NIRANTAR SCIENCE & TECHNOLOGY

Class 9

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विषय : पाठ्यसामग्री स्वीकृति सम्बन्धमा ।

श्री निरन्तर प्रकाशन,
काठमाडौं ।

प्रस्तुत विषयमा त्यस प्रकाशनबाट मूल्याङ्कन र स्वीकृतिका लागि तोकिएको अवधिभित्र पेस हुन आएका तपसिलबमोजिमका पाठ्यसामग्री आवश्यक निर्णयार्थ पाठ्यसामग्री व्यवस्थापन तथा मूल्याङ्कन समितिमा पेस हुँदा विद्यालय शिक्षाको राष्ट्रिय पाठ्यक्रम प्रारूप २०७६, आधारभूत शिक्षा (कक्षा ६-८) पाठ्यक्रम २०७७, पाठ्यसामग्री विकाससम्बन्धी विद्यमान प्रावधान, ऐन, कानुन, निर्देशिका, कार्यविधि, प्रकाशन शैलीका प्रावधान, पाठ्यक्रम विकास केन्द्रले विभिन्न समयमा जारी गरेका र पाठ्यसामग्री सुधार/परिमार्जन/पुनर्लेखनका लागि दिइएका सुझाव र निर्देशनको परिपालना गरी स्वीकृति दिन सिफारिस भएअनुसार यस कार्यालयको मिति २०७८।१२।१४ गतेको निर्णयानुसार तपसिलमा उल्लिखित निर्देशनको पूर्ण परिपालना गरी शैक्षिक वर्ष २०७९, २०८० र २०८१ गरी तीन शैक्षिक वर्षका लागि गुणस्तरीय एवम् त्रुटिरहित पाठ्यसामग्री विकास गरी प्रकाशन गर्न स्वीकृति प्रदान गरिएको छ । विद्यमान संवैधानिक व्यवस्था, ऐन, कानुन, निर्देशिका, कार्यविधि, पाठ्यक्रम विकास केन्द्रले विभिन्न समयमा जारी गरेका निर्देशनलगायतका प्रावधानहरूको पूर्ण परिपालना नगरी गुणस्तरहीन पाठ्यसामग्रीको विकास, प्रकाशन र बिक्री वितरण गरेको पाइएमा, पाठ्यक्रम परिवर्तन भएमा वा यस केन्द्रबाट अन्य निर्णय भएमा यो स्वीकृति जुनसुकै बेला रद्द हुने छ ।

तपसिल

(क) पाठ्यसामग्रीको नाम

१	निरन्तर नेपाली	आधारभूत तह/ कक्षा ७

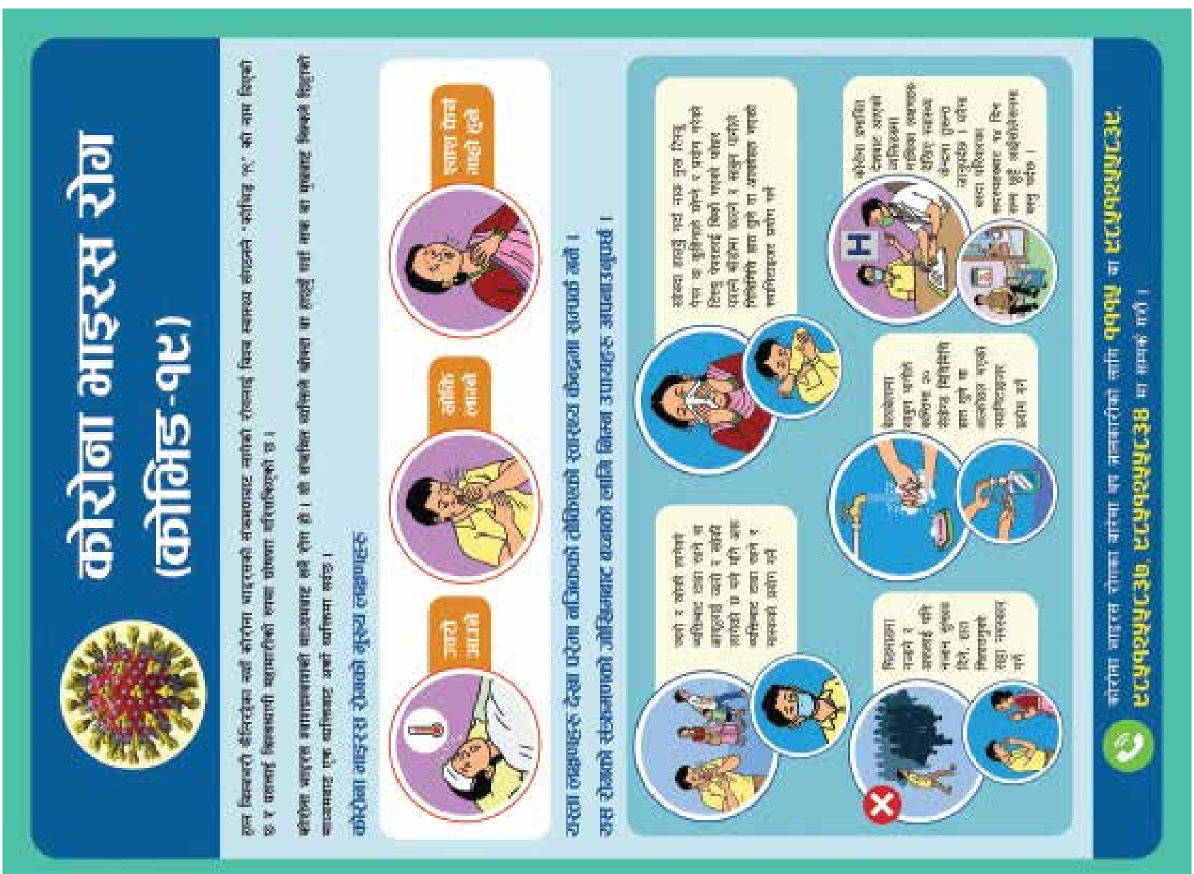
हीरा पाण्डे तिवारी
पाठ्यक्रम अधिकृत

(ख) निर्देशन

१. पाठ्यसामग्री विकाससम्बन्धी विद्यमान प्रावधान तथा पाठ्यसामग्री सुधार र परिमार्जनका लागि यस अघि दिइएका निर्देशनको पूर्ण परिपालना गर्ने ।
२. पाठ्यक्रमको मूल मर्म र भावनाअनुरूप पाठ्यक्रमका सम्पूर्ण पक्ष एवम् विषयवस्तु समावेश गरी पाठ्यसामग्रीलाई गुणस्तरीय बनाउने ।
३. आवरण पृष्ठको अघिल्लो (Front) भागको बायाँ (Verso) पृष्ठमा नेपालको आधिकारिक नक्सा र आवरण पृष्ठको पछिल्लो (Back) भागको दायाँ (Recto) पृष्ठमा कोभिड १९ सङ्क्रमण रोकथामसम्बन्धी सूचना यस केन्द्रको वेबसाइटबाट डाउनलोड गरी समावेश गर्ने । विषयवस्तुको प्रकृति र आवश्यकताका आधारमा पाठ्यसामग्री भित्रका विषयवस्तु र पाठमा समावेश गरिने तथ्याङ्क तथा नक्सा आधिकारिक र प्रामाणिक हुनुपर्ने ।
४. स्वीकृति पत्र स्क्यान गरी पाठ्यसामग्रीको शीर्षक पृष्ठभन्दा पछि दायाँ (Recto) पृष्ठमा समावेश गर्ने । पाठ्यसामग्रीको प्रत्येक पृष्ठको पुछार (Footer) मा पाठ्यक्रम विकास केन्द्रबाट स्वीकृत भन्ने व्यहोरा उल्लेख गरी प्रकाशन गरेका पाठ्यसामग्रीका तीन प्रति यस केन्द्रमा पेस गरेपछि मात्र बिक्री वितरण गर्ने । शिक्षा, विज्ञान तथा प्रविधि मन्त्रालयको निर्णयअनुसारको मूल्य कायम गर्ने तथा मूल्य र मुद्रण प्रतिको सङ्ख्या सर्वाधिकार पृष्ठमा अनिवार्यरूपमा राख्नुपर्ने । प्रतिलिपि अधिकार (Copy right) को सम्बन्धमा लेखक र प्रकाशक स्वयम् जिम्मेवार हुने ।
५. राष्ट्र, राष्ट्रिय एकता, सार्वभौमिकता, भौगोलिक अखण्डता, स्वाधीनता, राष्ट्रिय हित, पहिचान, सम्मान र समृद्धिमा आँच आउने तथा विभिन्न जातजाति, भाषा, धर्म, संस्कृति, सामाजिक सहिष्णुता, सद्भाव, सांस्कृतिक मूल्यमान्यता, रहनसहन आदिमा प्रतिकूल प्रभाव पार्ने कुनै पनि विषयवस्तु, उदाहरण, चित्र, अभ्यास, सिकाइ क्रियाकलाप समावेश नगर्ने ।
६. जातजाति, भाषा, धर्म, संस्कृति, वर्ण, क्षेत्र, लैङ्गिकता, अपाङ्गता, पेसा, व्यवसाय, सामाजिक सांस्कृतिक अवस्थाका आधारमा भावनात्मक रूपमा चोट पुऱ्याउने, आक्षेप लाग्ने, होच्याउने र विभेदीकरण गर्ने किसिमका विषयवस्तु, उदाहरण, चित्र, अभ्यास, सिकाइ क्रियाकलाप समावेश नगर्ने ।
७. पाठ्यसामग्रीमा समावेश गरिएका चित्र, नक्सा, चिह्न, सङ्केत आदि शुद्ध, स्पष्ट र बोधगम्य हुनुपर्ने ।
८. विद्यार्थीलाई बढी भार पर्ने गरी पाठ्यक्रममा समावेश नगरिएका विषयवस्तु, अभ्यास तथा सिकाइ क्रियाकलाप पाठ्यसामग्रीमा समावेश नगर्ने ।
९. पाठ्यक्रम एवम् दिइएका सुझाव र निर्देशनबमोजिम पूर्णरूप दिइएको त्रुटीरहित गुणस्तरीय पाठ्यसामग्री मात्र प्रकाशन र बिक्री वितरण गर्ने ।

पुनश्च : यो स्वीकृति शैक्षिक वर्ष २०७९, २०८० र २०८१ का लागि प्रदान गरिएकाले सोहीबमोजिम प्रकाशन, बिक्री वितरण र प्रयोग गर्नु गराउनहुन सम्बन्धित सरोकारवाला सबैमा अनुरोध छ ।


नेपालको नक्सा
(राजनीतिक तथा प्रशासनिक)


कोरोना भाइरस रोग
(कोभिड-१९)
कोरोना भाइरस रोगको मुख्य लक्षणहरू
ज्वरो आउने
खोकि लाग्ने
स्वास फेर्न गाह्रो हुने
यस्ता लक्षणहरू देखा परेमा नजिकको तोकिएको स्वास्थ्य केन्द्रमा सम्पर्क गर्ने ।
यस रोगको संक्रमणको जोखिमबाट बच्नको लागि निम्न उपायहरू अपनाउनुपर्छ ।

PREFACE

Nirantar's Science & Technology as a series I-X grade has been prepared strictly in a line to the recently new syllabus and curricula issued by Curriculum Development Centre, Sanothimi, Bhaktapur, under the ministry of education, and the government of Nepal for the learners of basic level to secondary level with regard to educational framework 2063 B.S.

The series aims at providing both theoretical and practical cognitivity to the students of far and wide having some flair to science, scientific facts and processes with ample activities considering their needs, level, aptitude, intelligence and age factor by creating interest through proper selection and gradation of the subject matter to be taught and learnt. The entire desk of authors and editors claims that the series has come to adopt a thematic and activity centred approach, abundant illustrations and so on in order to make an understanding of science more effective and comprehensive.

The new curriculum 2078 and updated version in your hand is solemnly dedicated to those scholars far and wide with a provision of richly sophisticated but only relevant pictures, diagrams, table, charts, fact files, reasons and logics, etc. as the soul of science. Apart from these, several other efforts have been put forward collectively in order to make the book more concise and student friendly so as to address the requirement of a perfect book to many students and teachers who like to culminate real practice in science in the days to come. Beside this, our another attempt through this presentation is to eradicate some misconceptions to science appeared in the growing mind of students especially in the classroom context by illuminating them in terms of these salient features incorporated within each book of the series.

Home Assignments/Worksheets: The revision exercises at the end of every chapter can be given as home assignments after teaching particular concepts.

Varieties of Questions: Objective type questions like, fill in the blanks, choose the correct answer, etc. are given in the exercises at the end of every chapter in this book, in order to fulfill the objectives of each lesson.

Activities : Numerous activities in the classroom can provide platform for active involvement of students in application of their theoretical knowledge and learning. Thus, interesting activities are given so as to arouse interest of the students in science.

Projects: Lots of activities in the book are dedicated to investigate research projects with information gathering and deducing. Some of these can be individual research projects and others assigned to group of students with an aim to make them more participatory.

Any constructive suggestions and recommendations for the betterment of this series will be highly acknowledged.

- Authors

Nirantar

Science & Technology

Class 9

Contents

Unit 1

Scientific Study

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- introduce the fields of science, scientific studies and science and to look for career opportunities in these fields
- review the achievements and challenges brought by science and technology
- adopt safety measures to be adopted while conducting scientific experiments
- use scientific notation, metric prefixes, proper precision and average in measurements

Galileo Galilei

Albert Einstein called Galileo the "father of modern science" Galileo Galilei was born on February 15, 1564, in Pisa, Italy but lived in Florence, Italy for most of his childhood. His father was Vincenzo Glilei, an accomplished Florentine mathematician and musician.

1.1 Introduction to Scientific Study

The term Science comes from the Latin word *scientia*, meaning 'knowledge'. It can be defined as a systematic attempt to discover, by means of observation and reasoning, particular facts about the world, and to establish laws connecting facts with one another and, in some cases, to make it possible to predict future occurrences. There are other ways to define science. It is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence. Science can be also defined as any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, science involves a pursuit of knowledge covering general truths or the operations of fundamental laws. Science refers to a systematic and organized body of knowledge in any area of inquiry that is acquired using 'the scientific method' i.e. Scientific Study.

Scientific method, can be defined as mathematical and experimental technique employed in the sciences. More specifically, it is the technique used in the construction and testing of a scientific hypothesis . The scientific method is used when creating and executing an experiment. The purpose of the scientific method is to have a systematic way of testing ideas and reporting results in the process of scientific inquiry. A key component of the use of the scientific method is that it ensures that the experiment should be able to be replicated by anyone. If that is not possible, then the results are considered invalid.

There are various types of scientific studies such as experiments and comparative analyses, observational studies, surveys, or interviews. The choice of study type will mainly depend on the research question being asked. When making decisions, patients and doctors need reliable answers to a number of questions.

The scientific method is a process for experimentation that is used to explore observations, answer questions, and search for cause and effect relationships in a research project. There are typically six steps involved in the scientific method. These include asking a specific question, conducting background research on the topic, constructing hypotheses, testing the hypothesis through experimentation, analyzing and drawing conclusions about the data, and communicating the results.

The scientific method consists of six steps :

The Question

The scientific method starts when you ask a question about something that you can observe: How, What, When, Who, Which, Why, or Where? In order for the scientific method to answer the question it must be about something that is measurable, preferably quantitatively.

Background Research

Conduct an extensive literary review of the information known about the topic and question you have identified (that both supports and contrasts your hypothesis). This provides you a plethora of information to help you make your hypothesis and identify methodologies and assumptions that have both succeeded and failed in the past.

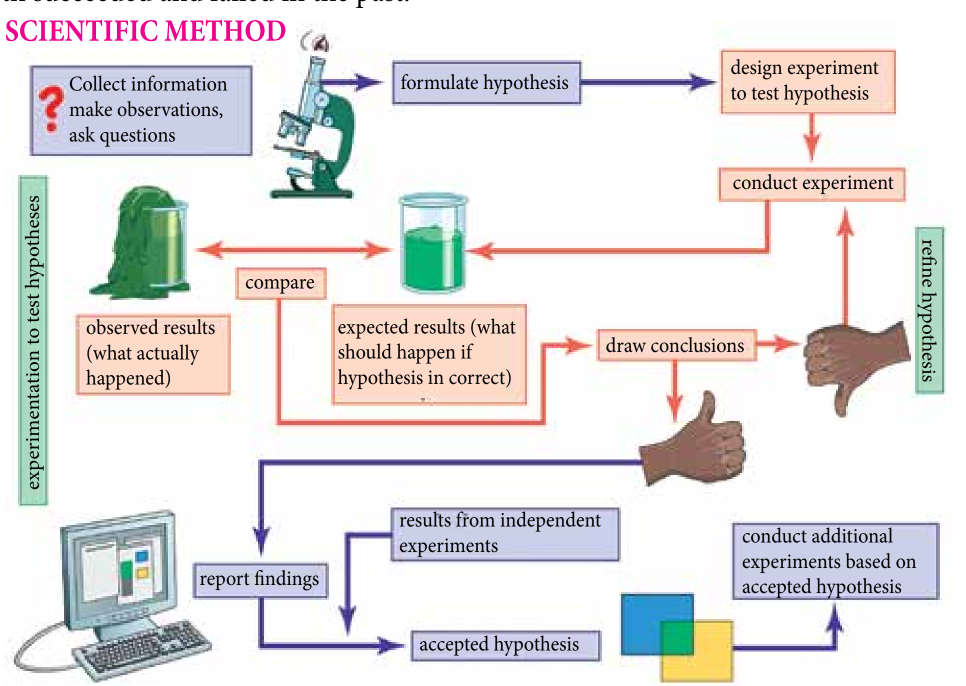


Fig 1.1

Construct a Hypothesis(es)

Make an educated guess about the results of your research. Your hypothesis must be measurable and constructed in such a way that will help you answer your original question.

Experimentation

Your experiment tests whether your hypothesis is true or false. It is important that experimental methodology is well controlled.

Analyze Your Data and Draw a Conclusion

Data should be organized in the most efficient manner and analyzed in as many ways as possible, preferably with statistical analyses although this is difficult when small sample sizes are used. Make informed conclusions about the data analyses and determine if your hypothesis is true or false. Oftentimes, if the hypothesis was false, a new hypothesis may be made and the entire process of the scientific method may be initiated again. Never change your hypothesis to match the results.

Communicate the Results

One of the main goals of completing a research project is to disseminate the results, hopefully to a scientific peer-reviewed journal or by presenting the results on a poster at a scientific meeting.

Before you can use the scientific method correctly in your own experiments, you must have a good understanding of independent and dependent variables. To better understand how the scientific method works in action, consider the following example of simple experiments you can try yourself in everyday life.

Example: Freezing Water

Consider how the scientific method applies in this simple experiment with freezing water under two different conditions.

