amount of rainfall in deserts is very little (less than 250 mm) which is not even distributed throughout the year. There may be frequent rains during one particular year but then many years may go completely dry. The plants in deserts are widely spaced due to insufficient water.

  The desert plants are very small in number. Atmospheric humidity is also low. Due to hot and dry winds, the variation between day and night temperatures may be as great as 50^0 C. In the absence of any barriers the strong winds cause damage to plants.

  Extreme shortage of water has made plant and animal to develop special adaptations to conserve water in their bodies.

- **Location**

  Sahara desert in Africa is the largest desert in the world. Other deserts are found in Australia, North America, Gobi desert in Mangolia, Chilli etc. In Pakistan the deserts are found mainly in the parts of Balochistan and Sindh i.e. Thar, and Cholistan.

- **Producers**

  Deserts plants are of two types;

  a. Surface Feeders

  b. Deep feeders

a. Surface Feeders

The plants in this category have shallow roots that spread just below the surface soil they absorb water very quickly before it is evaporated after rain. These plants have ability to complete their life cycle very rapidly in few days.

b. Deep Feeders

Most of the desert plants are deep feeders. They have deep roots and absorb water from deeper layers of the soil. The deep feeders live for many years as compared to surface feeders. Following are the major adaptations of desert plants to conserve water.

Desert plants have thick, fleshy stems and leaves to store water. This water is used in dries water. Many desert plants have very reduced leaves to check the loss of water during transpiration. Desert plants have thick cuticle, spines these features check the loss of water during transpiration. Even many desert plants close their stomata during day and open them in night.

- **Consumers**

  Very few animals live in deserts. Those living there have certain adaptations to conserve water in their bodies like plants Adaptations are as follows.

  Many animals live in burrows where humidity is higher and temperature is less than that of outside the burrow. They are nocturnal i.e. only come out of their burrows during night.

  Many desert animals drink either little water or do not drink and rely on the water present in their succulent food like cactus plants. The fat in the body of camel is converted to water to meet the water demands of the body. Camel can live for seven days without drinking water.

  Some desert animals like reptiles and insects excrete nitrogenous wastes in the form of uric acid which doesn't need water for removal out of the body.

  A few species of mammals have become secondarily adapted to desert by excreting concentrated urine.

  Absence of sweat glands, possession of salt secreting glands and large ears to radiate heat are the other adaptations to check loss of water from body, and keeping it cool.

v. Tundra Ecosystem

Tundra is a derivative of a Russian word meaning large treeless area. Tundra is referred to describe all types of vegetation in treeless high latitudes between taiga and polar ice caps.

- **Location**

  Tundra is found at very high altitudes across the mountains above the timberline. Timberline is an area where no tree can grow due to severe cold. In Pakistan tundra is present on Karakoram and Hindukush mountains. Tundra is also present near Polar Regions. There are two types of tundra depending upon their location:

  i. Arctic Tundra ii. Alpine Tundra

  i. Arctic Tundra

  Tundra of high latitudes is called arctic tundra. It is found in North America, Northern Europe and Siberia in Russia.

ii. **Alpine Tundra**

Tundra found on high altitudes of mountains is called alpine tundra. In alpine tundra the ultraviolet rays are very intense. Alpine tundra is found in mountains worldwide. The flora of the alpine tundra is characterized by dwarf shrubs close to the ground. The cold climate of the alpine tundra is caused by the low air pressure, and is similar to polar climate. There are strange sweeping winds. Water is available only for a short growing season. The most important feature is the permafrost.

Permafrost is a subsoil layer which remains permanently frozen due to very low temperature.

In permafrost trees or plants roots cannot penetrate. During summer upper, 10-20 cm. thick layer of soil thaws and allows some herbaceous plants to grow in it. But it freezes during the winter again.

- **Producers and Consumers**

As it has been mentioned earlier, there are no trees in tundra ecosystem. The producers of tundra are dominated by herbaceous plants such as grasses, sedges rushes and heaths, mosses, lichens and small flowering plants. The number of producers in tundra is small because of severs winters and permafrost.

Plants and animals have developed many adaptations to combat severe climatic conditions. For example rosette shape of the plants is an adaptation to protect delicate buds. A rosette is a concentric ring of leaves around a central bud. This shape of the plant serves to protect the fragile growth bud from cold winds. It may also serve to trap insulating snow in winter and dew during the dry growing season.

Animals are also limited in number. Due to extreme cold conditions and low productivity very little amount of food supply is available to animals tundra animals include caribou, Reindeer, Musk etc. They have large feet which act as snow shoes. Large animals like caribou, musk ox, and reindeer are migratory because there is not enough vegetation in one local area to support them. Predators of tundra include foxes, wolves and polar bears. The number of animals varies greatly. Due to unstable conditions during summer many birds like geese, migrate to plains areas to complete their reproductive cycle.