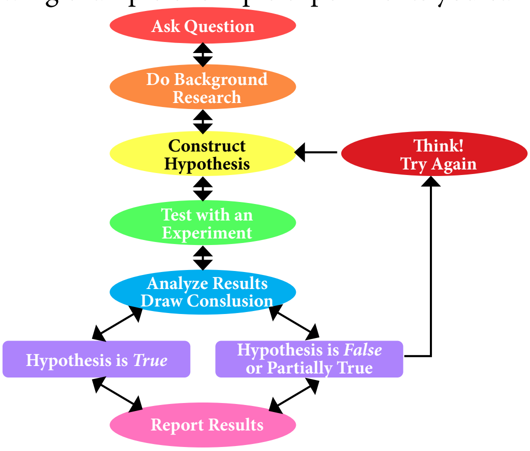


Fig 1.2

1. Define Purpose : I want to know if water freezes faster on its own or with sugar added to it.
2. Construct Hypothesis : The null hypothesis is that there will be no difference in how long it takes the water to freeze, whether or not it has sugar added to it. The alternative hypothesis is that there will be a statistically significant difference in freezing time between the two scenarios.
3. Test Hypothesis and collect Data : Fill two identical containers with the same amount of room temperature water. Add a measured amount of sugar to one of the containers. Place the two containers into the freezer. At regular intervals of 15 minutes, open the freezer and observe the status of the water in each container. Continue until both have completely frozen. Write down the time it took for each container of water to reach a fully frozen level.
4. Analyze Data : Look at the time it took for each container of water to freeze. Did the water with sugar added take a significantly longer or shorter amount of time to freeze?
5. Draw conclusion : Based on the results of your experiment, come to a conclusion as to whether water with sugar freezes faster, slower, or at the same rate as water without sugar added.
6. Communicate Results: Report your findings in the form of a written report as an oral In the case of this experiment, you may choose to vary the amount of sugar added (during step 3 of the scientific method above) to see if it alters the results as well. This could be a more robust experiment as you would then have additional data to report.

Activity 1.1

How the scientific method applies in the Growing Bean Plants ? Write down with six steps .

The process of executing an experiment using the scientific method ensures that your work is well thought out and organized, and that all data is recorded and can be shared easily. This, along with the possible replication of the experiment's circumstances, reduces any bias on the part of the scientist performing the experiment. Furthermore, the communication of the results allows for peers to review the work to ensure the results are precise, accurate, and correctly interpreted.

When you are ready to present the findings of your own experiments, be sure to follow the correct report writing format . Be mindful of the various elements, as well as your choice of font and use of headings. Keep your science learning going strong by discovering some inventions from the Scientific Revolution.

1.2 Science Process Skills

Science process occurs naturally, spontaneously in our minds. By logically breaking down the steps in our thinking, we can use science process to find out how to answer our questions about how the world works. Science process is not just useful in science, but in any situation that requires critical thinking. When we interact with our surroundings, we are implementing processes such as observing, questioning, classifying, interpreting, predicting and communicating .These basic science process skills form the foundation of the scientific method. These skills are integrated together when scientists design and carry out experiments or in everyday life when we all carry out fair test experiments . All the basic skills are important individually as well as when they are integrated together . You may find in some examples some more advanced process skills sometimes referred as integrated skills like identifying and controlling variables, hypothesizing, interpreting data, defining operationally, experimenting and constructing models. In simple words, Science process skills are the processes which are being used by various scientists while doing science.

Observing

Observation of real phenomena begins the inquiry process and continues throughout all its phases. Using your 5 senses (seeing, hearing, touching, smelling and tasting when appropriate) along with the right tools to gather informations .

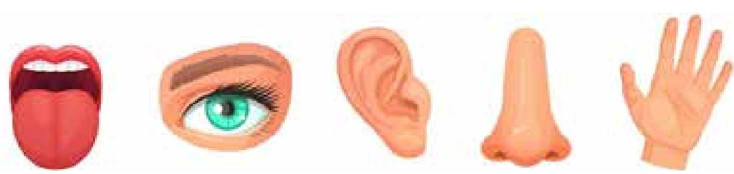


Fig 1.3

Observations must be free from any inferences.

Example: Only record what you see, not what you think you see.

Questioning

Curiosity drives the inquiry process-it generates questions and search for answers. In process of asking series is first step finding questioning. It is process of habit mind that can be encouraged any learning setting. Thinking of and asking questions about an object, event, or a science topic.

Classifying

Classifying is the process of grouping and ordering objects . There is an overwhelming number of things around us -nonliving and living things. Order can be attained by observing similarities, differences and interrelationships and by grouping them accordingly to suit some purpose .

Example: Placing all rocks having certain grain size or hardness into one group .

There is an overwhelming number of things around us–

Things	:	Nonliving and Living Things
Hair Color	:	Brown, Black, Blond, Red
Eye Color	:	Blue, Brown, Hazel/Green
Sex	:	Boys, Girls

fig 1.4

Interpreting

Interpreting includes finding a pattern of effects and synthesizing a variety of information in order to make a statement about their combined meaning. It may include making associations between variables and making sure that the data support the hypothesized connections. It is critical to relate findings to initial questions and observations.

Predicting

Predictions are central to the process of testing whether or not a hypothesis is on the right track. This process takes away the need for guessing. A prediction goes beyond available evidence to suggest what will happen in the future. Typically, a prediction is based on evidence from past knowledge and/or experience, and upon immediate evidence gained through observation. It is important to know how to gather evidence and how it can be used to get best advantage. Predictions invite the orderly gathering of evidence for a specific purpose. Forecasting the outcome of a specific future event based on a pattern of evidence or a hypothesis. It is not a wild guess.

Communicating

Communication includes taking notes in the course of an investigation. It also includes choosing the appropriate way to translate knowledge to others, by making representations such as charts or diagrams, for example, that illustrate data and results. It implies that socially gathered and shared information informs individual learning.

To give and receive information. Describes only what is observed

Ways of Communicating :–

A. Speech B. Writing C. Pictures D. Graphs E. Maps

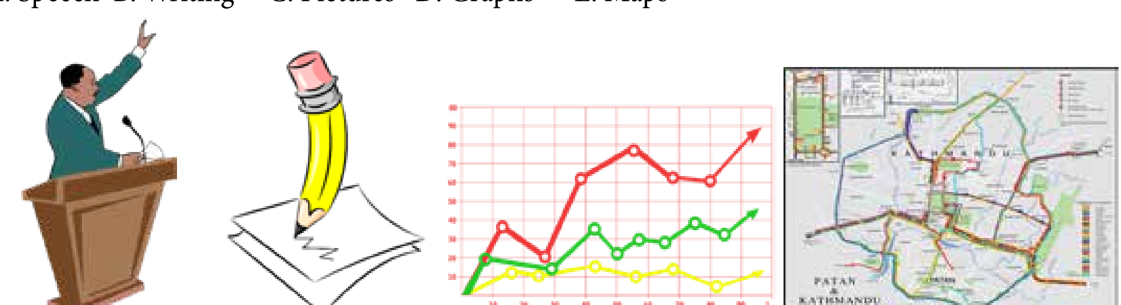


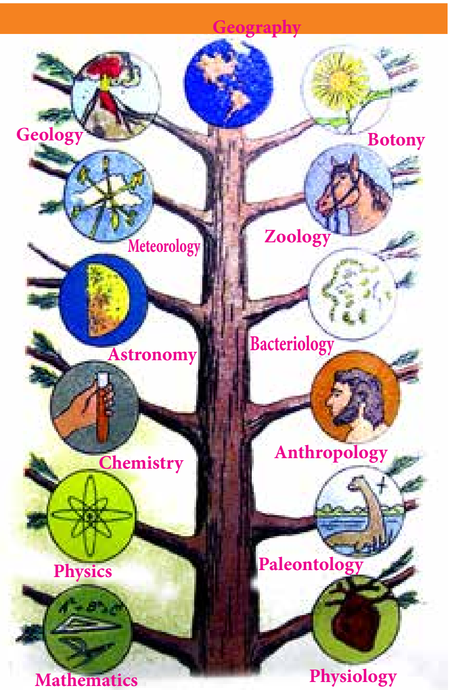
fig 1.5

1.3 Scientific Learning

The Science of Learning is an approach that recognizes the value and importance of cross-fertilization across traditional fields of study, drawing on many different methods and techniques to understand how learning occurs— with the ultimate goal of optimizing learning for all.

Sometimes a related field called 'sciences of learning' is confused with learning sciences. These terms represent distinct research traditions and inform our understanding in different and complementary ways.

Sciences of learning recognizes that many sciences inform our understanding of how people learn, such as neuroscience, psychology, sociology, anthropology, and more. Research questions often start from foundational theories, for example, about how the brain works. After investigating these in a laboratory, often using experimental methods, the findings are applied in other settings.



The Tree of Science

fig 1.6

On the other hand, learning sciences is informed by the same wide net but, as described above, investigates specifically how learning happens in real-life settings (e.g., schools, classrooms, museums, the workforce) with research questions, data gathering processes, and insights that are highly responsive to needs in those specific settings.

Beyond the potential scientific breakthroughs, there are individual benefits to learning science, such as developing our ability to ask questions, collect information, organize and test our ideas, solve problems, and apply what we learn. Even more, science offers a powerful platform for building confidence, developing communication skills, and making sense of the world around us—a world that is increasingly shaped by science and technology.

1.4 Fields of Science

Science can be divided into different branches based on the subject of study. The **physical science** the **inorganic world** and comprise the fields of **physics**, **astronomy**, **chemistry** and **the Earth science**. The **biological sciences** such as **biology** and **medicine** study the **organic world** of life and its processes. **Social sciences** like **anthropology** and **economics** study the social and cultural aspects of human behaviour .

Science can be grouped into two broad categories, too . i.e, natural science and social science. Natural science is the science of naturally occurring objects or phenomena, such as light, objects, matter, earth, celestial bodies, or the human body. Natural sciences can be further classified into physical sciences, earth sciences, life sciences, and others. Physical sciences consist of disciplines such as physics (the science of physical objects), chemistry (the science of matter), and astronomy (the science of celestial objects). Earth sciences consist of disciplines such as geology (the science of the earth). Life sciences include disciplines such as biology (the science of human bodies) and botany (the science of plants). In contrast, social science is the science of people or collections of people, such as groups, firms, societies, or economies, and their individual or collective behaviours. Social sciences can be classified into disciplines such as psychology (the science of human behaviours), sociology (the science of social groups), and economics (the science of firms, markets, and economies).

1.4.1 Biological Science

Biological sciences is the study of life and living organisms, their life cycle, adaptations and environment. There are many different area of study under the umbrella of biological science including biology, medicine, genetics,biochemistry, agriculture, microbiology and evolutionary biology.

a. Biology

Biology literally means 'the study of life' . It is a natural science concerned with the study of life and living organism, including their structure, function, growth, evolution, distribution, identification and taxonomy. The field deals with all the physiochemical aspects of life. The modern tendency toward cross-disciplinary research and the unification of scientific knowledge and investigation from different fields has resulted in significant overlap of the field of biology with other scientific disciplines. Modern principles of other fields:chemistry, medicine, and physics, for example are integrated with those of biology in areas such as biochemistry, biomedicine, and biophysics.

Biology is subdivided into separate branches for convenience of study, though all the subdivisions are interrelated by basic principles. Thus, while it is custom to separate the study of plants (botany) from that of animals (zoology), and the study of the structure of organisms (morphology) from that of function (physiology), all living things share in common certain biological phenomena, for example, various means of reproduction, cell division, and the transmission of genetic material.

Biology is often approached on the basis of levels that deal with fundamental units of life. At the level of molecular biology , for example, life is regarded as a manifestation of chemical and energy transformations that occur among the many chemical constituents that compose an organism. As a result of the development of increasingly powerful and precise laboratory instruments and techniques, it is possible to understand and define with high precision and accuracy not only the ultimate physiochemical organization (ultrastructure) of the molecules in living matter but also the way living matter reproduces at the molecular level. Especially crucial to those advances was the rise of genomics in the late 20th and early 21st centuries.

Scope Of Biology

- In a progressive forward-looking society, Biology can play a truly liberating role, helping people out the vicious circle of poverty, ignorance and superstitions.
- Biology, tempered with wisdom, is the surest and the only way to human welfare.

b. Medicine

Medicine is the field of health and healing. It includes nurses, doctors, and various specialists. It covers diagnosis, treatment, and prevention of disease, medical research, and many other aspects of health. Medicine aims to promote and maintain health and wellbeing.

Conventional modern medicine is sometimes called allopathic medicine. It involves the use of drugs or surgery, often supported by counseling and lifestyle measures. Alternative and complementary types of medicine include acupuncture, homeopathy, herbal medicine, art therapy, traditional Chinese medicine, and many more. Medical science covers many subjects which try to explain how the human body works.

c. Genetics

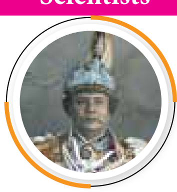
Genetics is a branch of biology which studies heredity and variation in organisms. Genetics studies the transmission of genes from one generation to another. A blueprint of traits and characteristics is established for the new offspring from the genes transferred from both parents. The genotype is the genetic makeup while the phenotype is the physical makeup.

d. Agriculture

Agriculture is the art and science of growing plants and other crops and raising animals for food, other human needs, or economic gain. Nepal is an agriculturally important country. Two-thirds of its population is engaged in agricultural activities. Agriculture is a primary activity, which produces most of the food that we consume. Besides food grains, it also produces raw material for various industries. Agriculture is an age-old economic activity in our country. Over these years, cultivation methods have changed significantly depending upon the characteristics of physical environment, technological know-how and socio-cultural practices. Farming varies from subsistence to commercial type. The Nepal Agricultural Research Council (NARC) is the country's main agricultural research and development agency. It was established in 1991 as an autonomous organization under 'Nepal Agricultural Research Council Act - 1991' to conduct agricultural research in the country to uplift the economic level of the people. NARC announced the release of six new wheat varieties for multiplication and distribution to the country's wheat farmers, offering increased production for Nepal's nearly one million wheat farmers and boosted nutrition for its 28 million wheat consumers in 2020. The new varieties are: Zinc Gahun 1, Zinc Gahun 2, Bheri-Ganga, Himganga, Khumal-Shakti and Borlaug 2020.

fig 1.7

Let's Know about some Nepali Scientists

Scientists	Introduction
 Gehendra Shamsher	**Gehendra Shamsher** was a Nepali innovator, firearm designer. He is generally regarded as the first scientist of Nepal. He was born in Kathmandu, Nepal. His interests were largely confined to the manufacture and design of firearms. As opposed to importing arms and ammunition from other countries, he wanted to manufacture them within the country, especially by exploiting locally available raw materials like iron and coal.
 Mahabir Pun	**Mahabir Pun** is a Nepali scientist, who introduced Wireless Internet technology in remote areas of Nepal. He was born in Nangi, a remote village in the mountainous district Myagdi of western Nepal . He is widely known as the 'Wireless Man' in Nepal .

Sanduk Ruit

Sanduk Ruit is an eye surgeon (ophthalmologist), who has restored the sight of over one lakh people across Africa and Asia using small-incision cataract surgery. He was the first Nepali doctor to perform cataract surgery with intraocular lens implants and the first to pioneer a method for delivering high-quality microsurgical procedures in remote eye camps. Ruit was born to rular illiterate parents in the remote mountainous village Olangchunggola in Taplejung of northeast Nepal. He is also famous as 'God of Sight' in Nepal.

1.4.2 Physical Science

Physical science, is the systematic study of the inorganic world, as distinct from the study of the organic world, which is the province of biological science. In the nineteenth century, physical sciences were divided into five distinct disciplines; physics, chemistry, astronomy, geology and meteorology.

Some examples of everyday physical science

The light bulb in the lamp represents physical science because the invention of it demonstrates the understanding of the way electrons act in certain situations . There is a tungsten wire inside the bulb,which glows white-hot when electricity passes through it. The electricity goes into the electrons of the tungsten atom, causing them to give off photons, light particles.

Glass represents physical science because it is created by a chemical process of heating silica sand and various other ingredients to liquid state, then allowing the molten mixture to cool back to a solid . The kind of glass depends on which other ingredients are melted with silica sand . In science, glass also means any solid that has an amorphous (non-crystalline) molecular structure.

The towel soaking up the spilled water represents physical science because it is an example of capillary action. Though the spill was small, the water travels through the tiny gaps (usually called capillaries) in the paper towel and ctreats a very wide water mark. This is caused by the adhesion of water to the material of the paper towel.

The phenomenon of water and oil not mixing represents physical science because it is caused by a lack of chemical reaction. Water and oil do not mix because water is a polar solvent,and oil is a non-polar solvent. Like dissolves like. That means polar molecules dissolve other polar molecules and non-polar molecules dissolve other non-polar molecules. The oil and water cannot bond with each other for that reason, and oil is forced to rest on top the water without mixing (it doesn't sink to the bottom collectively because oil isn't as dense as water).

fig 1.8

Activity 1.2

i. What is the importance of physical science in daily life. Explain it with proper example?
ii. Does stretched rubber band represent Physical Science ? Give scientific reason.
iii. How can you relate physics in our everyday life?

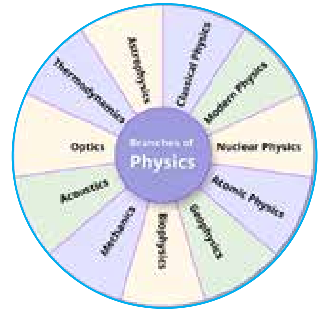
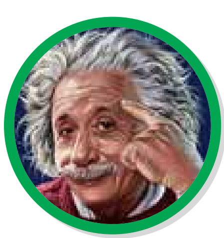


Fig. 1.9

a. Physics

Physics is considered to be one of the primitive subjects and academic disciplines to be discovered. It encompasses the study of matter, its motion and behaviour along with energy and force. Physics very often defines a wide range of principles and methodologies studied by other areas of sciences. It is the study of how matter and energy interact with each other and how they affect each other over time and through space. Physics functions in an exciting dimension. What we mean by this is that things keep changing in the world of physics with every discovery. As a vast discipline, it intersects with many different subjects and disciplines such as biophysics and quantum chemistry. Modern definition of Physics is a natural science based on experiments, measurements and mathematical analysis with the purpose of finding quantitative physical laws for everything from the nanoworld of the microcosmos to the planets, solar systems and galaxies that occupy the macrocosmos. The physicist deals with all aspects of matter and energy. His or her work ranges from basic research into the most fundamental laws of nature to the practical development of devices and instruments. And hence, a physicist is a person who does research connected with physics or who studies physics.

Some Famous Scientist

Scientists	Introduction
 **Isaac Newton**	Co-inventor of calculus, a major contributor to the science of optics and gifted mathematician, Isaac Newton (1843-1727), who was born in Lincolnshire, outlined the laws of mechanics that now underpin vast swaths of classical physics. Most important of all, Newton outlined the *principle of gravity*, which explained how the planets revolve round the sun.
 **Albert Einstein**	Three great theories define our physical knowledge of the universe; relativity, quantum mechanics and gravitation. The first is the handiwork of German-born Albert Einstein (1879-1955), who remains the physicist with the greatest reputation for originality of thought. His work showed that space and time are not immutable but are fluid and malleable. Einstein, who took US citizenship in 1940, also provided the world with the most famous equation, E= mc2, which demonstrates the equivalence of mass and energy. His name has become synonymous with the idea of genius and he died a celebrity. He was awarded the 1921 Nobel prize of physics.

James Clerk Maxwell

In contrast to Newton and Einstein, Edinburgh-born *maxwell* (1831-79) is virtually unknown to the general public. Yet his contribution to physics was every bit as significant, particularly his discovery of the theory of *electromagnetism*. This showed that electricity, magnetism and light are all manifestations of the same phenomenon, the electromagnetic field. The development of radio, TV and radar were the direct consequences. Maxwell also carried out pioneering work in optics and colour vision. However, in his later years, his God-fearing Scottish upbringing brought evolutionary thinking of Darwin and others and he wrote papers denouncing natural selection.

Niels Bohr

Born is Copenhegan, Bohr (1885-1962) developed the modern idea of an atom, which has a nucleus at the centre with electrons revolving round it, When electrons move from one energy level to another, they emit discrete quanta of energy. The work won Bohr a Nobel prize in 1922. For his achievements, Carlsberg brewery gave Bohr a special gift: a house with a pipeline connected to its brewery next door, thus providing him with free beer for life. In 1954, Bohr helped establish Cern, the European particle physics facility. In 1975, his son, Aage, won a Nobel Prize in Physics for his research on atomic nuclei.