Key Points

1. There are two types of ecosystems, aquatic ecosystem and terrestrial or land ecosystem.
2. Aquatic or water based ecosystem can further be classified into two categories:
   i. Fresh water ecosystem
   ii. Marine ecosystem
3. Running water ecosystem is of two types:
   Fast or rapid flowing water
   Slow flowing water or pool
4. Aquatic or water based ecosystem can be classified into two categories, fresh water ecosystem, and marine ecosystem.
5. Ecosystems of standing water include ponds and lakes.
6. On the basis of depth of various parts of the lake or pond standing water ecosystems is divided into three parts or zone: i) Littoral Zone, ii) Limnotic Zone, and iii) Profundal Zone
7. There are many types of land of terrestrial ecosystems. Some of the major types of land ecosystem are forest ecosystem, grassland ecosystem, savanna ecosystem, desert ecosystem and tundra ecosystem.
8. The forest ecosystem can further be divided in three categories including tropical rain forest, temperate deciduous forest and coniferous forest.
9. Permafrost is a subsoil layer which remains permanently frozen due to very low temperature.
10. In the desert ecosystem, there are two types of plants; surface feeders and deep feeders.
11. Tundra is a derivative of a Russian word meaning large treeless area.

Self Assessment Exercise 9.3

Q.1 Select the correct answer:

a. What are arboreal animals? Animals which …
   i) dig burrows
   ii) have a body armor
   iii) live on trees
   iv) fly in the air

b. What is the amount of rainfall in tropical rain forests?
   i) 500mm
   ii) 1000 mm
   iii) 1500 mm
   iv) 2000 mm

c. Why plants in tropical rain forest compete for light? Because …………
   i) in tropical areas days are very short and nights are long
   ii) forest is too thick to allow light to reach the ground
   iii) all plants are of the same type and need same amount of light
   iv) none of the above

d. Which of the following plants are epiphytes?
   i) Coniferous trees
   ii) Pine trees
   iii) Lichens
   iv) Cheer

e. Grasslands are found in the areas which have average annual rainfall…
   i) 250 – 270 mm
   ii) 300 – 350 mm
   iii) 400 – 450
   iv) 500 – 550 mm

f. What is the characteristic feature of nocturnal animals?
   i) They live in tunnels
   ii) They have long hard claws.
   iii) They pray and feed at night.
   iv) They live in northern hemisphere

g. How camels can live for seven days without drinking water?
   i) They store water in their stomach
   ii) They eat little so that they do not need water
   iii) The fat stored in their hump is converted in to water
   iv) The excretion of water from their body is minimum

Q.2 Answer the following questions:

i. What is a biome?
ii. Define productivity? In which ecosystem productivity is greater?
iii. Differentiate between coniferous alpine and boreal forests.
iv. Explain the term savanna.
v. Why grass lands are the areas of stress for animals?
vi. For which crops grass lands are suitable?
vii. What is the meaning of the term tundra?
viii. What is timberline or tree line?
ix. Why plant roots cannot penetrate permafrost?
x. Why plants are rosette like in tundra?

9.4 Cycles in Ecosystem

As you may know living things obtain all the materials required for their survival from the environment. For example plants obtain minerals and water from the soil, oxygen and carbon dioxide from the air. Earth's biosphere contains a fixed amount of water, carbon, nitrogen, oxygen, and other materials that cycle through the environment and is reused by different organisms.

There are two main types of cycles in the ecosystem: gaseous and sedimentary. In a gaseous cycle, the element is mainly stored in the earth's atmosphere where it exists as a gas. Sedimentary cycles have the earth's crust as the main storage area for their elements.

Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous and sulfur etc. circulate between living organisms and their non living environment. The circulation of these materials between living and non-living environment is called as "biogeochemical cycling". The term "bio" means life, "geo" refers to rocks, soils, water and air, and "chemical" refers to the changes that occur as the elements go through these cycles. The biogeochemical cycles are important for normal functioning of ecosystems. In any ecosystem green plants capture solar energy and convert it into chemical energy of food. From green plants food energy flows to animals this flow of food energy from green plants to animals is called food chain.

By definition, we can interpret biogeochemical cycles as follows.

Green plants take up mineral substance from their environment and convert them into various biochemical compounds. By means of food these chemicals flow from plants to animals.

When the living organisms die their bodies are decomposed. As a result of decomposition complex compounds are broken down into simpler compounds or elements which become part of the soil and plants use them for their needs. In this way the materials are used and reused and biogeochemical cycles continue.

To explain how these cycles function in an ecosystem and how any disturbance in these cycles can affect the system examples of three major cycles have been cited below and on the following pages.

1. The Carbon Cycle

Carbon is an important element of all living and non living things. All living things are made of carbon. Carbon is also a part of the ocean, air, and even rocks.

In the atmosphere, carbon exists in the form of a gas called carbon dioxide. Plants use carbon dioxide and sunlight to make their own food and grow. In this way the carbon becomes part of the plant. Plants that die and are buried over millions of years may turn into fuels made of carbon like coal and oil. This is called fossil fuel.

The term fossil has been derived from Latin word “fossus”, which means “having been dug up. The term is used for the preserved remains or traces of animals, plants, and other organisms from the remote past. When humans burn fossil fuels, most of the carbon quickly enters the atmosphere as carbon dioxide. Carbon dioxide is referred to as greenhouse gas since it traps heat in the atmosphere.

Without it and other similar gases which trap heat, Earth would be a frozen world.

However, if the level of carbon dioxide in the atmosphere is too high that is also dangerous for life. Humans have burned so much fuel that there is about 30% more carbon dioxide in the air today than there was about 150 years ago. Higher than required level of carbon dioxide in the atmosphere is affecting the life on the planet.