Ernest Rutherford

New Zealand-born Rutherford (1871-1937) is considered one of the greatest of all experimental physicists. He discovered the idea of radioactive half-life and showed that radioactivity involved the transmutation of one chemical element to another. He was awarded a Nobel in 1908 "for his investigations into the disintegration of the elements". Rutherford later became director of the Cavendish Laboratory at Cambridge University where, under his leadership, the neutron was discovered by James Chadwick in 1932 and the first experiment to split the nucleus was carried out by John Cockcroft and Ernest Walton. The element Rutherfordium was named after him in 1997.

b. Chemistry

Chemistry is the branch of science concerned with the substances of which matter is composed, the investigation of their properties and reactions, and the use of such reactions to form new substances. Chemistry is often referred to as the central science because it joins together physics and mathematics, biology and medicine, and the earth and environmental sciences. Knowledge of the nature of chemicals and chemical processes therefore provides insights into a variety of physical and biological phenomena. From the definition of chemistry, we can say that the main goal of chemistry is to seek to understand the behavior of matter by studying the behavior of atoms and molecules. **Chemist** is person who studies chemistry, or a scientist who works with chemicals or studies their reactions. Chemistry plays an important and useful role towards the development and growth of a number of industries. This includes industries like glass, cement, paper, textile, leather, dye etc. We also see huge applications of chemistry in industries like paints, pigments, petroleum, sugar, plastics, pharmaceuticals.

Chemistry's vast scope comprises **organic, inorganic, physical, analytical, and industrial chemistry**, along with biochemistry, environmental chemistry, medicinal chemistry, and much more.

Dmitri Mendeleev : Discovered the periodic table in a dream. Utilized the organizing principles of the periodic table to correctly predict the existence and properties of six new chemical elements.

John Dalton : Dalton's Atomic Theory is the basis of chemistry; discovered Gay-Lussac's Law relating gases' temperature, volume, and pressure; discovered the law of partial gas pressures.

Alfred Nobel : Invented dynamite, the blasting cap, gelignite, and ballistite; grew enormously wealthy manufacturing explosives; used his wealth to bequeath annual prizes in science, literature, and peace.

Dmitri Mendeleev 1834-1907 | John Dalton 1766-1844 | Joseph Priestley 1733-1804 | Antoine Lavoisier 1743-1794 | Michael Faraday 1791-1867 | Alfred Nobel 1833-1896

fig 1.10

Activity 1.3

What were the inventions of Joseph Priestley, Antoine Lavoiser and Michael Faraday?

More Branches of Chemistry

In addition to the main four or five branches of chemistry, there are many other disciplines. Here are some of them:

- **Agrochemistry –** Agrochemistry examines chemical processes important to agriculture.
- **Astrochemistry –** Astrochemistry is the study of chemical reactions in space.
- **Coordination Chemistry –** Coordination chemistry is the study of coordination complexes, which consist of a central atom (usually a metal) surrounded by ligands.
- **Forensic Chemistry –** Forensic chemistry applies chemical principles to investigate crime.
- **Geochemistry –** Geochemistry is the study of minerals, rocks, and the atmosphere of the Earth or other planetary body.
- **Medicinal Chemistry –** Medicinal chemistry designs, synthesizes, and studies drugs and other therapeutic agents.
- **Organometallic Chemistry –** Organometallic chemistry bridges both organic and inorganic chemistry. It is the study of compounds containing chemical bonds between carbon and a metal.
- **Petrochemistry –** Petrochemistry is the branch of organic chemistry focusing on petroleum and natural gas processing and refining.
- **Phytochemistry –** Phytochemistry is the study of chemicals derived from plants.
- **Polymer Chemistry –** Polymer chemistry is the sub-discipline of organic chemistry concerned with the chemistry of plastics and polymers.
- **Nuclear Chemistry –** Nuclear chemistry studies atoms and chemical reactions at the nuclear level. It includes the chemical study of fission, fusion, and radioactive decay.

- **Radiochemistry –** Radiochemistry studies radioisotopes and uses radioactive materials to study chemical reactions.
- **Solid-State Chemistry –** Solid-state chemistry examines reactions and properties of matter in the solid-state phase.
- **Spectroscopy –** Spectroscopy is the study of the interactions between light and matter.
- **Stereochemistry –** Stereochemistry studies the spatial arrangement of atoms within molecules.
- **Surface Chemistry –** Surface chemistry examines chemical processes on the surfaces of materials.
- **Thermochemistry –** Thermochemistry is the branch of physical chemistry dealing with heat in chemical systems.
- **Quantum Chemistry –** Quantum chemistry applies quantum mechanics and mathematics to describe the motion and interaction of subatomic particles in atoms and molecules.

c. Interconnected Fields

Science describes an area of knowledge, typically about something in the physical world, that can be explained in terms of scientific observation or the scientific method.

The sciences that describe the physical universe are categorized in different ways. The largest distinction in science is whether a science is pure, or theoretical, or whether it is applied, or practical. Pure science explains a phenomenon, while applied science determines how a particular phenomenon may be put to use. In general, pure science is divided into the following categories:

- Physical sciences, which deal with matter and energy and allow us to describe the material universe in terms of weight, mass, volume, and other standard, objective measures.
- Earth sciences, which explain the phenomena of Earth, its atmosphere, and the solar system to which it belongs.
- Life sciences, which describe living organisms, their internal processes, and their relationship to each other and the environment.

However, these three categories of pure science have areas of overlap, where one type of phenomenon may be associated with another. For example, light (studied in physics) is the energy source behind the (chemical) process of photosynthesis, or food production, in plants (studied in biology). For this reason, distinctions between pure sciences, and even between pure and applied sciences, can blur, and a new compound science can develop. An example of this is biochemistry, in which the chemical processes of living things (such as photosynthesis) are observed and explained.

Branches of Earth Science	
A. Astronomy • Study of objects beyond the Earth's atmosphere • Ex: Stars, moon, comets	**B. Meteorology** • Study of the atmosphere • Processes of weather and climate • Ex: Clouds, Rain, Hurricanes
C. Geology • Study of materials that make-up the Earth • Processes that form and change those materials • Ex: rocks, minerals, earthquakes, volcanoes	**D. Oceanography** • Study of the oceans • Ex: trenches, marine animals 

The interdisciplinary (interconnected) fields of science include earth science, astronomy, environmental sciences, etc. **Earth Science** is the study of the Earth and its neighbors in space. It is an exciting science with many interesting and practical applications. Some Earth scientists use their knowledge of the Earth to locate and develop energy and mineral resources. Others study the impact of human activity on Earth's environment, and design methods to protect the planet. Some use their knowledge about Earth processes such as volcanoes, earthquakes, and hurricanes to plan communities that will not expose people to these dangerous events.

Astronomy is the scientific study of celestial objects (such as stars, planets, comets, and galaxies) and phenomena that originate outside the Earth's atmosphere (such as the cosmic background radiation).

It is concerned with the evolution, physics, chemistry, meteorology, and motion of celestial objects, as well as the formation and development of the universe. Astronomy is one of the oldest sciences. Astronomers of early civilizations performed methodical observations of the night sky, and astronomical artifacts have been found from much earlier periods. However, the invention of the telescope was required before astronomy was able to develop into a modern science.

Environmental science, is the interdisciplinary academic field that draws on ecology, geology, meteorology, biology, chemistry, engineering, and physics to study environmental problems and human impacts on the environment. Environmental science is a quantitative discipline with both applied and theoretical aspects and has been influential in informing the policies of governments around the world. Environmental science is considered separate from environmental studies, which emphasizes the human relationship with the environment and the social and political dimensions thereof. For example, a researcher in environmental studies might focus on the economic and political dimensions of international climate-change protocols, an environmental scientist would seek to understand climate change by quantifying its effects with models and evaluating means of mitigation.

Physical sciences	Life sciences	Earth sciences
Physics Kinetics Mechanics Electromagnetics Thermodynamics	Biology Botany Zoology	Geology Meteorology Astronomy
Chemistry Inorganic Chemistry Electrochemistry Analytical Chemistry →		

Table 1.1

1.5 Safety measures to be taken while conducting scientific experiments

The science lab is an inherently dangerous place, with fire hazards, dangerous chemicals, and risky procedures. No one wants to have an accident in the lab, so it's imperative to follow lab safety rules.

- Never eat, drink, or smell the chemicals .Rather carefully 'fan' the fumes to your nose.
- Never look directly into a test tube or flask. Look at the contents from side.
- Never taste a chemical unless you are instructed by your teacher to do so .
- Always wear an apron or protective clothing when working with chemicals.
- Always tie back loose hairs.

In January 2010, a Chemistry lab at Texas Tech University exploded while two students were conducting some experiments to make derivatives of an explosive substance called nickel hydrazine perchlorate. They made a very dangerous mistake: they created 10 grams of the substance, despite the warning of the supervisor not to make more than 100 milligrams. When one of the students crushed the substance with a pestle, a terrible explosion occurred. Fortunately no one died, bout the student suffered from burns and lost three fingers.

In 1997, the famous chemist Karen Wetterhahn died because some drops of dimethyl mercury fell on her hands despite wearing gloves. The drops penetrated those gloves, reached the skin, and entered her body. After a few months she began to experience symptoms of mercury poisoning, such as loss of balance and poor speech, vision and hearing ability. She then entered into a coma and died.

Marie Curie died as a result of leukemia caused by the action of radiation that she faced during her experiments with radioactive elements.

- Always wear safety goggles or glasses to prevent getting materials in your eyes.
- Always read the labels on chemicals and heed all warnings.
- Listen and follow all directions.
- Use hot mitts to handle hot object.
- Never work in lab alone.
- Always wash your hands after handling lab materials
- Never run or push someone else in lab
- Never play around during experiments
- Keep your work area clean .
- Do not taste the chemicals.
- Immediately alert your teacher if an accident occures.

1.6 Achievements and Challenges of Science and Technology

Science and technology is the ultimate need of an hour that is changing the overall perspective of the human towards life. Over the centuries, there have been new inventions in the field of science and technology. Right from connecting with people to using digital products, everything involves science and technology. In other words, it has made life easy and simple. Moreover, humans now can live a simple life. There are modern equipments explored by tech experts to find something new for the future.

Science and technology have now expanded its wings to medical, education, manufacturing and other areas. Moreover, they are not limited to cities, but also rural areas for educational purposes.

Every day new technologies keep coming making life easier and comfortable.

Throughout history, science has come a long way. The evolution of the person is the contribution to science. Science helped humans to find vaccines, medicines and scientific aids. Over the centuries, humans have faced many diseases and illnesses taking many lives. With the help of science, medicines are invented to bring down the effect or element of these illnesses.

S.N.	Fields	Achievements	Challenges
1.	Health	- Development of effective treatment methods - Easy diagnosis of diseases - Eradication of some diseases (malaria) - Organ transplantation in human body - Development of check-in technology (X-ray, CT scan, ultrasound) etc.	When the amount of radiation is high, the cells are destroyed and there is a possibility of cancer
2.	Transport	Access to water, land, air transport	Pollution from smoke
3.	Agriculture	Insecticides DDT, BHC, Fertilizers, Scientific Agricultural Systems, Advanced seed production, Increased Production, Reduced Hunger	Local technology and seeds disappear Increasing dependence Soil degradation, Effect on human health
4.	Education	Increased access to ICT, distance education, research, information	Management of pollution caused by overuse, disruption of socialization
5.	Factory	Access to consumption, Use of sophisticated equipment	Management of chemical pollution, Environmental degradation, Global warming .
6.	Artificial inteligence	Development of automated technology Human life is comfortable	Automation-spurred job loss. Privacy violations. 'Deepfakes' Algorithmic bias caused by bad data. Socioeconomic inequality. Market volatility. Weapons automatization.
7.	Environment	Awareness, conservation efforts	climate change, pollution, environmental degradation, and resource depletion.

Table 1.2

The mobile we use for connectivity or communication or the smart technology which we use in our daily life, are a part of technology. From the machinery used in the factory to the robots created all fall under tech invention. In simpler words, technology has made life more comfortable. Advancement in science and technology has changed the modern culture and the way we live our daily life.

Science and technology have changed this world. From TV to planes, cars to mobile, the list keeps on going how these two inventions have changed the world we see-through. For instance, the virtual talks we do use our mobile, which was not possible earlier. Similarly, there are electrical devices that have made life easier.

Furthermore, the transportation process we use has also seen the contribution of science and technology. We can reach our destination quickly to any part of the world. Science and technology are not limited to this earth. It has now reached Mars.

With the progress in science and technology, we humans have become lazier. This is affecting the human mind and health. Moreover, several semi-automatic rifles are created using the latest technology, which takes maximum life. There is no doubt that the third world war will be fought with missiles created using technology. Man has misused the tech and used it for destructive purposes. Man uses them to do illegal stuff. Inproper use of technology such as a smartphone, etc. has affected children's health and edcuation. Terrorists use modern technology for damaging work.

Activity 1.4

Study and discuss the achievements and challenges gained from the development of science and technology and make a list of them.

1.7 Scientific Measurement

Scientific measurements generally adhere to the International System of Units (SI units). It is important to always include units when recording data, doing calculations and reporting results! Units are globally recognized and necessary for sharing information between scientists around the world.

When taking scientific measurements, it is important to be both accurate and precise. Accuracy represents how close a measurement comes to its true value. This is important because bad equipment, poor data processing or human error can lead to inaccurate results that are not very close to the truth. Precision is how close a series of measurements of the same thing are to each other. Measurements that are imprecise do not properly identify random errors and can yield a widespread result.

What is the difference between accuracy and precision and which is most important to scientific measurement? Accuracy describes the difference between the measurement and the part's actual value, while precision describes the variation you see when you measure the same part repeatedly with the same device.

1.7.1 Scientific Notation

The scientific notation is a simple but scientific way to write large or small numbers by expressing them in some power of ten. The Moon is 384000000 metres away from the Earth. Distance of the moon from the Earth can also be expressed as 3.84 x10^8m. This form of expressing a number is called the standard form or scientific notation. This saves writing down or interpreting large numbers of zeros. Thus

Scientific Notation

$$4500000 = 4.5 \times 10^{6}$$

Coefficient Base Exponent

$$0.00453 = 4.53 \times 10^{-3}$$

fig 1.11

In scientific notation a number is expressed as some power of ten multiplied by a number between 1 and 10.

For example, a number 62750 can be expressed as 62.75×10^3or 6.275×10^4or 0.6275×10^5. All these are correct. But the number that has one non-zero digit before the decimal i.e. 6.275×10^4 preferably be taken as the standard form. Similarly, the standard form of 0.00045 s is $4.5\text{x}10^{-4}$ s.

Example 1: Convert 1,500,000 to scientific notation. We move the decimal point so that there is only one digit to its left, a total of 6 places.

1.500,000 = 1.5×10^6

Example 2: Convert 0.000025 to scientific notation. For this, we move the decimal point 5 places to the right. 0.000025 = 2.5×10^{-5} (Note that when a number starts out less than one, the exponent is always negative.)

1.7.2Rules of Scientific Notation

To determine the power or exponent of 10, we must follow the rule listed below:

- The base should be always 10.
- The exponent must be a non-zero integer, that means it can be either positive or negative.
- The absolute value of the coefficient is greater than or equal to 1 but it should be less than 10.
- Coefficients can be positive or negative numbers including whole and decimal numbers.
- The mantissa carries the rest of the significant digits of the number.

Scientific notation must always be written with the same components as the following model

1.5876×10^6

A number in the ones' place.

decimal

$\times10^?$

(Any positive or negative exponent.)

As many numbers as necessary after the decimal

Let us understand how many places we need to move the decimal point after the single-digit number with the help of the below representation.

1. If the given number is multiples of 10 then the decimal point has to move to the left, and the power of 10 will be positive.

   Example: 6000 = 6×10^3 is in scientific notation.
2. If the given number is smaller than 1, then the decimal point has to move to the right, so the power of 10 will be negative.

   Example: 0.006 = 6×0.001 = 6×10^{-3} is in scientific notation.

Scientific Notation Examples

The examples of scientific notation are:

490000000 = 4.9×10^8

1230000000 = 1.23×10^9

50500000 = $5.05\text{ x }10^7$

0.000000097 = $9.7\text{ x }10^{-8}$

0.0000212 = $2.12\text{ x }10^{-5}$

Positive and Negative Exponent

When the scientific notation of any large numbers is expressed, then we use positive exponents for base 10. *For example:* 20000 = $2\text{ x }10^4$, where 4 is the positive exponent.

When the scientific notation of any small numbers is expressed, then we use negative exponents for base 10. *For example:*

$0.0002 = 2 \times 10^{-4}$, where -4 is the negative exponent.

From the above examples, we can say that the number greater than 1 can be written as the expression with positive exponent, whereas the numbers less than 1 with negative exponent.

Problems and Solutions

Question 1: Convert 0.00000046 into scientific notation.

Solution: Move the decimal point to the right of 0.00000046 up to 7 places.

The decimal point was moved 7 places to the right to form the number 4.6

Since the numbers are less than 10 and the decimal is moved to the right. Hence, we use a negative exponent here.

$\Rightarrow 0.00000046 = 4.6 \times 10^{-7}$

This is the scientific notation.

Question 2: Convert 301000000 in scientific notation.

Solution: Move the decimal to the left 8 places so it is positioned to the right of the leftmost non zero digits 3.01000000. Remove all the zeroes and multiply the number by 10.

Now the number has become = 3.01.

Since the number is greater than 10 and the decimal is moved to left, therefore, we use here a positive exponent.

Hence, 3.01×10^{8} is the scientific notation of the number.

Question 3:Convert 1.36×10^{7} from scientific notation to standard notation.

Solution: Given, 1.36×10^{7} in scientific notation.

Exponent = 7

Since the exponent is positive we need to move the decimal place 7 places to the right.

Therefore, $1.36 \times 10^{7} = 1.36 \times 10000000 = 1,36,00,000$.

How do you write 0.00001 in scientific notation?

The scientific notation for 0.00001 is 1 × 10^{-4}.

Here,

Coefficient = 1 Base = 10 Exponent = -4

Three parts of a scientific notation

The three main parts of a scientific notation are coefficient, base and exponent.

1.7.3 Metric Prefix

A metric prefix is a convenient way of expressing mulitiples and subdivisions (larger and smaller) of any defined unit. In metric that means multiplying or dividing by 10, 100, 1000, etc. It consists of a partial word like 'kilo' or 'milli'.

For example, the prefix 'kilo' means 'times a thousand' or 'one thousand of ' the units in question. So 'kilometre' means one thousand metres, and 'kilogram' means one thousand grams.

Likewise, they can mean a fraction of a unit rather than a multiple. For example, the prefix 'milli' means 'one thousandth of '. So, a millimetre is one thousandth of a metre. Put another way, there are one thousand millimetres in a metre.

These prefixes can be applied to any fundamental metric unit like the metre for distance, the gram for mass or weight, the watt for power, and so on.

The metric prefixes have entered many parts of our language and terminology, especially measurements and performance data of very big and very small things (gigabyte, microgram, nanosecond, etc). Knowing the actual values of the metric prefixes enables us to have a better understanding of the terms which use them, and the real size of things that are described by them.

Prefix	Symbol	Multiplier	
exa	E	10^{18}	1,000,000,000,000,000,000
peta	P	10^{15}	1,000,000,000,000,000
tera	T	10^{12}	1,000,000,000,000
giga	G	10^{9}	1,000,000,000
mega	M	10^{6}	1,000,000
kilo	k	10^{3}	1,000
hecto	h	10^{2}	100
deca	da	10^{1}	10
deci	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro		10^{-6}	0.000,001
nano	n	10^{-9}	0.000,000,001
pico micro micro	p	10^{-12}	0.000,000,000,001
femto	f	10^{-15}	0.000,000,000,000,001
atto	a	10^{-18}	0.000,000,000,000,000,001

Table 1.3

'Factor' equates to the ten-times factor; the positive ones represent the number of zeros after the figure; the negatives show the number of decimal places after the decimal point. e.g., kilogram = $10\times10\times10 = 10^3$ (10 to the power of three is ten multiplied by itself three times =1,000. A milligram is 1gm x 10^{-3} = one thousandth of a gram = 0.001gm). The metric prefixes help us to appreciate measurements and sizes much more accurately .

Here are some common random words which include metric prefix words, which are interesting discussion points if you seek to explore numbers yourself, or especially if you are attempting to make the subject appealing and accessible to young people or trainees of others sorts.

- gigabytes, terabytes and petabytes in computing
- nanotechnology and nanobot
- micro-organisms, microwaves, micron, micrometer (although note that 'micro' also has the general meaning of small, from the Greek 'mikros')
- trillion (tn) as an increasingly used measure of monetary budget or debt or output of government and economy (fast-eclipsing the scale of billions and millions, which were once beyond imagination but are now are dwarfed by the extent of modern national and international finances)
- the words decimate and centurion from Roman times
- you and your students will no doubt think of plenty more examples..

The metric prefixes offer a simple and quick way to introduce the main principles of decimals and big number calculations, as well as providing a meaningful reference by which to explore or teach most other aspects of mathematics.

1.8 Least Count

The least count is the smallest value of a physical quantity which can be measured accurately by an instrument.

A metre rule is a length measuring instrument . It is commonly used in the laboratories to measure length of an object or distance between two points. It is one metre long which is equal to 100 centimetres. Each centimetre (cm) is divided into 10 small divisions called millimetre (mm). Thus one millimetre is the smallest reading that can be taken using a metre rule and is called its **least count**. While measuring length, or distance, eye must be kept vertically above the reading point . The reading becomes doubtful if the eye is positioned either left or right to the reading point.

The metre rule least count =0.1 cm=1mm

The Measuring Tape

Measuring tapes are used to measure length in metres and centimetres. The measuring tape used by blacksmith and carpenters. A measuring tape consists of a thin and long strip of cotton, metal or plastic generally 10 m, 20 m, 50 m or 100 m long. Measuring tapes are marked in centimetres as well as in inches.

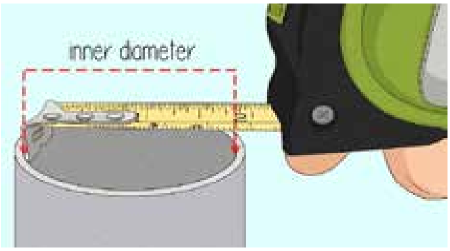


fig 1.12

Vernier Callipers

The accuracy obtained in measurements using a metre rule is upto 1 mm. However an accuracy greater than 1 mm can be obtained by using some other instruments such as a Vernier Callipers.

A Vernier Callipers consists of two jaws. One is a fixed jaw with main scale attached to it. Main scale has centimetre and millimetre marks on it. The other jaw is a moveable jaw. It has vernier scale having 10 divisions over it such that each of its division is 0.9 mm. The difference between one small division on main scale division and one vernier scale division is 0.1 mm. It is called least count (LC) of the Vernier Callipers. Least count of the Vernier Callipers can also be found as given below:

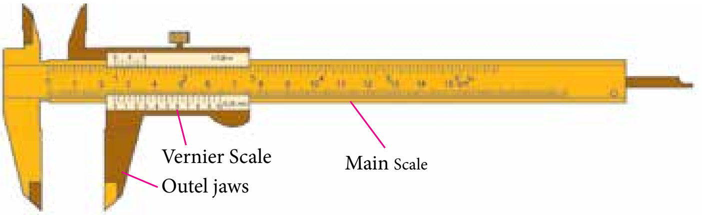


fig 1.13

$$\text{Least count of Vernier Callipers} = \frac{\text{smallest reading on main scale}}{\text{no. of divisions on vernier scale}}$$

$$= \frac{1\ \text{mm}}{10\ \text{divisions}} = 0.1\ \text{mm}$$

Hence LC $= 0.1\ \text{mm} = 0.01\ \text{cm}$

Screw Gauge

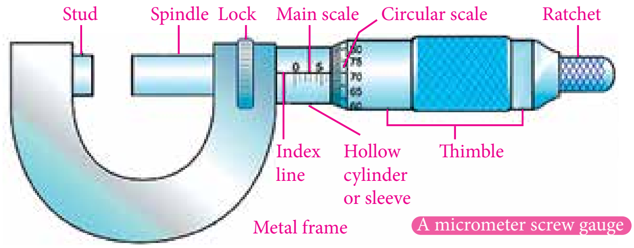


fig 1.14

A screw gauge is an instrument that is used to measure small lengths with accuracy greater than a Vernier Calliper. It is also called as micrometer screw gauge. A simple screw gauge consists of a U-shaped metal frame with a metal stud at its one end as shown in above figure . A hollow cylinder (or sleeve) has a millimetre scale over it along a line called index line parallel to its axis. The hollow cylinder acts as a nut. It is fixed at the end of U-shaped frame opposite to the stud. A Thimble has a threaded spindle inside it. As the thimble completes one rotation, the spindle moves 1 mm along the index line. It is because the distance between consecutive threads on the spindle is 1 mm. This distance is called the pitch of screw on the spindle. The thimble has 100 divisions around its one end. It is the circular scale of the screw gauge. As thimble completes one rotation, 100 divisions pass the index line and the thimble moves 1 mm along the main scale. Thus each division of circular scale crossing the index line moves the thimble through 1/100 mm or 0.01 mm on the main scale. Least count of a screw gauge can also be found as given below:

$$\text{Least count} = \frac{\text{pitch of the screw gauge}}{\text{no. of divisions on circularscale}}$$

$$= \frac{1\text{ mm}}{100} = 0.01\text{ mm} = 0.001\text{ cm}$$

Thus least count of the screw gauge is 0.01 mm or 0.001 cm.

1.8.1 Importance of Least Count

Least count of an instrument is one of the very important tools in order to get accurate readings of instruments like vernier caliper and screw gauge used in various experiments. Least count uncertainty is one of the sources of experimental error in measurements.

The least count of a measuring instrument is the smallest change in the measured quantity that can be resolved on the instrument's scale.The least count is related to the precision of an instrument; an instrument that can measure smaller changes in a value relative to another instrument, has a smaller 'least count' value and so is more precise.

1.8.2 Examples of Least Count

The least count of an instrument is inversely proportional to the **precision** of the instrument. For example, a sundial may only have scale marks representing the hours of daylight; it would have a least count of one hour. A stopwatch used to time a race might resolve down to a hundredth of a second, its least count.

1.9 Average in Measurement

Average means the sum of the numbers divided by the number of numbers. It is also known as the arithmetic mean. Average shows a single value which defines a group of numbers by the ratio of their sum to total count.

Often 'average' refers to **the arithmetic mean**, the sum of the numbers divided by how many numbers are being averaged. In statistics, mean, median, and mode are all known as measures of central tendency, and in colloquial usage any of these might be called an average value.

1.9.1 Importance of Average in Measurement

The mean, also referred to by statisticians as the average, is the most common statistic used to measure the center of a numerical data set. The mean is the sum of all the values in the data set divided by the number of values in the data set.

Importance of Average

It is also called measure of central tendency i.e. a measure of the central value in the population. It is representative of the entire data. If X is the average of a dataset, then the numbers to its left and right balance each other. It is easily affected by outliers. It is a term used for discrete random variables whereas for continuous random variables, the term used is expected value. They are widely used in physics, sociology, economics, meteorology, etc. This concept is used in our day to day lives as well for example how much money we spend per week or fuel consumed per mile etc.

Formula of Average

The formula is given as:

$$\text{Avg} = \frac{(a_1 + a_2 + a_3 + ... + a_n)}{n}$$

Where a_1, a_2, a_3.. a_n are numbers in a series and n is the total quantity of numbers

Example: Avg of 2,4 and 6 is calculated as (2+4+6)/3 = 4

Examples of Average

There are several examples which highlight how the value is calculated and is important is our day to day lives.

i. The mileage of vehicles or cars is an avg value. This shows the performance of a car i.e. how much fuel is used for the distance traveled. If the car covers a larger distance on lower consumption, it is a good car.

ii. In cricket, batting avg is the number of runs the batsman scores to the number of times he bats. The higher the score per innings show that the player is good as compared to someone who doesn't score many runs per innings.

iii. Calculating averages of marks is a common practice in schools and colleges. This helps to decide the rank of students based on the marks across several subjects.

Table : Fundamental and Supplementary Units

Fundamental Units

S.N.	Quantity	Unit	Symbol
1	Length	metre	m
2	Mass	kilogram	kg
3	Time	second	s
4	Electric Current	ampere	A
5	Thermodynamic Temperature	kelvin	K
6	Luminous Intensity	candela	cd
7	Amount of Substance	mole	mol

Supplementary Units

S.N.	Quantity	Unit	Symbol
1	Plane Angles	radian	rad
2	Solid Angles	steradian	sr

Table : The seven base units of the SI

Quantity	SI unit
Time	"The second, symbol s, is the SI unit of time. It is defined by taking the fixed numerical value of the caesium frequency $\Delta\nu_{Cs}$, the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom, to be 9192631770 when expressed in the unit Hz, which is equal to s^{-1}.
Length	"The metre, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum *c* to be 299792458 when expressed in the unit m s^{-1}, where the second is defined in terms of $\Delta\nu_{Cs}$.
Mass	"The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant *h* to be 6.62607015×10^{-34} when expressed in the unit J s, which is equal to kg m^2 s^{-1}, where the metre and the second are defined in terms of c and $\Delta\nu_{Cs}$.
Electric current	"The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge *e* to be $1.602176634\times10^{-19}$ when expressed in the unit C, which is equal to A s, where the second is defined in terms of $\Delta\nu_{Cs}$.
Thermodynamic temperature	"The kelvin, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant *k* to be 1.380649×10^{-23} when expressed in the unit J K^{-1}, which is equal to kg m^2 s^{-2} K^{-1}, where the kilogram, metre and second are defined in terms of *h, c* and $\Delta\nu_{Cs}$.
Amount of substance	"The mole, symbol mol, is the SI unCit of amount of substance. One mole contains exactly $6.022\,140\,76 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, N_A, when expressed in the unit mol^{-1} and is called the Avogadro number. The amount of substance, symbol *n*, of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.
Luminous intensity	"The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540×10^{12} Hz, K_{cd}, to be 683 when expressed in the unit lm W^{-1}, which is equal to cd sr W^{-1}, or cd sr kg–1 m–2 s3, where the kilogram, metre and second are defined in terms of *h, c* and $\Delta\nu$

Source : The International Bureau of Weights and Measures (BIPM), Paris France, 2021

Table 1.4

NOTE : The values mentioned here need not be remembered or asked in a test. They are given here only to indicate the extent of accuracy to which they are measured. With progress in technology, the measuring techniques get improved leading to measurements with greater precision. The definitions of base units are revised to keep up with this progress.

Project Works

i. With the help of the internet and magazines, you collecte data on the topics mentioned in the table below. Express the data you have collected in scientific notation and present it in the classroom.

Topics	Data	Scientific notation
Population of Nepal		
Population of women in Nepal.		
The size of Nepal's annual budget		
Annual production of paddy in Nepal		
Population of the world		
Approximate speed of light in Kilometer per hour		1.08×109 km/h
Distance from the Earth to the sun in miles		
Approximate number of cells in the human body		
Mass of an electron		
Distance from the sun to the nearest star (Proxima Centauri) in Kilometer	39,900,000,000,000 km	

ii. Make a list of the five items you use on a daily basis. Now measure the lengths of all of them and show them to your classmates by expressing them in appropriate units and at least counting.

iii. Prepare a brief report by searching for professional opportunities in any one field of science.

Exercise

A. Choose the correct one and put the tick mark (√)

i. Science refers to a systematic and organized body of knowledge in any area of inquiry that is acquired using :

a. The scientific method
b. The fundamental method
c. The theoretical method
d. The hypothesis method

ii. Veterinary profession is related to which branch of science?

a. Biology
b. Physics
c. Chemistry
d. Geology

iii. **The physical science is related to**

a. Chemical world b. Biological world

c. Inorganic world d. Organic world

iv. **The scientific notation of 75 is :**

a. 75×10 b. 7.5×10

c. 0.75×10 d. 075×10

v. **The metre rule least count is :**

a. 0.1 cm b. 0.01m

c. 0.01mm d. 0.10m

vi. **Sir Isaac Newton is related to which field of science ?**

a. Biology b. Physics

c. Chemistry d. Astronomy

B. Write the field and branch of science based on the professional opportunities given below :

i. Chemist ii. Physist iii. Mechanical Engineer

iv. Geologist v. Radiologist v. Astronomer

vii. Environmentalist viii. Botanist ix. Farmer

C. Write the branches of following field of sciences :

i. Biology ii. Physics

iii. Chemistry iv. Earth Science

D. Write any three achievements of following field of science :

i. Biology ii. Physics

iii. Chemistry iv. Earth Science

v. Environment science

E. Complete the following :

i. A science involves a pursuit of knowledge covering general truths or the operations of ....

ii. Physical sciences were divided into five distinct disciplines; physics, chemistry, ..., geology and meteorology.

iii. **Biology** literally means....................

iv. The least count of an instrument is inversely proportional to the .... of the instrument.

v. Physical measurements are usually expressed for small and large quantities in ...., with powers of 10.

vi. Genetics is a branch of biology which studies .... and variation in organisms.

vii. Earth Science is the study of the ....and its neighbors in space.

vii. Conventional modern medicine is sometimes called ....medicine

F. Answer the following questions .

i. What is meant by science ?

ii. What do you understand by the term 'Physical Science' ?

iii. What are the requirements for scientific method ?

iv. Name any four fields of science .

v. Name the three branches of physics and chemistry .

vi. What is physics ?

vii. Write down how scientific studies are done.

viii. Make a list of fields of science .

ix. Explain the interrelationships of the fields of science with examples.

x. What is the significance of experiment in scientific method? Explain with examples.
xi. Make a list of safety precautions to be taken while conducting scientific experiments.
xii. Write the definition of scientific notation.
xiii. Why is a metric prefix necessary? Explain with examples.
xiv. Write down the importance of least count .
xv. Write down the importance of average in measurement .

G. Numerical Problems :

i. The size of bacteria is 1 micron. Find the number of bacteria present in 1 m length.
ii. The distance of a galaxy is 5.6×10^{25} m. Assuming the speed of light to be 3×10^8 ms^{-1}. Find the time taken by light to reach the galaxy.

[**Hint:** Time taken = $\frac{\text{Distance travelled}}{\text{speed}}$]

iii. Estimate your age in seconds.
iv. Your hair grows at the rate of 1mm per day . Find their growth rate in nms^{-1} .
v. A screw gauge has 50 divisions on its circular scale. The pitch of the screw gauge is 0.5 mm. What is its least count?
vi. Convert 0.00000046 into scientific notation.
vii. Convert the following to scien tific notation.

a. 0.005 = ____________ b. 5050 = ____________
c. 0.0008 = ____________ d. 1000000 = ____________
e. 0.025 = ____________ f. 0.0025 = ____________

vii. Convert the following to standard notation .

a. 1.5×10^3 = ________ b. 1.5×10^{-3} = ________
c. 3.75×10^{-2} = ________ d. 1.2×10^{-4} = ________
e. 2.2×10^5 = ________ f. 4×10^0 = ________

viii. Perform the following operations and express the answers in scientific notation.

a. $1.2 \times 10^5 + 5.35 \times 10^6$ b. $6.91 \times 10^{-2} +2.4 \times 10^{-3}$

H. Some Extra activities :

i. Complete the following table :

Numbers (Measurement)	Step of transformation	Scienctific notation
83,0000000000000000W	....	....
Distance between the Earth and Sun 150000000km	....	....
The size of an amoeba 0.00000004m	....	....

ii. Write the Least Count of the devices in the table :

S.N.	Devices	Least Count
1	Ammeter	
2.	Voltmeter	
3.	Measuring Tape	
4.	Measuring Cylinder	
5.	Hand Watch	
6.	Chemical Balance	

Unit 2
Classification of Living Beings

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- introduce the binomial system of nomenclature of organisms (living beings) and write the scientific names of some of the prevalent organisms.
- define a genus based on the concept of a species and define a species as a basic unit of classification.
- clarify the relationship between the different levels of classification of organisms according to the five kingdom system
- describe the main characteristics of Monira, Protista and Fungi kingdom with examples.

Taxonomy is the part of science that focuses on naming and classifying or grouping organisms. A Swedish naturalist named Carolus Linnaeus is considered the 'Father of Taxonomy' because, in the 1700s, he developed a way to name and organize species that we still use today.

2.1 Introduction

Every living thing is made of cells. Cells are the basic unit of all organisms (living beings). Cells are like little factories inside all living things that have specific jobs to do, working each day to keep the organism alive and functioning. Some creatures are made up of just one cell, while others are made up of trillions of cells. Human beings are made up of many different types of cells, including skin cells, nerve cells, brain cells, blood cells, and muscle cells. Cells are tiny, but they can be seen with a microscope.

Scientists study cells of all kinds to learn more about how life works. There are two main kinds of cells that make up living things: **prokaryotic** and **eukaryotic**.

Biologists categorized different organisms into several kingdoms.

Classification	Proposed by	Type of organisms
Two kingdom classification	Carolus Linnaeus in 1753	1. Plants
		2. Animals
		1. Monera
Five Kingdom classification	Robert Whittaker in 1969	2. Protista
		3. Fungi
		4. Plantae
		5. Animalia
	Carl Woese in 1977	1. Monera
		i. Archaea
		ii. Eubacteria
		2. Protista
		3. Fungi
		4. Plantae
		5. Animalia

Table 2.1

Eukaryotic cells, such as those in animals and plants, are known as eukaryotes (you-carry-oats). Eukaryotic cells are larger and more complex. They contain smaller components called organelles, such as mitochondria which makes energy for the cell, and ribosomes which make proteins.

Prokaryotic cells, such as those making up bacteria, are known as prokaryotes (pro-carry-oats). Prokaryotic cells are small, simple cells that contain no nucleus or organelles. They have a membrane on the outside, with cytoplasm and DNA on the inside.

Plant and animal cells are both eukaryotic, but they are different in structure. For example, only plant cells have rigid cell walls and contain chloroplasts, which make food for the plant in a process called photosynthesis. Animal cells have a flexible cell membrane, but no cell wall.

Scientists have identified **1.7 million** different **species** on Earth, but they estimate there are at least 10 million species yet to be discovered. Every year scientists identify and name more new organisms. Living things include everything from the blue whale, which is as long as three school buses, to tiny bacteria that you cannot even see with neked eye. How can anyone keep track of so many living things? For as long as humans have lived, people have tried to classify organisms, or sort them into groups, based on their similarities and differences.

All the living beings of the world are divided into various group depending upon their similarities and characteristics. It makes easy to study about the organisms. We cannot study about the living beings separately, it is very difficult. Thus, they are arranged into different groups and sub-group which is known as a **classification of living beings**.