There are gases in the atmosphere that absorb and emit radiation within the thermal infrared range. The primary greenhouse gases in the Earth's atmosphere are:

- water vapor (H_2O)
- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- ozone (O_3)

These gases greatly affect the temperature of the Earth; without them, Earth's surface would be colder than at present; the temperatures on average will be about 33 °C (59 °F).

Keeping in view the importance of carbon as a part of living and non living things and as a factor in maintaining atmospheric temperature it is essential that its amount should be maintained at an optimum level in the atmosphere. The natural cycle of rotation of carbon atoms from living to non living things in a cyclic manner maintains its levels in the ecosystem.

Let's study carbon cycle and explore how carbon atoms move through our natural world. Plants, animals, and soil interact to make up the basic cycles of nature. In the carbon cycle, plants absorb carbon dioxide from the atmosphere and use it to manufacture their food through a process called photosynthesis.

The process of photosynthesis incorporates the carbon atoms from carbon dioxide into sugars. Herbivorous (plant eating animals) animals, such as the cows, goats and rabbits eat the plants and use the carbon to build their own tissues. Meat eating i.e. carnivorous animals such as the lions, cats and fox, eat herbivorous animals. In this way carbon atoms are transferred from the atmosphere to plants and to animals and again to the soil.

These animals return carbon dioxide into the air when they breathe, and into the soil when they die, and are decomposed. The carbon atoms in soil may then be used in a new plant or small microorganisms. Ultimately, the same carbon atom can move through many organisms and even end in the same place where it began. In this way the same atoms are recycled for millennia.

The carbon cycle is an important gaseous cycle. Most of the carbon in our world is stored as carbon dioxide, in either the atmosphere or dissolved in the ocean. Plants need carbon dioxide to carry on photosynthesis, a process where the carbon atoms become part of molecules of simple carbohydrates (sugars) and may later be changed to fats, proteins or complex carbohydrates. The carbon becomes part of the energy system for ecosystems, since fats and carbohydrates are forms of stored energy. The carbon atoms travel through food chains, with decomposers at any step of the way. To fuel their bodies living things take in oxygen from their environment and use it to oxidize carbohydrates to release energy, the reverse process of photosynthesis. The process in which this energy is made available for growth and other activities is called respiration, and produces carbon dioxide which must be excreted from the body, usually through lungs, gills or leaves.

The process of respiration makes carbon dioxide available for photosynthesis. In animals Carbon is present in the bones. When the bones decay after the animal's death, it becomes part of the soil and the plants use them.

Cycle is started by photosynthesis in which all the terrestrial and aquatic green plants utilize CO_2 and water to synthesize carbohydrates. Carbohydrates are utilized by all living organisms both plants and animals, in their respiration. Photosynthesis is also a source of releasing oxygen into atmosphere; process can be presented by following equation.

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

$$(\text{Carbon dioxide + water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose Oxygen})$$

Some part of the glucose synthesized during photosynthesis is used in their own growth and metabolism. When herbivore animals eat green plants Carbon, Hydrogen and Oxygen come in the bodies of animals. There are two methods by which these elements can return back to environment.

i. Respiration
ii. Decomposition

In both cases energy is released. During respiration animals utilize glucose and convert it to carbon dioxide and water along with energy production. This energy is used for growth and metabolism of animals while CO_2 and water are returned to atmosphere. The process of respiration can be represented as follow.

$C_6H_{12}+60_2$ + Enzymes ⟶ $6Co_2+6H_2O$+ Energy

Glucose + oxygen+ Enzymes ⟶ Carbon dioxide + water.

After the death of the living organisms organic compound present in their bodies are decomposed by decomposers like bacteria and fungi. After decomposition organic compounds are converted into inorganic nutrients.

Combustion is another process in which fossil fuels or dry plant materials are burnt with the help of oxygen and carbon dioxide and water vapors are released into atmosphere, along with energy (heat).

Thus photosynthesis, respiration and decomposition are the main processes responsible for operating the carbon-hydrogen and oxygen cycle in nature.

Thus photosynthesis, respiration and decomposition are the main processes responsible for operating the carbon cycle in nature.

2. Nitrogen Cycle

Nitrogen is essential for all living organisms to prepare proteins and nucleic acids (DNA and RNA) moreover nitrogen is present in vitamins, chlorophyll, fats and many hormones, antibodies etc. Its importance for living organisms should never be overlooked. The earth atmosphere contains about 78-79% nitrogen gas. But green plants cannot absorb and utilize atmospheric nitrogen directly. Green plants absorb Nitrogen in the form of No_3 (nitrate ions) mostly other plants can also absorb nitrogen in the form of ammonium compounds. It is therefore essential that atmospheric nitrogen is converted into nitrate ions or some other form in which green plants can absorb it. The conversion of nitrogen into nitrate occurs by following methods:

i. Decomposition of nitrogenous compounds
ii. Nitrogen fixation
iii. Thunder storms

The detail of each is as follows:

i. Decomposition of Nitrogenous Compounds

Decomposition means break down of organic matter into inorganic form. Decomposition of nitrogenous compounds like proteins, DNA, RNA, vitamins, chlorophyll etc. is the chief source of soil nitrates it occurs in two steps:

a. Ammonification
b. Nitrification

The description of each step is as follows:

a. Ammonification

In this process the nitrogenous compounds present in the dead bodies of plants and animals are acted upon by certain bacteria and fungi which affect the breakdown of these compounds. After decomposition water, carbon dioxide and amino acids are released. Energy is also produced during this breakdown which is used by bacteria and fungi for their own metabolism. Amino acids are then converted into ammonia or ammonium ions therefore this process is termed as ammonification.