2.2 Classification of Living Beings

In earlier classification systems, the living beings was divided and classified into two kingdoms i.e. are plants and animals. In previous years the taxonomist was agreed on five-kingdom classification after developing the two-kingdom classification system and three kingdom classification systems. However, in recent years the taxonomist agreed on five-kingdom classification systems. The only difference in the five-kingdom classification system and six kingdom classification system is that the kingdom Protista was further divided into two kingdoms.

The Hierarchy of Classification- Groups

Biologists, such as **Ernst Haeckel (1894), Robert Whittaker (1969)** and **Carl Woese (1977)** have tried to classify all living organisms into broad categories, called kingdoms. The classification Whittaker proposed has five kingdoms: Monera, Protista, Fungi, Plantae and Animalia, and is widely used. These groups are formed on the basis of their cell structure, mode and source of nutrition and body organisation. The modification Woese introduced by dividing the Monera into Archaebacteria (or Archaea) and Eubacteria (or Bacteria) is also in use.

Further classification is done by naming the sub-groups at various levels as given in the following scheme:

Kingdom

Phylum (for animals) / Division (for plants)

Class

Order

Family

Genus

Species

Thus, by separating organisms on the basis of a **hierarchy of characteristics** into smaller and smaller groups, we arrive at the basic unit of classification, which is a **species**. So what organisms can be said to belong to the same species? Broadly, a species includes all organisms that are similar enough to breed and perpetuate.

The important characteristics of the five kingdoms of Whittaker are as follows:

1. Kingdom: Monera
2. Kingdom: Protista
3. Kingdom: Fungi
4. Kingdom: Plantae
5. Kingdom :Animalia

The characteristics of the Monera, Protista and Fungi Kingdoms are mentioned here –

Kingdom : Monera

The kingdom Monera includes single-celled prokaryotic organisms. The members of this kingdom do not have a true nucleus without membrane-bound organelles.

Characteristics of Monera

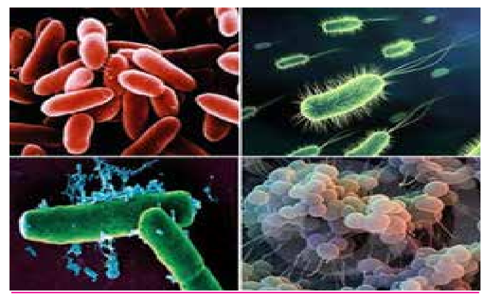


Table 2.2

- They are unicellular, although some types form clusters, colonies, and change of cell.
- Some organisms in the kingdom Monera produce their food through photosynthesis, and most of them are heterotrophs, meaning they cannot produce their food and rely on other plants and animals such as algae. The organisms that perform photosynthesis have chlorophyll in their cytoplasm.
- The kingdom Monera includes three different kinds of organisms that are Archaabacteria, Eubacteria and Cyanobacteria.
- They contain 70S (where S=Svedberg units) ribosomes.
- The DNA is naked and is not bound by a nuclear membrane.
- It lacks organelles like mitochondria, lysosomes, plastids membrane, Golgi bodies, endoplasmic reticulum, centrosome, etc.
- They reproduce asexually by binary fission or budding.
- The cell wall is rigid and made up of peptidoglycan.
- Flagellum serves as the locomotory organ.
- These are environmental decomposers.
- They show different modes of nutrition such as autotrophic, parasitic, heterotrophic, or saprophytic.

Kingdom:Protista

v. The protista (a collection of single-celled organisms that do not fit into any other category) includes many kinds of **unicellular eukaryotic organisms**. Some of these organisms use appendages, such as hair-like cilia or whip-like flagella for moving around. The term 'Protista' is derived from the Greek word "protistos", meaning '*the very first*'. Their mode of nutrition can be **autotrophic or heterotrophic**. Scientists speculate that protists form a link between plants, animals and fungi as these three kingdoms diverged from a common protist-like ancestor, billions of years ago. Examples are unicellular algae, diatoms and protozoans.

Characteristic of Kingdom Protista

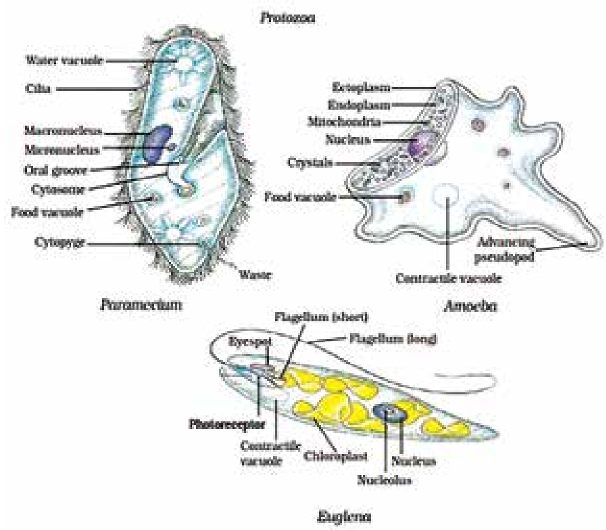
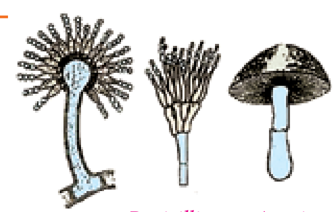


Fig 2.3

- These are usually aquatic, present in the soil or in areas with moisture.
- Most protista species are unicellular organisms, however, there are a few multicellular protists such as kelp. Some species of kelp grow so large that they exceed over 100 feet in height. (Giant Kelp).
- Just like any other eukaryotes, the cells of these species have a nucleus and membrane-bound organelles.
- They may be autotrophic or heterotrophic in nature. An autotrophic organism can create their own food and survive. A heterotrophic organism, on the other hand, has to derive nutrition from other organisms such as plants or animals to survive.
- Symbiosis is observed in the members of this kingdom. For instance, kelp (seaweed) is a multicellular protista that provides otters, protection from predators amidst its thick kelp. In turn, the otters eat sea urchins that tend to feed on kelp.
- Parasitism is also observed in protista. Species such as Trypanosoma protozoa can cause sleeping sickness in humans.
- A few organisms belonging to kingdom Protista have pseudopodia that help them to move.
- Protista reproduces by asexual means. The sexual method of reproduction is extremely rare and occurs only during times of stress.

Kingdom : Fungi

These are **heterotrophic eukaryotic organisms**. They use decaying organic material as food and are therefore called saprophytes. Many of them have the capacity to become multicellular organisms at certain stages in their lives. They have cell-walls made of a tough complex sugar called chitin.



Aspergillus *Penicillium* *Agaricus*

Fig 2.4

Some fungal species live in permanent mutually dependent relationships with bluegreen algae (or cyanobacteria). Such relationships are called **symbiotic**. These symbiobic life forms are called **lichens**. We have all seen lichens as the slow-growing large coloured patches on the bark of trees.

Fungus, plural fungi, any of about 144,000 known species of organisms of the kingdom Fungi, which includes the yeasts, rusts, smuts, mildews, molds, and mushrooms. There are also many funguslike organisms, including slime molds and oomycetes (water molds), that do not belong to kingdom Fungi but are often called fungi.

There are three types of fungi based on nutrition:–

i) **Saprotrophic fungi** - Fungi obtain food from dead and decayed materials.e,g: Mucor, Mushroom, Penicillium etc.

Fig 2.5

ii) Parasitic Fungi - Get feed from living organisms and destroy them.e.g.Puccinia, Taphrina etc.

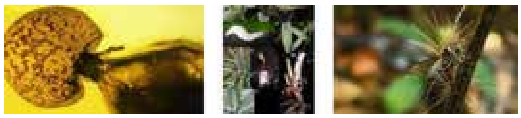


Fig 2.6

iii) Symbiotic Fungi - Grow in a living organism and get mutually benefited. e.g.: Mycorrhizal (live on plant root), Lichens (contain algae) etc.

Fig 2.7

Characteristics of Fungi :

- Fungi are eukaryotic, non-vascular, non-motile and heterotrophic organisms.
- They reproduce by means of spores.
- They may be unicellular or filamentous.
- Fungi exhibit the phenomenon of alternation of generation.
- Fungi lack chlorophyll and hence cannot perform photosynthesis.
- Fungi store their food in the form of starch.
- Biosynthesis of chitin occurs in fungi.
- The nuclei of the fungi are very small.
- The fungi have no embryonic stage. They develop from the spores.
- The mode of reproduction is sexual or asexual.
- Some fungi are parasitic and can infect the host.
- Fungi produce a chemical called pheromone which leads to sexual reproduction in fungi.
- Examples include mushrooms, moulds, yeast.

Fungi are one of the most important groups of organisms on the planet as it plays a vital role in the biosphere and has great economic importance on account of their both benefits and harmful effects.

Following are some of the important uses of fungi:

- **Recycling** – They play a major role in recycling the dead and decayed matter.
- **Food** – Mushrooms species are edible which are cultured and are used as food by humans.
- **Medicines** – There are many fungi which are used to produce antibiotics, to control diseases in humans and animals. Penicillin antibiotic is derived from a common fungi Penicillium.
- **Biocontrol Agents –** Fungi are involved in exploiting insects, other small worms and help in controlling pests. Spores of fungi are used as spray-on crops.
- **Food spoilage –** Fungi play a major role in recycling organic material and are also responsible for major spoilage and economic losses of stored food.

Classification of Kingdom Animalia

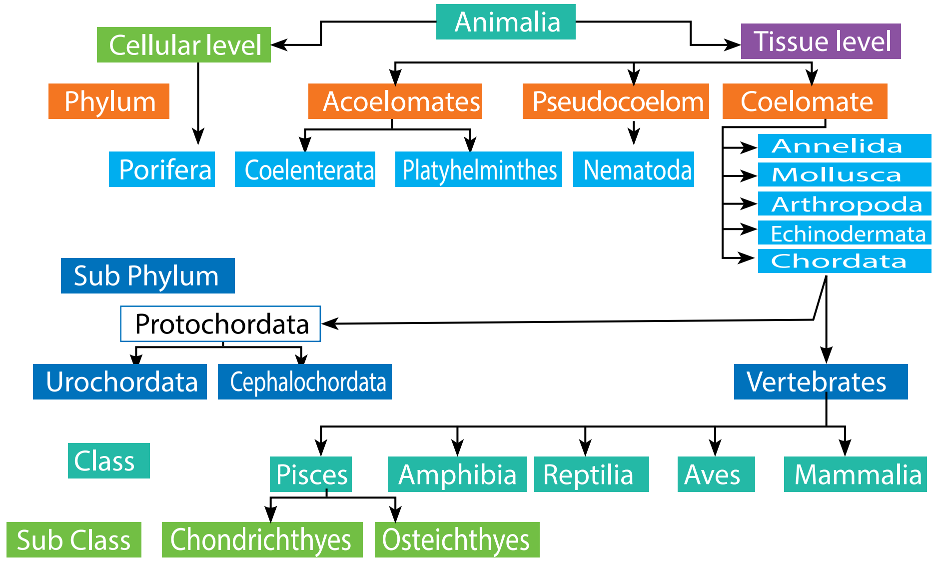


Fig 2.8

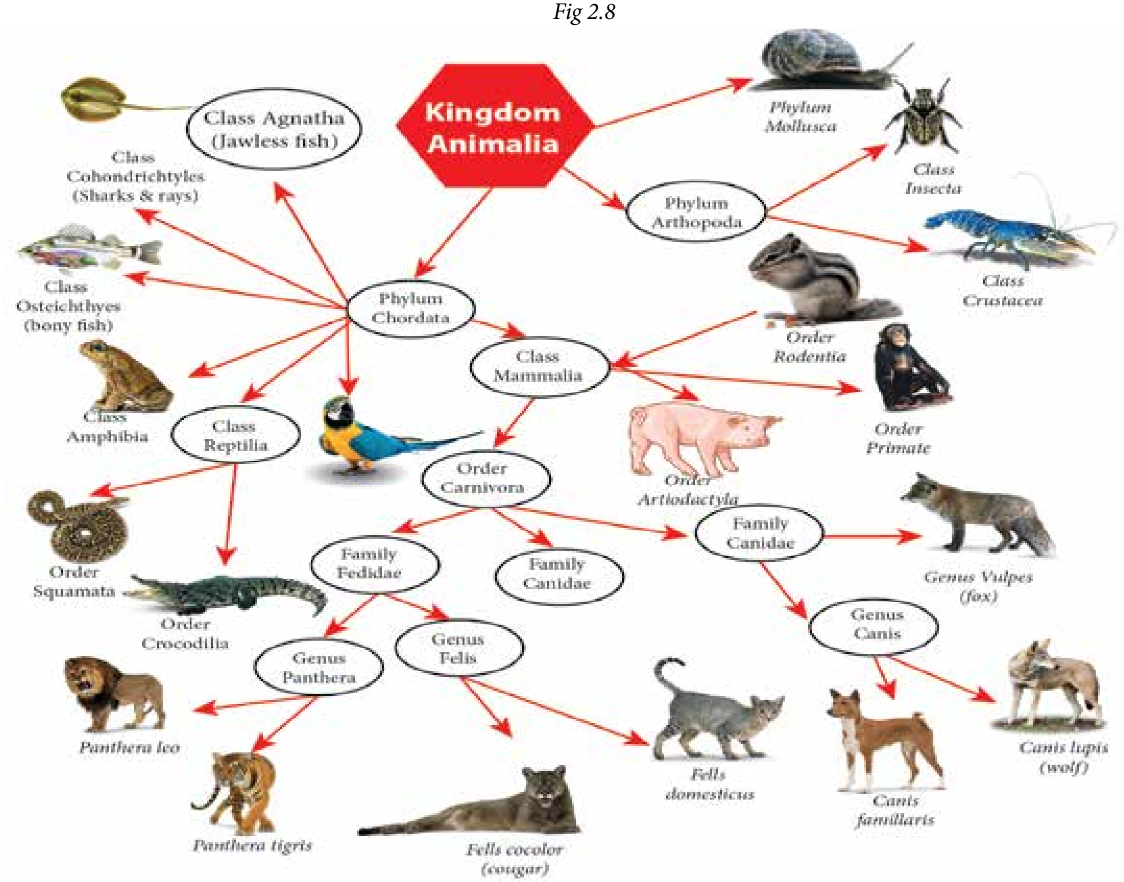


Fig 2.9

2.3 Importance of Classification of Living Beings

- Classification systems improve our ability to explain relationships among living beings.
- Classification helps in identifying living organisms into their correct groups for reference.
- Classification helps in avoiding chaos and confusion when dealing with animals as it arranges the information on organisms in an orderly manner.
- Classification brings living organisms with similar characteristics together but separate those with different features.
- Taxonomic systems provide relatively stable, unique, and unequivocal names for organisms.
- It makes the study of such a wide variety of organisms easy.
- It projects before us a good picture of all life forms at a glance.
- It helps us understand the interrelationship among different groups of organisms.
- It serves as a base for the development of other biological sciences such as biogeography etc.
- Various fields of applied biology such as agriculture, public health and environmental biology depend on classification of pests, disease vectors, pathogens and components of an ecosystem.

2.3.1 Binomial System of Nomenclature

Nomenclature is the assignment of **distinctive names** to each species. Plants and animals are known by different common names in different parts of the world. Within the same country, people of different area and regions might use different common names. For example, *Ipomoea batatas* (sweet potato) is called **Sakharkand** or **Tarul** or **Gulio Aaloo** in Nepali, **Suthuni** in Maithili, **Alhuwa** in Magahi and Bhojpuri , **Meetha aloo** in Bengali,

Activity 2.2

Find out the names of following animals and plants in as many languages as you can:

i) Ant **ii) Neem** **iii) Lotus** **iv) Peacock** **v) Tiger** **vi) Potato**

Similarly, the common house sparrow is called **Bhangera** in Nepal, **Goraiya** in India, Sparrow in England, and **Haussperling** in America.

Thus, common names are very confusing. The earliest scientific names were polynomial and were composed of many words (which gave the characteristics of plants).

For example, *Sida acuta* (a member of Malvaceae) was named as *Chrysophyllum folis, ovalis superne glabris parallel striatis subtus, tomentosonitidis*.

Such long names were of course very **difficult to remember**. Hence, to make things easier, a binomial system of nomenclature was introduced soon after.

The binomial nomenclature system was given by **Carolus Linnaeus**, a Swedish naturalist. Carolus Linnaeus used this nomenclature system for the first time on a large scale and proposed the scientific names of many plants and animals. He first employed this system in his book *Species Plantarum* which was published in the year 1753.

Linnaeus proposed the scientific names of **plants** in his book *Species Plantarum* which was published on 1 May 1753. So, this was the initiation of a binomial system for plants (Note: any name proposed for plants before this date is not accepted today).

Linnaeus proposed the scientific names of **animals** in his book *Systema Naturae* (10th edition). It was published on 1 August 1758. So initiation of a binomial system for animals is believed to have started then.

According to binomial nomenclature system, the name of a plant or animal is composed of two Latin (or Latinised) words. They are **derived from Latin** irrespective of their origin. For example,

- *Solanum tuberosum* is the scientific name for potato.
- *Passer domesticus* is the scientific name for house sparrow.
- *Mangifera indica* is the scientific name for mango.

Binomial nomenclature of mango:–

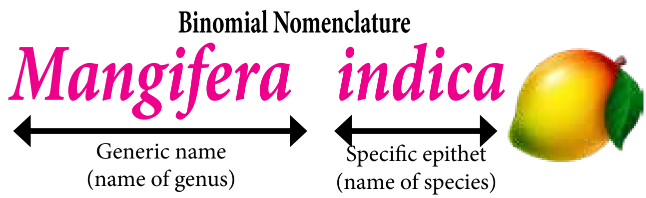


Fig 2.10

Each name has two components, the **generic name**, and the **specific epithet**. The first word indicates the **name of the genus** (also called generic name). The second word denotes the **name of the species** (also called specific epithet). The generic name always begins with a **capital letter** and the specific name with a **small letter**. Both the words, when handwritten, are **separately underlined** and they're printed in **italics** to indicate their Latin origin. The generic and specific names always have some meaning. They are based on some special characters of the plant and animals, or the name of any scientist or on some legend.

Usually, the **name of the author**, who names the organism, is also written in full or in abbreviated form after the specific name. The name of the scientist should be **neither underlined nor in italics**, but written in Roman letters (simple alphabets).

Thus, in the case of *Mangifera indica* L., the L. stands for Linnaeus, and in *Lychnis alba* Mill., the Mill. stands for Miller.

Sometimes a single species is described under different names by different authors. These names are called **synonyms**. In such cases, the name under which the species is first described is considered to be valid.

Binomial Nomenclature is important to standardize the naming of living organisms. Naming of living organisms should be such that a particular organism is known by the same name all over the world. Description of an organism should enable the people of any part of the world to arrive at the same exact name.

Common names aren't unique, unlike scientific names. Hence, the use of common names can lead to great **confusion** and **conflict** as to what animal or plant is being referred to and what is its relationship with other plants or animals.

Obviously it is not possible to identify the enormous number of living organisms based on their common/vernacular/local names hence scientific names are given to them.

Binomial Nomenclature is important because it allows people from all over the world to **communicate** unambiguously about the various plant and animal species. Also, it makes sure that every scientific name is **unique**.

For example, if tigers are given the scientific name *Panthera tigris*, no other animal species can be given the same exact name.

So, if you are an Nepali scientist studying the relatives of tigers and you wish to discuss it with an American scientist, both of you can use the scientific name to address tigers. This way, you will know exactly what the other person is talking about and vice versa.

Scientific names of a particular plant/animal also tell us about its **relationship** with other plants/ animals. Scientific names consist of a generic epithet (name of the genus) and a specific epithet (name of species). Most of the genera are made up of many species.

In the genus *Panthera*, there are other species as well. For example,

- *Panthera tigris* (tiger)
- *Panthera uncia* (snow leopard)
- *Panthera onca* (jaguar)
- *Panthera leo* (lion)
- *Panthera pardus* (leopard)

All of these species share the same generic epithet (name of the genus), this indicates that they're closely related to each other.

Activity 2.3

Find out the scientific names of any five common animals and plants. Do these names have anything in common with the names you normally use to identify them?

Trinomial nomenclature

Trinomial nomenclature is basically an extension of Binomial nomenclature. Certain species can be divided into smaller units, called **subspecies** or varieties, on the basis of finer differences. The name of the variety is written after the specific epithet. Thus, the name may become a trinomial or a three-word name.

According to this system, the name of any organism is composed of **three** words:

a. Generic name
b. Specific epithet
c. Subspecific epithet (Name of variety)

For example,

- *Homo sapiens europeus* is the name of the man of European race.
- *Brassica oleracea botrytis* (Cauliflower)
- *Brassica oleracea capitata* (Cabbage)
- *Brassica oleracea caulorapa* (Gyamtha kobhi)

Code of Biological Nomenclature

Anyone can study, describe, identify, and name an organism provided he/ she follows certain universal rules. These rules are framed and standardized by the **International Code of Botanical Nomenclature (ICBN)** for plants and the **International Code of Zoological Nomenclature (ICZN)** for animals. The codes help in avoiding errors, duplication, confusion, and ambiguity in scientific names. They're established and improved upon at the **International Botanical and Zoological Congress** held from time to time.

The names of bacteria are decided by the **International Code of Bacteriological Nomenclature (ICBN)**.The names of viruses are decided by the **International Code of Viral Nomenclature (ICVN)**. Similarly, there is a separate **International Code of Nomenclature for Cultivated Plants (ICNCP)**. If both generic and specific names are the same, these are called **tautonyms**. In plant nomenclature, tautonyms are not valid. Generic name and specific epithet should not be the same in plants. But tautonyms are valid in animal nomenclature. For example,

- *Naja naja* (Indian cobra)
- *Rattus rattus* (Rat)

2.3.2 Taxonomy

The term "*taxonomy*" was developed from two Greek words, "*taxis*," meaning arrangement, and "*nomia*," meaning distribution or method. In simple words, the definition of taxonomy is a branch of science that deals primarily with the *description*, *identification*, nomenclature, and *classification of organisms*. It is essential to classify living organisms into different groups and subgroups.

In biology, taxonomy is defined as the classification of biological organisms. Starting from grouping the organisms into taxa (singular: taxon) and then given taxonomic rank. These groups can be collected to form high-ranked supergroups that lead to the taxonomy hierarchy.

Taxonomists are biologists who analyze the relationship among organisms and aggregate them into groups. For instance, the insect taxonomist understands the relationship between different fly types and vice versa to group them into one category.

2.3.3 Genus

The term *genus* was borrowed from Latin. It means 'birth', **descent**, 'origin', 'sort', or 'type'. The plural form is **genera**. Thus, the meaning of genera pertains to more than one genus as most taxonomic families are comprised of several genera. The synonym of genus is generic name. Biological genus is defined as a taxonomic rank comprised of species with common attributes. It includes group(s) of species that are structurally similar or phylogenetically related.

Genus classification ranking lies between family and species, consisting of structurally or phylogenetically related species or a single isolated species exhibiting unusual differentiation (monotypic genus). The genus name is the first word of a binomial scientific name (the species name is the second word) and is always capitalized.

Examples :

- A plant genus containing many species is ***Rosa***, which contains more than 100 species of roses.
- The best example is animals like zebra, horses, and donkeys which belong to the same genus '***Equss***'.
- ***Canis*** is a genus of the Caninae which includes multiple extant species, such as dogs, foxes, wolves, coyotes and golden jackals.

2.2.4 Species

Species: classifications comprising related organisms that share common characteristics and are capable of interbreeding. This biological species concept is widely used in biology and related fields of study.

Species is a group of living beings that can breed to produce viable offsprings. This means the babies of their own. Some different (but biological similar) species can interbreed, such as a horse and a zebra, but the offspring cannot reproduce.

Species are characterized by the fact that they are reproductively isolated from other groups, which means that the organisms in one species are incapable of reproducing with organisms in another species. The term species can also be defined as the most basic category in the system of taxonomy. Species can also be defined based on a shared evolutionary history and ancestry. This method of defining species is called **phylogenetics**, which is the study of the evolutionary relationships among organisms. The evolutionary process by which a new species comes into being is called **speciation.**

2.3.5 Classification Based On The Properties of Living Beings

The seven levels of classification, from biggest to least, are Kingdom, Phylum, Class, Order, Family, Genus, and Species. Kingdoms are divided into phylum which are divided into classes which is divided into orders which is divided into families which is divided into genuses which is finally divided into species. As each level of classification gets divided, the groupings get smaller until an organism is it's own unique type of organism. There are a total of 6 kingdoms. Kingdom is the largest level after Domain. Species is the smallest levels. The level of species are the groupings of animals that are so similar, they aren't like any other organism.

We have the seven levels of classification because we need a way to group organisms. There are about 75 billion organisms in the world. The seven levels help us to narrow down the organism into its species. The way we know that it has been narrowed down to the end is when it mates with same kind to get fertile offspring. If we didn't have the seven levels, every organism would be grouped together and we would not be able to identify and separate the different kinds of organisms. There are differences between each level of classification.

The differences in each of the levels of classification is that it get lower and more similar everytime you go down. For instance, a group of animals were to be together. At every level you bring the animals down, you see that the animals starts to be more similar to each other than the organism that were picked out of that group. It keeps on going like that until you get down to an animal that is so specific, it is no like any other organism but itself. As the kingdoms are split, they split into phylum of invertebrates and vertebrate. Then the phylums get split into classes based on whether they are a mammal, fish, reptile, etc. Then the classes are split into families where they are split down to very similar looking organisms.

Kingdom :

The most basic classification of living things is kingdoms. Currently there are six kingdom. Living things are placed into certain kingdoms based on how they obtain their food, the types of cells that make up their body, and the number of cells they contain.

The basic taxonomy of living things includes six **kingdoms**. Each of the domains are associated with particular kingdoms.

Eubacteria (domain Bacteria) - common bacteria like the good bacteria found in yogurt and the bad bacteria that cause bacterial infections.

Archaebacteria (domain Archaea)- uncommon bacteria such as those found in environments that are devoid of oxygen or are extremely acidic.

Plantae (domain Eukarya) - all plants.

Animalia (domain Eukarya) - all animals.
Fungi (domain Eukarya) - spore producing organisms (mushrooms, tree, yeast, and most mold.
Protists (domain Eukarya) - microorganisms that don't fall into one of the other kingdoms (algae and slime mold).

Example :

Classification of Humans

Kingdom	:	Animalia	Phylum	:	Chordata
Class	:	Mammalia	Order	:	Primates
Family	:	Hominidae	Genus	:	Homo
species	:	sapiens			

Phylum :

The phylum is the next level following kingdom in the classification of living things. It is an attempt to find some kind of physical similarities among organisms within a kingdom. These physical similarities suggest that there is a common ancestry among those organisms in a particular phylum.

Once a decision has been made about which kingdom a living organism should be classified in, the next step is to determine which **phylum** it belongs in. There are multiple phyla (plural of phylum) for each kingdom. Examples of some of the most commonly known phyla include :

Anthophyta (kingdom Plantae) - flowering plants, including vegetables, fruit, beans, and nuts
Arthropoda (kingdom Animalia) - invertebrate animals with an exoskeleton, segmented bodies, jointed limbs, and a vented central nervous system
Chordata (kingdom Animalia) - animals that have a notochord (like the umbilical cord on a baby), a dorsal hollow nerve cord (spinal cord), pharyngeal slits, and a functional or vestigial tail
Coniferophyta (kingdom Plantae) - plants that stay green year-round, such as fir and juniper trees

Example : Humans are in the phylum Chordata.

Class :

Classes are way to further divide organisms of a phylum. As you could probably guess, organisms of a class have even more in common than those in an entire phylum. Humans belong to the class mammalia because we drink milk as a baby.

Once an organism has been assigned to a phylum, assigning it to a **class** is the next step in classification. Many classes are assigned to each phylum. Examples of several classes in the phylum Chordata include :–

Amphibia - animals born with gills that later develop lungs and spend parts of their lives in water and parts on land; they must reproduce in water.
Aves - warm blooded animals with wings; they reproduce through internal fertilization and lay eggs.
Mammalia - vertebrate animals that have specialized teeth, strong jaws, are conceived and born via the mother's reproductive tract, and nurse from their mothers.
Reptilia - cold-blooded animals with dry, rough skin; all except for snakes are tetrapods (which means they have four legs.

Example: Humans are in the class Mammalia.

Order :

Organisms in each class are further broken down into orders. A taxonomy key is used to determine to which order an organism belongs. A taxonomy key is nothing more than a checklist of characteristics that determines how organisms are grouped together.

Once an organism has been assigned to a class, the next step in classification would be to use a taxonomic key to assign it to an **order**. Each class includes several orders. For example, there are 19 orders within class Mammalia. A few examples include:

Carnivora - mammals that have canine teeth beneficial to their primarily meat-centric diet; most are fur covered and tend to be small to medium in size.
Chiroptera - consists solely of bats, which are the only mammals that have the ability to fly.
Primates - mammals with flat nails on theirs hands (instead of claws), relatively large brains, ability to sit and stand upright, requires care for an extended time after birth.
Example: Humans are in the order Primates.

Family :

Orders are divided into families. Organisms within a family have more in common than with organisms in any classification level above it. Because they share so much in common, organisms of a family are said to be related to each other. Humans are in the Hominidae Family.

After identifying an organism's order, the next step in classification is to determine which family it is in. Each order has multiple families. A few of the dozen primate families include:

Callitrichidae- the smallest primates (marmosets and tamarins)
Hylobatidae –the lesser apes(gibbons and siamags)
Hominidae –the great apes (cimpanzees, gprillas, organgutans, and human.
Example : Humans are in the family hominidae.

Genus :

Genus is a way to describe the generic name for an organism. The genus classification is very specific so there are fewer organisms within each one. For this reason there are a lot of different genera among both animals and plants. When using taxonomy to name an organism, the genus is used to determine the first part of its two-part name.

Each family in the taxonomy of living things can be identified by **genus**. For the family Hominidae, the genus divisions are as listed below :–

- *Pan*(chimpanzees)
- *Gorilla* (gorillas)
- *Pongo*(orangutans)
- *Homo* (humans)

Example : Humans are in the genus Homo

Species:

Species are as specific as you can get. It is the lowest and most strict level of classification of living things. The main criterion for an organism to be placed in a particular species is the ability to breed with other organisms of that same species. The species of an organism determines the second part of its two-part name.

The final level of classification is species. In some cases, there is only one species per genus, while there are multiple species for others.

- The genus *Homo* has only one species *(sapiens).*

- The genus *Gorilla* has two species: *Gorilla beringei* (eastern gorillas) and *Gorilla gorilla* (western gorillas)

Example: Humans are in the species (sapiens)

Advantages of five kingdom system of classification include:

- Five kingdom classification is better and more natural than two kingdom classification.
- It places the unicellular and multicellular organisms separately.
- It places the autotrophs and heterotrophs separately.
- It places the fungi in a separate group (kingdom Fungi) as it has a different mode of nutrition.
- It places the prokaryotes in a separate group (kingdom Monera)

Bases for five kingdom system of classification

This five kingdom system of Classification takes into account the following:

1) **Complexity of cell structure:** There are two main types, Prokaryotes and Eukaryotes. The only kingdom encompassing all prokaryotes is Monera.
2) **Complexity of body organisation:** There are two main types, Unicellular and Multicellular. The only kingdom encompassing all unicellular organisms is Protista.
3) **Mode of nutrition:** There are two main modes, Autotrophic and Heterotrophic. The kingdom primarily comprising all autotrophs is Plantae.
4) **Ecological role:** There are two main roles played by the heterotrophs, decomposers and consumers. kingdom animalia encompasses the consumers and kingdom fungi encompasses all decomposers.
5) **Phylogenetic relationship:** Evolution has been one of the backbones of the five kingdom system of classification.

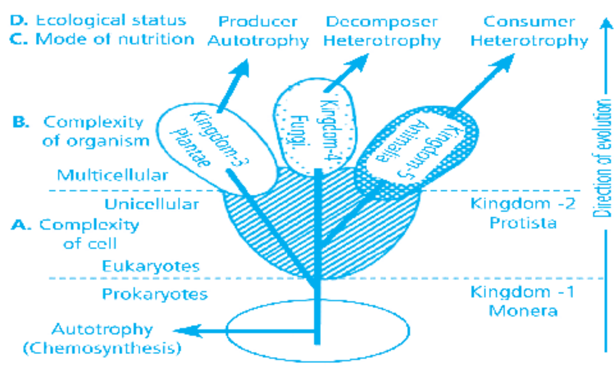


Fig.: Whittaker's five kingdom classification

Fig 2.11

Project Works

i. Make a schematic diagram of the hierarchy of organisms and demonstrate it in the classroom.
ii. Prepare a PowerPoint presentation and present it to the class by downloading photos and videos of the Kingdom of Monera from the Internet.

Exercise

A. Choose the correct answers the followings :–

1. The animals (Kingdom Animalia) are mainly grouped under two categories

a. bilaterally symmetrical and radially symmetrical
b. coelomate and acoelomate
c. aquatic and terrestrial
d. vertebrates and invertebrates

2. Which one of the following examples does not come under the particular group?

a. Mushroom, Yeast, Fern - Fungi
b. Paramoecium, Euglena, Sponge - Protista
c. Starfish, Cuttlefish, Dogfish - Pisces
d. Bat, Parrot, Oyster - Vertebrates

3. Which one of the following is an example of binomial scientific name?

a. Green algae
b. Snow leopard
c. Rana tigrina
d. China-rose

4. Which one of the following is the correct statement about the respective animal(s)?

a. Donkey and horse should be considered one single species because they can successfully mate and produce an offspring.
b. Donkey and horse are two different genuses.
c. Mule is a separate species.
d. Mule is neither a donkey nor a horse.
e. Which two characters out of a.-e. given below are common to dog, humans, squirrel, bat, camel and monkey?
   i. scales on the skin
   ii. wings
   iii. external ears
   iv. give birth to young ones
   v. a functional tail

B. Match the items in Column I with as many as possible and even repeatedly from column II.

Column I	Column II
1. Man	i. *Pissum sativum*
2. Dog	ii. *Panthera tigris*
3. Cow	iii. *Oryza sativa*
4. Paddy	iv. *Canis Iupus*
5. Tiger	v. *Homo sapiens*
6. Pea	vi. *Bos taurus*
	vii. *Felis catus*
	viii. *Panthera leo*

C. Complete the sentences :

a. Heterotrophs feed on.....................................
b. Autotrophs obtain energy....................
c. Prokaryotes have......................in the cell.
d. Eukaryotes have...........................in the cell.
e. The body of plants and animals consists........

D. Write one main character based on the structure of the body of given animals and write the name of its Kingdom, Phylum, Class, Order, Family, Genus and Species :

a. bat
b. mushrooms
c. man
d. maize
e. cow

E. Give reason :

a. A bat possesses wings but it is a mammal.
b. Carolus Linnaeus is considered as the 'Father of Taxonomy'.

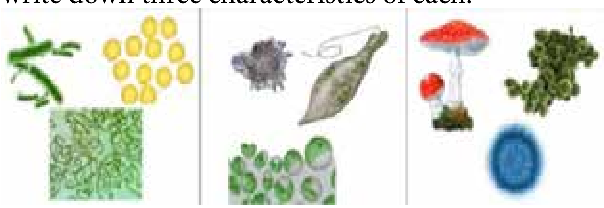
c. Animal cells have a flexible cell membrane, but no cell wall.
d. The most basic classification of living things is kingdoms.
e. The five kingdom system is more suitable and scientific than the two kingdom system of living beings.
f. An organism belonging to the fungi kingdom is also called saprophyte.
g. Organisms under Protista are considered to be more developed than those in the Monera kingdom.

F. Write the difference:

a. Prokaryotes and Eukaryotes organisms
b. Genus and Species
c. Monera and Protista
d. Saprotrophic and Parasitic fungi
e. Two kingdom systemof classification and five kingdom system of classification
f. Yeast and Mushroom
g. Protista and Fungi
h. Kingdom and Phylum
i. Class and Family
j. Photosynthetic and Non-photosynthetic living beings

G. Answer the following questions.

a. Name one basic characteristic for classifying organisms.
b. What is meant by classification?
c. Why is it difficult to classify bacteria? Give two reasons.
d. Explain the basis for grouping organisms into five kingdoms?
e. What is binomial system of nomenclature?
f. Why is nomenclature required?
g. Who had introduced the binomial system of naming living beings?
h. Give the scientific names of man, domestic cat, and peepal tree.
i. Why are scientific names of living beings considered better than their common names?
j. Name the five kingdoms of life and mention the three features on which this classification is based.
k. Write the characteristics of the Monera kingdom with examples.
l. Write the characteristics of the Protista kingdom with examples.
m. Write the characteristics of the Fungi kingdom with examples.
n. Make a classification chart of the five kingdom system of classification.
o. Explain with an example the interrelationship between different levels of classification of organisms.
p. Study the given pictures and identify which kingdom these living beings belong to. Also write down three characteristics of each.



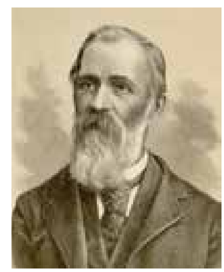
Unit 3 Life Cycle

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- Describe the importance of mushroom.
- identify edible mushroom and poisonous mushroom
- summarize the life cycle of a mushroom

Job Bicknell Ellis (1829 – 1905) was a pioneering North American mycologist known for his study of the Ascomycetes,especially the grouping of fungi called the Pyrenomycetes (known today as the Sordariomycetes). Born and raised in New York, he worked as a teacher and farmer before developing an interest in mycology. He collected specimens extensively, and together with his wife, prepared 200,000 sets of dried fungal samples that were sent out to subscribers in series between 1878 and 1894.



How big can mushrooms grow? What medicinal benefits do mushrooms have? Do farmers grow mushrooms? Find out the answers to these questions.

Aguricus bisporus | Fly agaric | Death cap | Scarlet waxcap | Shiitake Mushroom | Oyster Mushroom

Fig 3.1

3.1 Introduction

There is decline in income of farmers in traditional agriculture. To ensure that the farmer gets assured income year after year, there is a need for diversification in agriculture, that is, we need to cultivate different type of crops. One of the options is to grow mushrooms which can be grown on straws and other agricultural wastes. Unlike plants, mushroom cultivation is an indoor activity. It is possible to grow mushrooms in a particular season under natural conditions. It is possible to grow mushrooms throughout the year under controlled conditions. An additional advantage is that very less land is required for

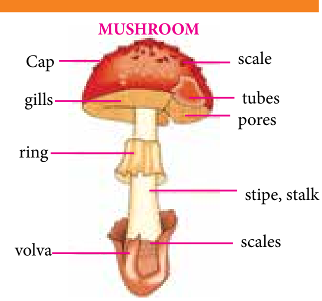


Fig 3.2

growing mushrooms. You must have seen that after rains many mushrooms appear from nowhere, especially in grassland, near manure heap, dung or rotting straws/ wood. We must be aware that all mushroom occurring in the nature are not edible. At present there is no simple method to differentiate an edible mushroom from non-edible type. Some mushrooms have medicinal value. A few of these are poisonous and thus it is important to cultivate edible mushrooms.