b. Nitrification

In this process ammonia or ammonium compounds are converted into nitrates. Bacteria control the reaction. It occurs in soils which has abundant air spaces in it because bacteria require oxygen for their respiration. There are two kinds of bacteria involved in nitrification and thus they are called nitrifying bacteria.

ii. Nitrogen Fixation

Nitrogen Fixation means the process of conversion of free atmospheric nitrogen into nitrates by bacteria and certain members of blue green algae. Bacteria which convert nitrogen to nitrates are of two types. First type includes those forms which live in the roots of higher plants symbiotically (symbiosis is a term used to describe a mutually beneficial relationship between two different types of organisms. Second type of bacteria lives freely in the soil and fixes nitrogen. On the basic of bacteria involved there are two types of nitrogen fixation.

a. Symbiotic N- fixation

This type of nitrogen fixation is carried out by bacteria living symbiotically in the roots of higher plants. Mostly these bacteria are present in the roots of plants in the family leguminosae. Plants such as moongphali, imli, shesham, kikar, siris or sirin, belong to this family of plants.

Of these plants there are certain swellings or knot like structures called nodules. Rhizobium is a kind of bacteria which is present in root nodules of these plants. Rhizobium absorbs nitrogen from pores or spaces in the soil where plants are growing and convert it into nitrates (NO_3) thus the nitrogen requirements of the leguminous plants are fulfilled. In return the plants provide bacteria with energy for their life activities.

> The term “Symbiosis” has been derived from a Greek word meaning “living together”. In ecology, it is used to describe close and often long-term interaction between different biological species in which either one benefits from the other or both get benefit from each other.

b. Non Symbiotic Nitrogen Fixation

This type of Nitrogen fixation is carried out by bacteria and blue green algae. In this case the bacteria are not living on the plant but live freely in the soil. The examples of free living bacteria carrying out nitrogen fixation in soil are Azatobacter, and clostridium. There are many species of blue green algae which also fix atmospheric nitrogen. When the organisms which have nitrogenous compounds in their bodies die the nitrogenous compounds are decomposed and are converted into soil nitrates. The soil nitrates are used by new green plants in this way nitrogen atoms are transferred from atmosphere to soil to plants and other organisms and back to the soil in a cyclic manner.

c. Fixation by Thunderstorm

Thunderstorm is also a source of nitrogen fixation. During lightning and thunderstorm free nitrogen of air is converted into various oxides of nitrogen with the help of oxygen. Along with rain water these are brought into soil which is finally converted in nitrate. Soil nitrates from all sources are absorbed by green plants and synthesized into proteins and other nitrogenous compounds. When plants are consumed by herbivores the nitrogenous compounds are transferred in to animals. There are two sources by which nitrogen is returned to nonliving compounds like urea, uric acid and ammonia are returned to environment.

When plants and animals die the decomposers cause decomposition of their bodies releasing nitrates again in the soil thus cycle can be started by green plants again.

3. The Water Cycle

Water covers approximately 75% of the Earth's surface, in both liquid and frozen forms. For the past 3.8 billion years large amounts of water have flowed on Earth. According to scientists, water initially appeared on the surface of the earth through the volcanic eruptions. In our solar system earth is the only planet which has water. Water is a necessary substance for the development and nourishment of life. Without water life would not be possible on the earth.

Water is the only known substance that can naturally exist in all three forms of the matter that is liquid, solid and gas form. The amount of water content on the planet earth is about 1.39 billion cubic kilometers (331 million cubic miles). About 96.5%, of the earth's water is in the oceans. Approximately 1.7% is stored the polar icecaps as ice, or in the glaciers, and permanent snow form. Only 1.7% of the water is present in groundwater, lakes, rivers, streams, and soil. Only a very small amount (thousandth of 1% of the water on Earth) exists in the atmosphere as water vapors.

The apparently negligible amount of water vapors in the atmosphere has a huge influence on the weather and climate of the planet. Water vapor travels around the globe transporting latent heat with it. As the water changes from liquid to solid or vapor form water molecules obtain heat which is called Latent heat. When the water changes from vapors to liquid or solid form this heat is released. Water vapors in the atmosphere act as a powerful greenhouse gas, and it is a major factor which determines the Earth's weather and climate as it travels around the globe.

You may think that the earth has infinite amount of water. That water keeps going around and around and around and around and (well, you get the idea) in what we call the "Water Cycle".

This cycle consists of the following main stages:

i. Evaporation (and transpiration)
ii. Condensation
iii. Precipitation
iv. Collection

The discussion of each stage is as follows:

i. Evaporation

You are aware that when water is heated it changes from liquid form to vapor or stream form this process is called evaporation. The sun energy heats the water in the river, lake or ocean and changes it into vapors. The vapor or steam leaves the surface of water and become a part of the air.

ii. Condensation

You have also observed that when the water vapor gets cold it changes back into liquid. This process is called condensation. The water vapor in the air when gets cold it changes to water and we see it as clouds.

You often observe this happening in your daily life. When you pour cold water in a glass of on a hot day water drops appear on the outside of the glass. That water does not somehow leak through the glass! Actually, when water vapor in the warm air touches the cold surface of the glass it turns back into liquid.

iii. Precipitation

Precipitation occurs when so much water has condensed that the air becomes saturated with water vapor and cannot hold it anymore. The clouds get heavy and water falls back to the earth in the form of rain, hail, sleet or snow.

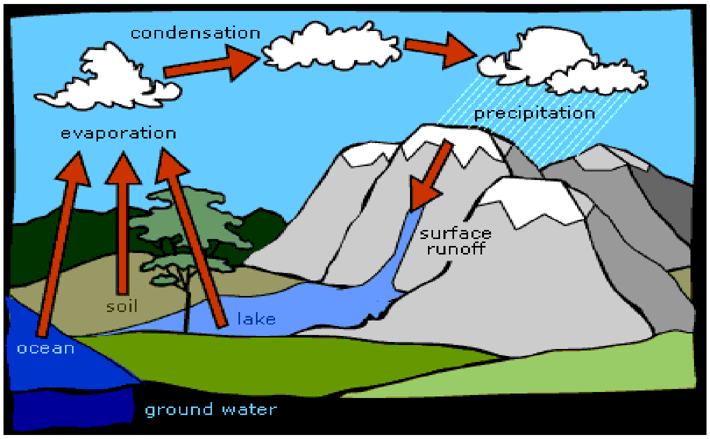


Fig. 14: Water Cycle

iv. Collection

When water falls back to earth as precipitation, it may fall into the oceans, lakes or rivers or it may fall on land and either is absorbed into the earth or become part of the "ground water" that plants and animals use to drink or it may run over the soil and become a part of the oceans, lakes or rivers where the cycle starts.

Here you may have noticed that moves in the form of cycle from earth to atmosphere. It is the same water which is used again and again.

4. The Oxygen Cycle

Just as carbon, water and nitrogen moves from earth to atmosphere and back to earth, oxygen is also cycled through the environment. Oxygen cycle depends on mainly two major life processes of animals and plants; photosynthesis and respiration.

You know that plants use the energy of sunlight to convert carbon dioxide and water into carbohydrates in this process oxygen is released which enters the atmosphere. This process is called photosynthesis.

$$- 6CO_2 + 6\ H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Animals breathe in oxygen released by the plants to use it to break carbohydrates down into energy. This process is called respiration. In this process carbon dioxide is released

Carbon dioxide produced during respiration is breathed out by animals into the air and is used by the plants in photosynthesis.

So plants release oxygen and animals use it for respiration. But plants also need oxygen to break carbohydrates down into energy just as animals do. During the day, plants use the oxygen which they produce in photosynthesis and use that oxygen to break down carbohydrates. At night, the plants absorb oxygen from the air and excrete carbon dioxide just as animals do.

From the previous sections you may have gathered that there is an inherent equilibrium in the ecosystems. Plants and animals interact so as to produce a stable, continuing system of life on Earth. For example, waste products produced by one species are used by another, and resources used by some are replenished by the others; the oxygen needed by animals is produced by plants while the waste product of animal respiration, carbon dioxide, is used by plants as a raw material in photosynthesis. The nitrogen cycle, the water cycle, and the control of animal populations by natural predators are other examples. However, the activities of human beings can, and frequently do, disrupt the balance of nature. Man's desire to make his life more comfortable and to modify the environment to the best of his interests has some very serious effects on the ecosystem which have put the whole life at stake. In the next section you will read about it in detail.

Key Points

1. Earth's biosphere contains a fixed amount of materials that cycle through the environment and in this way they are used again and again by different organisms.
2. Cycles of materials in the ecosystem are termed as "biogeochemical" cycles.
3. Many materials cycle through the environment, e.g. water, oxygen, nitrogen, carbon.
4. Carbon is a very important element. It is an important constituent of structure of all living organisms. It is also present in the atmosphere as carbon dioxide gas.
5. Carbon is one the important green house gases.
6. The term green house gas is used for the gases which trap heat
7. Carbon is a very important element. It is an important constituent of structure of all living organisms. It is also present in the atmosphere as carbon dioxide gas.
8. The term green house gas is used for the gases which have the ability to absorb and hold heat in the atmosphere, a phenomenon known as the "greenhouse effect."
9. Nitrogen is essential for all living organisms to prepare proteins
10. There are two methods by which carbon and other elements can return back to environment: respiration and decomposition.
11. Nitrogen is essential for all living organisms to prepare proteins which are an important part of structure of living organisms.
12. The earth atmosphere contains about 78-79% nitrogen gas.
13. Nitrogen is added back in the environment in three main ways: decomposition of nitrogenous compounds, nitrogen fixation, and thunder storms.
14. Decomposition of nitrogenous compounds is the chief source of soil nitrates it occurs in two steps: ammonification and nitrification.
15. Water is the most important compound to sustain life on planet.
16. Water cycles through environment in three forms: vapors, liquid and ice/snow.
17. Like other substances oxygen is also cycled through the environment. Oxygen cycle depends on mainly two major life processes of animals and plants; photosynthesis and respiration.

Self Assessment Exercises 9.4

Q.1 Answer the following questions:

i. Define biogeochemical cycles.
ii. Explain the importance of biogeochemical cycles in the ecosystems.
iii. Read the description of biogeochemical cycles and explain as to why it is said that we use the same water and other materials again and again?
iv. What is the contribution of human beings in adding to the amount of carbon dioxide in the environment?
v. How do plants help in maintaining the levels of oxygen in the ecosystem?