3.2 What are Mushrooms?

Fig 3.3

When we say mushroom, many people think of only button mushroom seen in figure. This is more so in West as the mushroom industry in the UK and other western countries is nearly 100% dominated by button mushroom. This could mislead you that this is the only species considered as mushroom. Actually, there are thousands of different species of mushrooms in nature. Unlike higher plants, mushrooms do not have chlorophyll (green part in leaves) which helps the plants to use water, carbon dioxide and energy from the sun to synthesize their own food. In the absence of chlorophyll, mushrooms cannot produce their own food and depend on higher plants for food. Mushrooms obtain nutrients from organic materials like straw, dead wood, manure, dung, etc. Earlier workers considered mushrooms as plants. Now we know that these are neither plants nor animals. In evolution plants evolved from lower organisms. Soon after that the fungi and animals also got separated (Fig.3). Plants make their own food. Fungi and animals depend upon other organisms for food. Mushrooms have cell wall that is different from plants. Animals do not have cell wall. Because of these characters and also the method of their nutrition, growth and reproduction, etc, scientists have grouped all fungi into a separate kingdom.

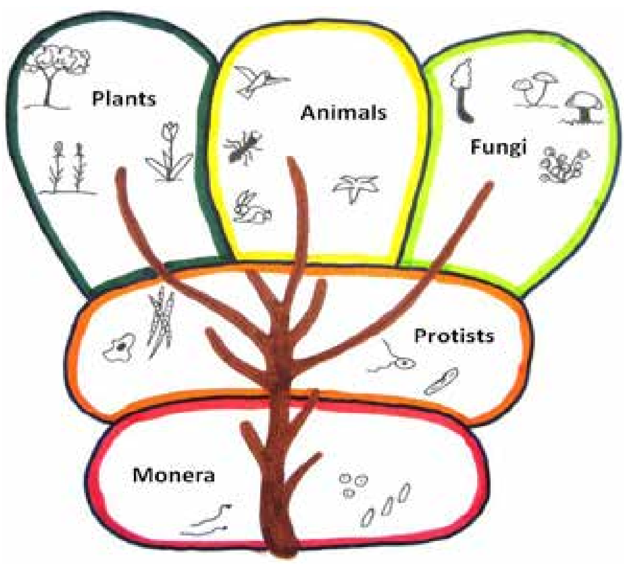


Fig 3.4

Mushroom is a macro fungus with a distinct fruiting body, which can be either epigeous or hypogeous and large enough to be seen with naked eye and to be picked by hand. Mushrooms have been in use by mankind since time immemorial.

The consumption of mushrooms probably occurred during prehistory, in the hunting and gathering period. Unlike plants, mushrooms could not be cultivated at first and were collected for a long period of time. Even today, relatively few species of mushrooms can be cultivated compared to the number of edible species. Mushrooms were thought to be special and supernatural in origin – 4600 years ago, the Egyptians believed mushrooms to be plants of immortality; the Pharaohs decreed that only they could eat mushrooms. Many people collect mushrooms for the purpose of consumption, but lots of myths and false concepts still survive today.

Classifications of Mushroom

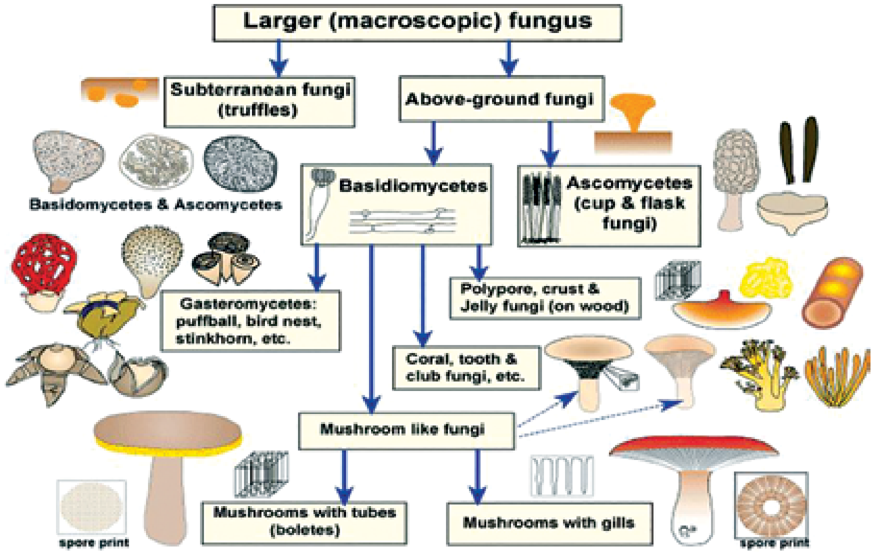


Fig 3.5

3.3 How Many Species of Mushrooms Exist?

Fungi are the 2nd largest group of organisms after insects. We know only about some of these. According to an estimate, there are about 15 lakhs fungi in the world (see in figure). However, we have not been able to study all and scientists have studied only 1.1 lakh fungi out of which 14000 are considered as mushrooms (Actual number of mushrooms in nature may be 10 times of this). All mushrooms are not edible. Some are even poisonous. Out of these, only 3000 have been considered to be truly edible. However, it is not possible to cultivate all of these. Despite all the efforts we succeeded to cultivate only about 200 species experimentally out of which 60-70 are cultivated commercially and about 10 are cultivated on industrial scale.

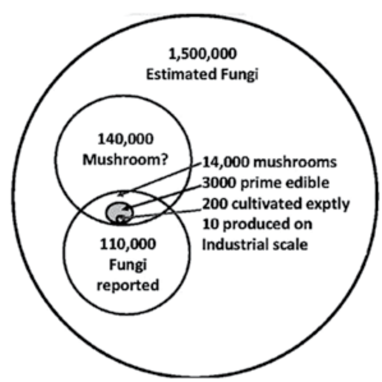


Fig 3.6

Specie Name	Common Name
Volvariella volvacea	Paddy straw mushroom
Lentinus edodes	Shiitake
Pleurotus ostreotus P. Floridanus P. eringyi	Oyster mushroom Royal trumpet mushroom
Flammulina velutipes	Velvet foot mushroom, Winter mushroom
Auricularia auricula	Ear fungus
Tremella fuciformis	White jelly fungi
Pholiota nameko	Nameko

Table 3.1

3.3.1 Structure of Mushroom

The mushroom is composed of an underground part (mycellium) and an aboveground, often edible part that is also the reproductive organ.

Cap

This is the part that gives the fungi its umbrella shape. The cap comes in a variety of colors, including white, brown, and yellow. In the same way that umbrellas protect us from the heat of the sun, rain, and other harsh weather conditions, the mushroom cap protects the pores or gills where mushroom spores are produced. And what are spores? Well, consider them as mushroom 'seeds,' although technically speaking mushrooms don't have seeds.

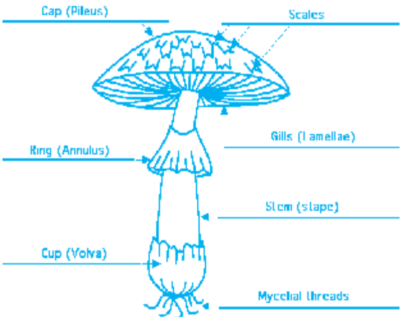


Fig 3.7

Gills, Pores, or Teeth

Have you ever seen a fish's gills? Mushroom gills look something like that. The gills are also called teeth or pores. The gill is a structure that appears right under the mushroom cap and produces spores.

Ring

The ring (also known as the annulus) is a partial veil that is left on the stem. It is an extra layer of protection for the spores that grow when the mushroom is still very young. When the cap grows out and breaks through the veil, the remnant is what forms the ring around the stem.

Stipe or Stem

The stipe or stem is the long, vertical part of the mushroom that holds the cap above the ground. Mushrooms growing in the wild propagate when the wind scatters the spores. For this reason, the cap and gills need to be held high enough from ground level by the stem, so that when the spores drop down, they can be carried away easily by wind.

Note that in some mushrooms, the spores grow right down the sides of the stem. Oyster mushrooms are a good example. Also, the way that a stem is attached to the cap can be an important clue in identifying a mushroom. For example, a morel's stem will attach to the inside of the hollow cap, whereas a false morel's stem will attach to the bottom of the cap.

Volva

Mushrooms are covered in a protective veil as they grow out of the ground. This protective veil is called the volva. The mushroom pushes through the volva as it matures, leaving parts of the veil at the bottom of the stem.

Mycelium

The mycelium is a collection of thin hair-like strands that grow outward and downward into the soil in search of nutrients. The mycelium of mushrooms acts like the roots in flowering plants and can produce new mushrooms when the conditions are suitable. Primary mycelium is the haploid or monokaryotic hyphae generated from the germination of basidiospores. Secondary mycelium is the dikaryotic hyphae formed from the conjugation of two mating types of fungi during the sexual reproduction. Therefore, primary mycelium contains one haploid nucleus while secondary mycelium contains two unfused haploid nuclei. Secondary mycelium represents the dominant stage of the life cycle, unlike primary mycelium. Moreover, secondary mycelium has a long life span compared to primary mycelium. Thus, this summarizes the difference between primary and secondary mycelium.

3.3.2 Life Cycle of Mushroom

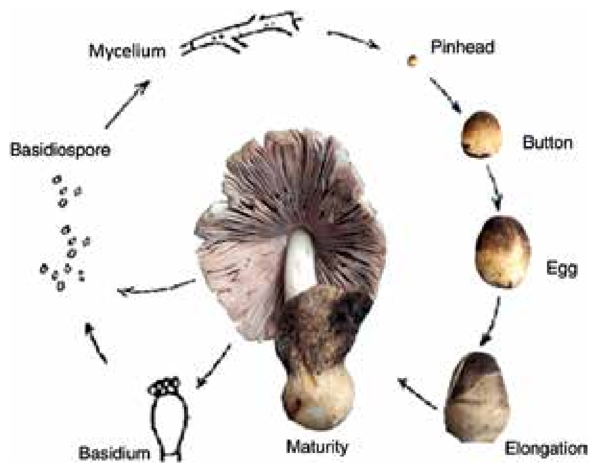


Fig 3.8

It all starts when the spores are released from the gills, (or whichever surface the mushroom happens to carry spores on). Millions of spores are released into the elements (air, water, animals etc). These spores are dispersed by various methods,(depending on the kind of mushroom). When the conditions are roght, the spores germinate sending out tiny threads called ***hyphae*** (single : hypha). In order for the hyphae to develop and eventually produce a mushroom it has to find other hyphae that are compatible. When two compatible hyphae meet, they fuse together to forms what is known as ***hyphal knot*** which grows and develops into a pinhead which in turn grows and develops into a mushroom and then it all starts again.

Basidiospores are the sexual spores which characterize a large group of fungi, the Basidiomycota or basidiomycetes. In comparison with the morphological diversity of ascospores, basidiospores are more uniform. They also show a smaller size range, from about 3 to 20mm, which is possibly related to their unique method of discharge. They are normally found in group of four attached sterigmata to the cell which bears them, the basidium.

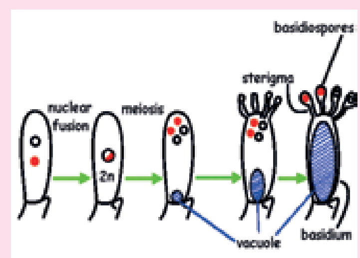


Fig 3.9

3.4 Use of Mushroom

Mushrooms are known as healthy foods throughout the world with proteins, vitamins, minerals, chitin, essential amino acid as well as low fat and calories. The nutritional value of mushroom is comparable to foodstuffs such as corn, soybeans or beans. They are especially important foods with the basic amino acids they contain. Within the mushrooms, there are protiens at levels ranging from 5-49% of dry weight. In addition to protein, dietary fibers, minerals such as potassium,phosphorous, iron and vitamins and carbohydrates. Mushrooms, which

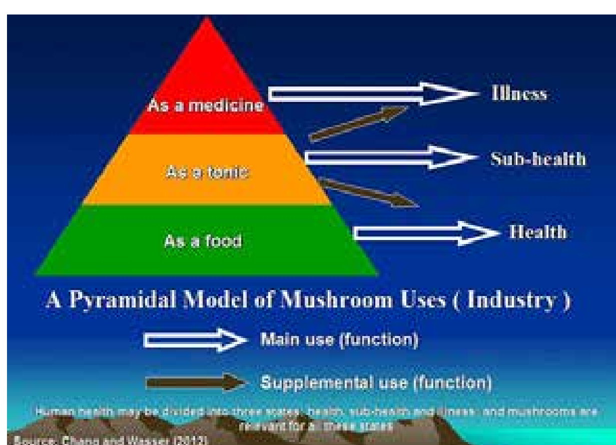


Fig 3.10

serve as a good source of food for human beings for centuries, have high nutritional value due to the vitamins and minerals they contain. Mushrooms are quite important natural sources used in alternative medicine.

3.4.1 Importance of mushroom

Mushrooms are good for heart as they have low fat and some of the mushrooms have compounds (like lovastatin in oyster mushroom) that are known to lower the cholesterol in the blood. Moreover, mushrooms have low-sodium and high potassium contents and thus are suitable food for persons suffering from high blood pressure. Mushrooms are a low calorie food with no starch and also have number of antioxidants and hence considered delight of diabetics. These are also rich in fibres and hence good for the intestine and digestive system. These are also a very good source of vitamins especially vitamin B complex. Mushrooms are the only vegetarian source of vitamin D. If we expose mushrooms to UV light after harvest for some time or expose to sunlight, the vitamin D content increases many folds. These also have vitamin B_{12} which is not available in plants. These are also rich in minerals, which also include copper (heart-protective) and selenium (anti-cancer).

Many of the mushrooms are known to have medicinal and anti-viral properties and their consumption activates the immune system of the human body. Compounds from number of mushrooms have found applications in cancer research and numbers of them have been found to reduce the side effects of radio-therapy and chemotherapy. The benefits have been summarized in given table. As mentioned earlier, mushrooms can be easily digested. Now we know that these can meet our nutritional needs and thus are a health food.

Characteristics	Benefits
High quality protein	Combats malnutrition
Low sodium high potassium	Controls hypertension
No starch, low sugar	Delight of diabetics
No cholesterol	Healthy heart
Rich in fibre	Improves digetion
Only vegetable with Vit. D	Cures Ricketsia
Folic acid, Vit. B and minerals	Improves health
Ascorbic acid and carotenoids	Anti oxidant
Low calorie food	Reduces obesity
Selenium	Anti cancer property

Table 3.2

a. As sources of protein

- In the mushrooms, protein content is between 19% and 35% of dry weight.
- Protein content of mushrooms depends on the confirmation of the substratum, size of pileus, harvest time and mushroom species.

- The amount of rudimentary protein of mushrooms grades below animal meats but it spositions is well above most other foods including milk.
- In 1987, scientist up-to-date that mushrooms are very beneficial for vegetarian because they contain some essential amino acids which are found in animal proteins. in 1989, Rai and saxena observed that the protein content of mushroom is decreased on storage.

b. As Source of Vitamines

Mushrooms are a virtuous source of vitamins such as Thiamine (Vitamin B). Riboflavin (vitamin B2), Niacin, Bio Tine and Ascorbic Acid (vitamin C), Folic Acid.

c. As source of Minerals

- Fruiting bodies of mushrooms are a good source of minerals. They include potassium, phosphorus, sodium, calcium and magnesium as well as copper, zinc, iron, molybdenum and cadmium.

d. As source of Fats:

- Fat content in mushroom ranges between 1-8%. But inside the Mushroom content of Linoleic Acids is very high. Due to which mushrooms are considered Healthy food.
- Inside the Mushrooms, the Fat content is very low as related to Carbohydrates and Proteins. The fats which are present in Fruiting Bodies of Mushroom are Unsaturated Fatty Acids.
- In 2006, Yilmaz and Pedneault reported that Fat Element in mushrooms is principally composed of unsaturated fatty acids.

e. As source of Carbohydrates:

- In the Mushrooms Carbohydrate content ranges between 50 to 65% on the basis of dry weight.
- About 11% of free Sugars present in the Mushrooms.
- Free Sugars present in the Mushrooms are Raffinose, Sucrose, Glucose, Fructose, and Xylose.

d. As source of medicine :

Mushrooms are not only sources of nutrients but also as therapeutic foods, useful in preventing diseases such as hypertension, diabetes, hypercholesterolemia and cancer. These functional characteristics of mushrooms are mainly due to the presence of dietary fiber and in particular chitin and beta glucans. Some mushrooms species have antitumor, antiviral, and antithrombotic and immunomodulating properties and some mushrooms may have potential to lower elevated blood sugar levels. According to a report, Pleurotus species have high medicinal value. *Agaricus blazei* is used as general medicine against different diseases, like cancer, chronic hepatitis, diabetes, arteriosclerosis, and hyperlipidemia. Interest in the use of this mushroom and/or its extracts as dietary supplements has increased significantly, in part because of its antitumor, anticarcinogenic, antiviral, anti-inflammatory, hypoglycemic, hypocholesterolemic, and antihypertensive effects. Mushrooms are also used for chronic catarrh diseases of the breast and hinges, lower the cholesterol level of blood, improves circulation, remedy for night sweating in tuberculosis, rheumatism, gout, jaundice, dropsy, intestinal worms and have anti-tumor, anti-viral and anti-cancer agents. Mushrooms are very effective for patients of hypertension, renal effects and diabetics, their immunemodualatory and antitumor activities of Polysaccharide-Protein Complex (PSPC) from mycelial cultures and their immunemodualatory and antitumor activities of lectins from edible mushrooms gives them valued in medicinal value. Bracket mushroom (Ganoderma lucidum) has been repeatedly used for disease management of patients with HIV and AIDS and can be justified by the increase in body weight. Various medicines (e.g, Concord, Sunchiha) are made from red mushrooms. It is used in asthma, diabetes, cancer, piles and valley related diseases.

At present about 30 percent of the world trade is related with medicinal mushrooms. In Nepal and India however, we have only recently started cultivating medicinal mushrooms.

Some of the medicinal mushrooms on which research is going on in different parts of the world including trials on human beings are: *Lentinus edodes, Grifola frondosa, Schizophyllum commune, Ganoderma lucidum, Trametes versicolor, Inonotus obliqus, Flammulina velutipes, Phellinus linteus, Cordyceps sinensis. Possibly most popular medicinal mushroom is Ganoderma.*

3.4.2 Economic Importance of Mushroom

Mushroom production is economically important as it can contribute to the economy in terms of nutritional value and reduce unemployement. Mushrooms are also called 'white gold'.

1. Meeting the food demand for the increasing population from the limited land resource is a big challenge. The global food and nutritional security of growing population is a great challenge, which looks for new crop as source of food and nutrition. In this context, mushrooms find a favour which can be grown even by landless people, that too on waste material and could be a source for proteineous food.
2. Comparatively, growing of mushroom needs low investment but it fetches high return within a short duration of time. This low investment with quick return reduces the vulnerability to proverty and strengthens the livelihood of small holder farmers and acts as a reliable source of income. It may also play significant role as a reliable source of employment generation. In the context of Nepal where most of the farmers are unable to cope high investment. Mushroom farming can be a good choice. Since, mushroom have medicinal values and hence they are the raw material for medicinal industry. So, by producing mushroom we not only generate income but also contribute to human health by producing medicine indirectly.