Q.2 Identify the correct and incorrect statements and also correct the incorrect statements.

a. The natural resources are infinite.
b. Water cycle consists of three stages.
c. Condensation means change of water from vapor to liquid form.
d. Collection is a stage in water cycle when the water collects in the form of clouds.
e. The amount of water vapors in the atmosphere plays a key role in determining the climate of an area.
f. Plants do not use oxygen during day time.
g. Carbon dioxide, vapors and some other gases are called green house gases because these are produced in green houses.
h. Ammonification is a process in which ammonium compounds are converted into nitrates.
i. Thunderstorm converts ammonia into nitrates.
j. Urea is a major source of adding ammonia back into the environment.

9.5 Pollution & Conservation of Environments

You hear a lot about environmental pollution and how dangerous it is for life in general and for human life in particular. But, have you ever thought what pollution is? What are its causes? And how or why it has put life in danger? Pollution is an undesirable change which alters physical, chemical and biological properties of atmosphere, water and soil. In other words it disrupts the balance in ecosystems.

Environmental pollution can be defined as:

Presence of matter (gas, liquid, solid) or energy (heat, noise, radiation) whose nature, location, or quantity directly or indirectly alters characteristics or processes of any part of the environment, and causes (or has the potential to cause) damage to the condition, health, safety, or welfare of animals, humans, plants, or property.

Man himself is the major culprit in causing pollution. Human activities which have caused imbalance and pollution in the ecosystem mainly include:

- Building industries for various human needs - directly and indirectly
- Use of transport for mobility of human beings
- Cutting forests to make the land available for various purposes and to use wood.
- Need for energy for various direct human needs and industrial needs.

Industrial revolution has, apparently, improved the quality of life. However it has caused serious damage to the ecosystem. Industrial wastes for example smoke chemicals etc.; have increased the amount of various substances to harmful levels, in the air, water and soil and in the atmosphere in general.

Vehicles are a major cause of addition of harmful matters in the air. Smoke, coming out of the vehicles, contains dangerous materials which are harmful for human health.
Man has destroyed forests to use the land for various purposes. Some of the reasons of cutting forests are as follows:

a. Demand of Land for Cultivation

This has been seen all over the world, especially in the countries that have agriculture as the backbone of their economy. Trees have been cut down to obtain land for cultivation of both subsistence and cash crops, both by governments and individuals.

b. Need for Firewood

People, especially those who live in rural areas where electricity and gas are unavailable, resort to use of firewood as a source of heat. Here, wood is cut down and burnt.

c. Need for Land to Build Industries

Industries require a lot of land and while industrialization is important for every country. **d. Need for Land to Build Houses**

With the worldwide increase in population, land to build houses for people to live in is very much required.

e. Need for Wood

For various purposes such as for fuel, for making furniture, to use in buildings wood is required.

The above mentioned activities add harmful materials in air, water and soil. Below and on following pages you shall read about air, water and soil pollution and its causes.

9.5.1 Types of Pollution

Following are some of the major types of pollution.

1. Air Pollution

The presence of unwanted substances in the atmosphere in such a concentration that adversely affect human being in particular and environment in general is called air pollution. Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere. A substance in the air that can cause harm to humans and the environment is known as an air pollutant. Pollutions can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made.

There are two types of air pollutions: primary and secondary pollutions. Usually, primary pollutions are directly emitted from a process, such as carbon monoxide gas emitted from a motor vehicle exhaust or sulfur dioxide released from factories or ash from a volcanic eruption. Secondary pollutions are formed in the air when primary pollutions react or interact. An important example of a secondary pollutant is ground level ozone. Some pollutions may be both primary and secondary: that is, they are both emitted directly and can be formed from other primary pollutions.

Major primary pollutions produced by human activity include:

Sulphur oxides (SO_2) - especially sulfur dioxide, a chemical compound with the formula SO_2. SO_2 is produced by volcanoes and in various industrial processes. Fuels such as coal and petroleum often contain sulfur compounds, their combustion generates sulfur dioxide. This is one of the reasons for concern over the effect of using these fuels.

Nitrogen oxides (NO) for example nitrogen dioxide (NO_2) are emitted from high temperature combustion, and are also produced naturally during thunderstorms by electrical discharge. Nitrogen dioxide is the chemical compound with the formula NO_2. It is one of the several nitrogen oxides. This reddish-brown toxic gas has a characteristic sharp, biting odor. NO2 is one of the most prominent air pollutions.

Carbon monoxide (CO) is a product by incomplete combustion of fuel such as natural gas, coal or wood. It is a colorless, odorless, non-irritating but very poisonous gas. A major source of carbon monoxide is vehicular exhaust.

Carbon dioxide (CO_2) is emitted from sources such as combustion, cement production, and respiration. It is also a colorless, odorless, non-toxic greenhouse gas. It naturally exists in the atmosphere and plants use it in photosynthesis. CO2 is a good transmitter of sunlight, but it also partially restricts infrared radiation going back from the earth into space, which produces the so-called greenhouse effect that prevents a drastic cooling of the Earth during the night

Increasing the amount of CO_2 in the atmosphere reinforces this effect and is expected to result in a warming of the Earth's surface.

Tiny particles of solid or liquid suspended in a gas, are referred to as particulate matter (PM) these particles and the gas together are called aerosol. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 percent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, lung diseases such as lung cancer.

Gases such as sulfur dioxide are also a cause of air pollution. When sulfur dioxide and nitric oxide are transported long distances by winds, they form secondary pollutions such as nitrogen dioxide, nitric acid vapor, and droplets containing solutions of sulfuric acid, sulfate, and nitrate salts.

These chemicals fall back on the earth's surface in wet form as rain or snow and in dry form as a gases fog, dew, or solid particles. It is known as acid rain. Acid rain can destroy plants and can cause deterioration of soil. In humans it can cause lung and heart diseases.

Pollutions – produced by nuclear explosions, nuclear events, war explosives, and many natural processes can also cause health problems to human and other living things.

2. Water Pollution

Water pollution may be defined as an addition of poisonous matter in ocean or fresh water. It may be possible by three ways.

- Domestic waste
- Industrial waste and
- Agricultural wastes

Domestic waste come from various industrial units like chemical industries, leather industry (tanneries), textile industry, food processing plants, paper mills and detergents. Agricultural wastes include fertilizers, pesticides, and fungicides, Oil refineries and mines also cause some water pollution. While heated water from power plants is also a source of water pollution.

3. Land Pollution

It is a product of solid waste in which residential waste, garbage, agricultural wastes and industrial wastes are included. These waste cause disease in human beings and thus they are very dangerous, sometimes these solid wastes prove fatal. Solid wastes are in the form of heavy metals like mercury, cadmium, beryllium etc. which enter human body through water or food and accumulate in various parts of the body and interfere with normal functions of enzymes. These may cause cancers.

Many chemicals like radioactive substances, sulfur and lead ultimately return to ground from atmosphere through rain and contaminate soil. These chemicals influence both flora and fauna of a particular ecosystem. The number and kinds of certain species are affected. In a forest ecosystem the pollutions affect the soil formation process and reduce the soil fertility. It is very difficult to remove the solid wastes from big lands.

4. Non material pollution

It includes radiation pollution which is a very serious problem at present. Cosmic rays, x-rays, radioactive isotopes, resulting from atomic explosions) are major sources of radiation pollution. These by products from nuclear reactors cause the ionization of biomolecules and result in mutations. Some radio- isotopes email alpha, beta and gamma rays, Alpha and beta rays have low power of penetration while gamma rays have high power of penetration into objects and cause damage to tissues.

5. Noise Pollution

One of the big dangers to human environment is noise pollution. The noise intensity is measured in decibels. According to decibel scale the noise of 80 to 130 decibels is undesirable.

Noise pollution is a common phenomenon of big cities. Height pitch sound is caused by factories vehicles, motor boats, ships, loud speakers, fast music, social gatherings and airplanes etc. Continued high pitched noise can cause deafness, headache, lethargy and irritation.

6. Thermal Pollution

It is a kind of non material pollution which results from industrial work, nuclear reactors and energy running centers which use water as a coolant. This hot water when released into springs and rivers causes increase in the temperatures of water bodies. Due to which aquatic plants and animals may die.

9.5.2 Conservation of Environment and Control of Pollution

The word conservation is derived from two Latin words: "con" meaning together and "servare" meaning to keep or guard. So conservation literally means to keep together any part of our natural environment such as land, water, air, minerals forest, wild life, fish, rangeland and over population; that human can utilize to promote his welfare.

The concept of conservation is the process of allocating natural and manmade resources so as to make optimum use of the environment for satisfying basic human needs at the minimum possible level; and at the same time preventing depletion and degradation of natural resources.

Land as resources should be conserved as man and all land animals directly or indirectly depend on soil for food. Similarly conservation of water implies making the best use of available water resources for human benefits, while not only preventing and controlling its depletion and degradation but also developing it in view of the present and future needs.

Following are some of the important measures/ steps for conservation of water.

- Development of ground, surface water sources and water storage capacity.
- De-salination of sea water and
- Reclamation of sewage and waste water.
- Waste water treatment and recycling of used water.
- Conservation and protection of water from pollution.

Besides protection of nature (environment) from exploitation to prolong its use for present as well as for future generations, agriculture, forestry, wild life, minerals and range land resources need to be conserved.

Other conservation steps include all measures to avoid waste to increase the quantity and quality of production and resources.

Control of Pollution

The pollution is a global phenomenon, it seems almost impossible to eradicate it. However, efforts can be mad to reduce the pollutions and ultimately pollution level. Following are some of the control measures to maintain environmental quality.

- More and more plantation should be maintained so that the level of green house gases may be reduced. The role of plants to maintain environmental quality is clear to everyone. In this respect laws should be developed to stop deforestation in tropical and temperate region of the world.

- The threat of global warming makes it imperative to use a source of energy that does not pollute the atmosphere. Nuclear power and several of renewable sources, such as solar and wind power are the possibilities.

- Adequate sewage treatment and waste disposal are necessary to prevent the pollution of rivers and oceans. New methods are needed to prevent pollution of underground water supplies.

- To reduce the level of green house gases, it is imperative to maintain the automobiles in good condition. Gasoline should be used instead of ordinary petroleum. Gasoline produces smaller quantities of green house gases. Automobiles should be tuned at regular intervals.

- Government should plan media campaign to educate common people regarding pollution.

Key Points

1. Pollution is presence of any form of the matter or energy (heat, noise, radiation) in the environment in such form, quantity or at such location, which directly or indirectly changes the characteristics or processes of any part of the environment, and causes or has the potential to cause, damage to the condition, health, safety, or welfare of animals, humans, plants, or property.

2. Pollutant is a substance which can cause harm to humans and other organisms of the environment

3. Humans have caused imbalance and pollution in the ecosystem mainly through following activities:
   - Building industries
   - Use of transport
   - Cutting forests
   - Unwise use of natural resources for energy.

4. Some of the control measures to control pollution include: More and more plantation, use a source of energy that does not pollute the atmosphere, development of adequate sewage treatment and waste disposal system, use of such materials for fuel which produce smaller quantities of green house gases and creation of awareness and knowledge among public about the dangers of pollution and their role in controlling it.

Self Assessment Exercise 9.5

Q.1 Answer the following:

i. What are the major sources of water pollution?

ii. What diseases are caused by drinking polluted water?

iii. Which frequency of sound is undesirable?

iv. What is the effect of hot waters in fresh water body or ocean?

Answers of Self Assessment Exercises

Self- Assessment Exercise 9.1

1. Surrounding of any organism is called its environment. Or environment means everything which exists around and which can influence us in any way.
2. The environmental conditions without interference of man are said to be environmental quality.
3. Human population growth has caused degradation of environmental quality.
4. The environmental resources which can be regenerated are called renewable resources, while the ones that cannot be regenerated are called non-renewable environmental resources.
5. Air, water, food, soil or land, forests, aquatic organisms and wildlife are some of the important renewable environmental resources.
6. Major components of earth environment are Atmosphere, Hydrosphere, Lithosphere and Biosphere.
7. The part of earth which can maintain life is called biosphere.
8. Place of living of organism is called as habitat.
9. Habitat is named after a prominent feature of habitat.
10. Size of habitat depends on kind of organism living there.
11. A self- sustaining system in a unit area in which both living and non-living environment interact and influence upon each other is called ecosystem.
12. There are two basic components of ecosystem: biotic and abiotic.
13. 390 nm to 760nm.
14. 18. $0\,^{o}C$ to $50\,^{0}C$
15. Fire
16. Soil provides place of living to organisms, moreover plants are rooted in the soil.
17. Loam or loamy soil.
18. (a) cattle (b) bacteria and fungi (c) human, crow
19. High temperature increases decomposition, at low temperature it is slow.
20. Unicellular green plants which swim on water surface are phytoplanktons.
21. This process helps in nutrient cycling.
22. Autotrophs can prepare its food by the process of photosynthesis (green plants), Heterotrophs cannot prepared food, they depend on green plants for food.

Self Assessment Exercise 9.2

Q.1

i. Flow of energy from green plants to animals through repeated stages of eating and being eaten is called food chain.
ii. Only upto two percent (20%) solar radiation is absorbed by green plants.
iii. Complex food chain is called as food web.

Q.2

i. a. Trophic level, b. Saprophyte, c. Decomposers, d. Food Web, e. Base
   f. Total mass of organic matter

Self Assessment Exercise 9.3

Q.1

a. iii. live on trees
b. iv. Upto 2000mm annually.
c. ii. The forests are very thick in tropical rain forest, light cannot reach on ground (forest floor) so these plants compete for light.
d. iii. Linchens, Orchids
e. i. 250-270 mm
f. iii. Animals which come out during night are called nocturnal animals.
g. iii. In camel the fat can be converted into water so it may not drink water for seven days.

Q.2

i. Ecosystem of any region can also be called as biome.
ii. The amount of carbohydrates prepared by green plants during photosynthesis per unit time per unit area is called productivity. It is highest in tropical rain forests.
iii. Boreal forests are coniferous forests found at high latitudes which alpine forest are coniferous forests found at high mountains.
iv. Savanna is a grassland with patches of trees.
v. Because there is no protection for animals from weather extremes.
vi. For wheat and maize crops.
vii. Tundra means a treeless land.
viii. On earth's surface a region above which no tree can grow is called timberline or tree line.
ix. Permafrost is a frozen soil that is why roots cannot penetrate in it.
x. Ultra violet rays cause division in meristematic cells so that many branches of same stem are produced and plants assume rosette (shrubby) like.

Self Assessment Exercise 9.4

For questions 1 read the relevant sections of the unit.

Q2.
a. Wrong. Natural resources are limited and through a system of cycling same resources are used again and again.
b. Wrong. It consists of four stages.
c. Correct
d. Wrong. It is a stage when it falls back on the earth surface and becomes a part of lakes, rivers, sea and oceans.
e. Correct
f. Wrong. Plants use part of the oxygen they produce during the day for respiration.
g. Wrong. They are called green house gases because they trap the heat and transmit it through the atmosphere.
h. Wrong. It is a process in which compounds breakdown into amino acids which are then converted into ammonia or ammonium ions.
i. Correct
j. Correct

Self Assessment Exercise 9.5

Q.1

i. Domestic waste. Industrial and agricultural waste are the causes of water pollution.
ii. Ulcers, hepatitis, typhoid, gastro- intestinal diseases.
iii. 80-130 decibels
iv. It kills the aquatic animals.

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