3.4.3 Mushroom Farming

Mushrooms like wood ear, winter mushroom and shiitake were cultivated in China on wood logs more than a thousand year ago while button mushroom was cultivated in France about four centuries ago. But the scientific cultivation of mushrooms started in the beginning of 20th century and in the initial years button mushroom was the most commonly cultivated mushroom. Subsequently, numbers of other mushrooms were brought under cultivation. In 1960, when mushroom production was low, white button mushroom cultivation was about 80 percent of world mushroom production, shiitake contributed 15 % and others were only 5%.

Over decades there has been increase in production of button, but the production of other mushrooms has increased much more as a result of which at present the relative contribution of button in world production is only 15% and it is no more world's number one mushroom. At present shiitake is number one cultivated mushroom. Six mushrooms, namely shiitake (Lentinula), oyster (Pleurotus), wood ear (Auricularia), button (Agaricus), winter mushroom (Flammulina) and paddy straw mushroom (Volvariella) account for 90% of the total world mushroom production. Today China cultivates around 60 different types of mushrooms and produces around 85% of the total of

40 million tonne mushrooms of the world. There are more than 110 species of edible mushrooms are identified in Nepal. Nepalese climate and cultural practices in Nepal has commercialized the major four types of mushroom cultivation as button mushroom(Agaricus bisporus),oyster mushroom (Pleurotus sajor-caju),paddy straw mushroom (Volvariella volvacea) and Shiitake mushroom (Lentinula edodes). Mushrooms are rich in flavor, aroma, have good texture and high productivity per unit area. Nepal is the best place for mushrooms cultivation. Button mushroom and Shiitake mushrooms are suitable for cool temperature whereas paddy straw mushrooms are best grown in tropical region and oyster mushrooms are found better in subtropical region.

Mushroom growing involves spawn production, composting, cultivation. After that we need to process and market these.

Cultivation technology is different for different mushrooms. Proper knowledge on mushroom life cycle and good training of all the steps is a must before starting cultivation of any mushroom. However the basic steps are the same for majority of mushrooms (given figure)

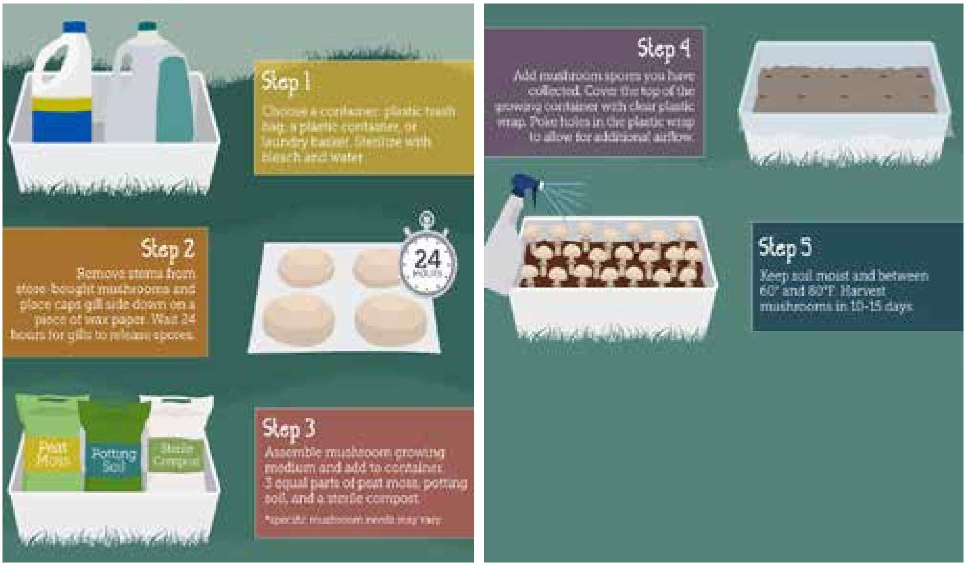
Spawn → **Substrate** → **Cropping**

- The first step before starting cultivation is to procure or produce spawn of good quality.
- Second step is to prepare the substrate of good quality. Method of spawning, that is mixing of spawn in compost, and amount of spawn required will also vary in different mushrooms. In some cases spawn may be mixed thoroughly whereas in other cases it may be put layer wise. Spawning in some cases can be done in open under hygienic conditions whereas in other cases, particularly where the substrate has been autoclaved, the spawning can be done only under sterile conditions. We need only half kg to one kg of spawn for 100 kg of compost in button mushroom, where as in oyster we need 2.5 kg and in milky mushroom we may require up to 5 kg spawn for 100 kg of substrate.
- The third step is cropping. After spawn run, that is allowing the fungus to spread throughout the substrate, we take steps to induce formation of mushrooms. In some cases it is required to put a layer of casing material whereas in other cases fruiting can be obtained as such. In all cases, to induce fruiting some sort of change is required. For example in case of button mushroom temperature is lowered from 25 to 17°C and carbon dioxide levels are lowered by giving fresh air. In Oyster, to induce fruiting both fresh air and diffused light is necessary.

In Nepal, mushroom cultivation in rural areas has emerged as an important activity for educated, school dropouts, women, landless people, etc. Considering the demand for quality foods, mushroom cultivation has emerged as an important avocation. Many commercial units that grow mushrooms under controlled conditions have also been set up in different parts of our country. However, before taking up this venture a thorough knowledge of the subject and scientific aptitude towards agriculture is necessary.

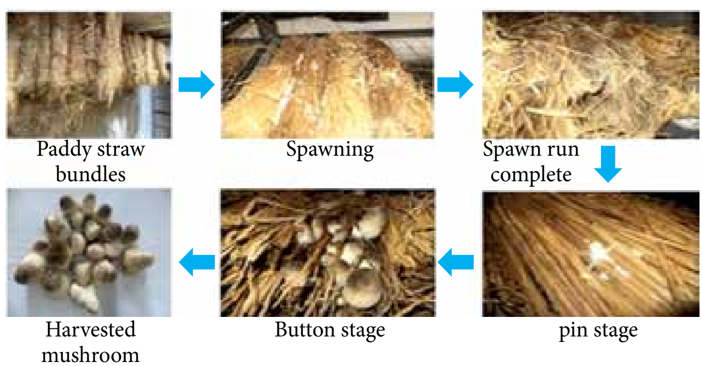
Project Works

Grow mushrooms at home or at school using the methods described below-



Method of cultivating of Paddy Straw mushroom (Parale Chyau)

- Select dry, fresh and hand-threshed paddy straw free from moulds and leafy portion. Make 25 cm long and 10 cm thick bundles, 60 bundles for each cage (bed).
- Soak the bundles in boiling water for 20-30 minutes followed by draining off excess water.
- Disinfect the cage and polythene sheet with 2%
- formaline or dettol solution.
- Arrange ten straw bundles uniformly in the cage as the bottom layer and put some spawn grains over and inside the bundles. Put second layer of ten bundles over the first and spawn as before



Steps in cultivation of paddy straw mushroom

Fig 3.11

- Repeat this till six layers of bundles are achieved or till the entire cage is filled.
- Spray 0.1% Malathion and 0.2% Dithane Z-78 solutions all over the bed. Cover with polythene sheet and bind securely with a binding thread.
- Keep the spawned cages in a room or under a shed for spawn run. A warm place with temperature around 30°C is helpful for better spawn run.
- Remove the polythene sheet after the spawn run is complete. Maintain high humidity in the bed and room till pinheads appear.
- Pinheads appear within 10-15 days after spawning. Harvest mushrooms at the egg stage.
- Continue water spray for the next flush of mushrooms to appear within a week or so.

Outdoor method

The best place to cultivate paddy straw mushroom outdoor is under shade created by trees or creepers. The steps inv olved are as follows:–

Fig 3.12

- Prepare a raised platform either using sand or bamboo poles or wooden planks or bricks.
- Prepare bundles of 45 cm length and 10 cm width.
- Soak the bundles in running water or in 2% CaCO3 solution.
- Prepare a layer of bundles (5 bundles x four layers) followed by spot spawning and covering spawn with gram dal powder.
- Lay 4 layers of bundles during summer months and 7 layers during rainy season.
- Topping of bed with 20 cm deep layer of rice straw followed by covering with polythene sheet.
- Remove polythene sheet after 4 days and sprinkle water carefully on 6th day. Water spray can be avoided during rainy season.
- Water should not be sprayed after appearance of mushroom pinheads.

The paddy-straw mushroom has a distinct flavor, pleasant taste, and rich protein content. It has low production costs and a cropping duration of approximately 45 days—making it an effective means for poverty alleviation for those farmers who grow it. Farmers in Nepal grow it. The mushroom can grow well in both outdoor and indoor conditions; however, outdoor cultivation has risks of exposure to rain, wind, and/or high temperatures, all which reduce yield. The yield of indoor mushroom production is higher and more stable, as such, indoor growing is preferred.

3.5 Storage and Use of Mushroom

Mushrooms continue to respire after harvest and they have a relatively high respiration rate compared to other fresh produce, the respiration rate of oyster mushroom being three times greater than most fruits for example. Respiration rate is a good indicator of storage life and respiration results in changes in mushroom texture.

Fig 3.13

Spoilage during storage can be caused by bacteria and fungi within the mushrooms. Bacteria and enzymes continue to increase during cold storage. This results in rapid deterioration when the mushrooms are removed from cold storage.

The mushrooms' texture is altered as they lose their firmness and their flesh darkens. The water inside the mushrooms is also favourable for bacterial growth.

Many mushrooms are white to gray in colour while they are growing. Under certain storage circumstances, however the enzymes react with oxygen and form brown pigments. Such discoloration seriously decreases the quality of mushrooms.

Mushrooms have 85-95% water of its dry weight. There are no barriers to water loss from their surface. Water loss in the mushrooms after harvesting is influenced by the status of the mushrooms, the humidity, fresh air and atmospheric pressure. When mushrooms wilt and shrivel, the quality of fresh mushrooms is lowered.

Fresh mushrooms have a short shelf life. Therefore it is necessary that they are either marketed soon after harvesting or preserved with special care such as in cold storage or other controlled environment storage.

Storage

Each species needs compatible and distinctive alternative techniques for their active, pure and viable physiology in terms of colour, texture, and taste. Preservation protocols are applied accordingly. The shelf life of fresh mushrooms may be extended by refrigeration at 1-4^{0}c. Cooling the mushrooms result in lower rates of all the physiological process within the mushrooms. During the initial cooling there is a high cooling load. Once the mushrooms are pre-cooled, however, the cooling load is much reduced. Freshly harvested mushroom is highly perishable as it is susceptible to deterioration by the enzyme and microorganisms. It has been realized that merely producing mushroom is of no use unless these are properly preserved, keeping in view the export objectives. Hence, following proper processing and storage methods is of supreme importance. Two types of preservation techniques are available:

- Short term preservation
- Long term preservation

Short term preservation

- Low temperature is effective for short-term preservation. Mushrooms may be packed in wooden cases with three compartments; ice is placed in the central compartment and mushrooms are packed in the two other sections. Mushrooms may also be packed in bamboo baskets and transported by airfreight. An aeration channel is formed at the centre of the basket and dry ice, wrapped in paper, is placed above the mushrooms.
- Mushrooms stored in a perforated plastic box at 10-15^{o}C have excellent keeping quality for up to 4 days and the loss of moisture is less than 5 per cent. Straw mushroom can be stored more effectively at button stage than at any other stage. At temperatures below 10^{o}C, however, the mushrooms liquefy rapidly, irrespective of type of packaging due to chilling injury.

Long term preservation

Canning, pickling, and drying, preparation of papads and use of chemicals are employed for long-term storage. These processes are not always suitable for all types of mushrooms. The quality of the finished product is rarely comparable with that of fresh mushrooms.

Drying method of mushroom

Mushrooms can be dried by sun drying and thermal power drying. For general drying, the picked mushrooms are exposed to the sun for about 2-4 days. Dried mushrooms are highly hygroscopic and readily absorb moisture from the air. The dried mushrooms should therefore, be put into polyethylene bags, sealed, and kept in a dry, cool, and dark place. For prolonged storage, dried mushrooms should be packed in cartons or wooden boxes and kept at 2-5^{o}C in a low temperature store.

Steps of Drying:

A. Cleaning:

The easiest way to clean mushrooms, except for morels, is to gently wipe or brush away any dirt and debris. Mushrooms - Depending on what type of mushroom you are planning on dehydrating you may want to keep the mushroom whole for presentation purposes of the dish. You can dehydrate the mushrooms whole, but it will take longer. For most mushrooms slices are a fine for dehydration. If you slice the mushrooms you will increase the available surface area to be dried and reduce your dry time. Cut mushrooms should never be washed. The exposed inner flesh will quickly absorb water, leaving them soggy. And washing whole ones usually isn't required. For those of you concerned about the potential of food borne illness that might be present in the growing substrate it may be sterilized in dry heat and pasteurized.

B. Drying:

Arrange the mushroom slices in the dehydrator and dry them until they are crisp and break easily instead of bending.(drying times will vary depending on the make and model of your dehydrator). At this point you can stop here if you want. For use in soups and other moisture rich dishes you can simply add the dehydrated slices in during the cooking process and the mushroom slices will rehydrate while the dish cooks. For fast cooking dishes or less liquid intense dishes, you will need to soak the dehydrated mushroom slices in warm water for around 20-30 minutes so they are plump and juicy instead of hard and splintery. Turn your hard dried mushroom slices into a fine powder in a grinder and sieve it. Once you have your desired consistency you want to store your mushroom powder in a cool dark place in an air tight container to avoid spoiling or rehydrating before you are ready to use it.

Canning

Canning is the most common process for preserving mushrooms. For this, cleaned mushrooms are placed in cans containing 2.5 % sodium chloride and 0.25–0.5 % citric acid. The cans are then sealed and sterilized in autoclave for one hour at 100-120°C. It is one of the best long term storage. Agaricus mushrooms. Canning is divided into six basic operations: cleaning, blanching, canning, sterilization, cooling, labelling and packing. Trimming the steps immediately after harvest can reduce Browning and blemishingof Agaricus. If the mushrooms are not canned immediately before processing then, refrigeration at 1-5° C along with high RH will help in retaining colour and texture. Soaking for 30 minutes prior to canning may increase canning yield. At this stage, an appropriate level of sodium meta-bisulphite or ascorbate is incorporated for colour retention. The mushrooms are then rinsed and blanched for 2 minutes. Blanching is used to reduce the activity of enzymes. After blanching, the mushrooms are placed in cans containing 2.5 per cent sodium chlorideand 0.25–0.5 percent citric acid. The cans are then sealed and sterilized. Sterilization methods vary according to the type of equipment used. The most commonly used method is the batch process in which the cans are placed in an autoclave and sterilized for an hour at 100-120° C.

Pickling

It is a useful mode of mushroom preservation.

Ingredients

- 1/2 kg fresh mushroom
- 1/2 kg water chestnuts 2 cup vinegar 40 gm jiggery (gud) 2 tsp red chilly powder (lal mirch) 2 tsp spice blend (garam masala)
- 2 tsp cumin seeds (jeera)
- 2 tsp salt
- 2 tbsp mustard seeds (tori)
- 2 tbsp aniseed (sup)

- 2 tsp fenugreek seeds (methiana)
- a pinch asafoetida (hing)
- a pinch ginger
- 250 gm mustard oil

Processing

- Boil and peel chestnuts.
- Wash mushrooms and cut them.
- Let mushroom and chestnut dry. Grind jeera, tori, sup, methidana.
- Make ginger paste.
- Heat 4 tbsp oil in a pan and fry singhade in it till it becomes light brown. Take them out.
- Now fry ginger and remove it from the flame.
- Add all the spices in it.
- Now mix mushroom and singhade well so that masala is mixed well.
- After 2-3 hours mix gud in sirka and cook.
- Let it cool and mix with aachar.
- Store in a jar and then put extra oil.

Use of Chemicals

This method of preservation can be used at places where facilities for canning, freezing and dehydration do not exist. According to study and research, mushrooms in the fresh condition may be possible to preserve for about 10 days at room temperature by steeping in a solution containing 2.5 per cent common salt, 0.2 per cent citric acid, 0.1 per cent ascorbic acid, 0.1 per cent sodium bicarbonate and 0.1percent potassium meta-bisulphite. The blanched mushrooms and steeped solution of (1:2)are put into clean glass containers, which are covered with lids and sealed with paraffin wax and stored at room temperature (21-28^{o} C) This method of preservation can be used at places where facilities for canning, freezing and dehydration do not exist.

Edible and Poisonous Mushroom

Mushrooms are classified into two broad categories: edible mushrooms and poisonous mushrooms.

A. Edible Species

White button

The most popular mushroom, white buttons represent about 90 percent of mushrooms consumed in the United States.

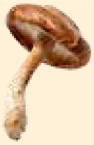
Crimini

Also known as baby 'bellas or browns, criminis are similar in appearance to whites, but have light-tan to rich-brown cap and a firmer texture.

Portabella

A large relative of criminis, Portabellas
have tan or brown caps and measure up to 6 inches in diameter.

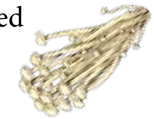
Shiitake



Shiitakes are tan to dark brown and have broad, umbrella-shaped caps, wide open veils, tan gills and curved stems that should be removed.

Oyster
Oysters can be gray, pale yellow or even blue, with a velvety texture.

Enoki
Enoki have tiny, button-shaped caps and long, spindly stems.



Beech
Beech mushrooms are pelite with either all-white or light-brown caps.

Maitake
Maitake appear rippling and tan-shaped, without caps. They are also called "Hen of the woods."

People normally have diverse reactions to the foods they ingest – this fact holds true for mushroom consumption. What may be edible for some people may not be necessarily edible to everyone. North America is known to be home to approximately 250 mushroom species. Edible mushrooms are those that pose no health issues whatsoever when consumed.

The safest way to identify edible from poisonous mushrooms is via accurate verification of their species by an expert collector. Though books are an acceptable alternative means towards identification of edible mushroom species, it can occasionally prove catastrophic. Empirical identification methods such as smell and taste can be extremely dangerous as some poisonous mushrooms could exhibit a pleasant smell and taste.

B. Poisonous Species

Poisonous mushroom species are those that cause health complications when ingested. Their mere resemblance to edible mushroom varieties has in numerous occasions confused mushroom collectors. In some cases an unwitting victim does not exhibit symptoms of poisoning immediately after consumption, but often shows up after 48 hours. Symptom severity, however, varies from case to case.

Poisonous mushrooms can lead to death within 3 to 6 days after ingestion. As such, it is very important that the victim seek medical attention immediately. Mushroom poisoning symptoms include dizziness, breathing problems, diarrhea, vomiting and dehydration. Some of the most poisonous mushroom species include the death cap mushroom, Amanita phalloides, Amanita virosa (the destroying angel), Amanita muscaria (the fly Agaric) and Cortinariusrubellus.

The following is a detailed list of some of the common physical characteristics that distinguish edible mushrooms from poisonous ones:

a. Warts or scales on the cap

These are universal veil's remnants that encompass the mushroom while it is young. Sometimes these patches look more like rows of raised dots. Edible mushrooms have smooth and more or less white caps with no visible or noticeable raised warts or scales. On the contrary, poisonous mushrooms, for instance, the toxic fly agaric have a different colored cap (usually red with white spots) which has conspicuous scales and raised lumps.

b. Cap shape

Most of the edible mushrooms have bun-shaped or convex caps and sometimes with a wide low-hump. Other edible mushrooms such as chanterelles have caps that are concave and wavy or even trumpet-shaped. Poisonous species, however, have convex caps while young and flattens as the mushroom matures. The cap of many edible mushrooms stretches from the stem as it grows developing a ring of tissue around the stem also known as the annulus. Toadstools or poisonous varieties do not have this ring around the stem.

c. Base Stem.

Some mushrooms have a rounded cup commonly referred to as the "volva", which is a universal veil remnant. To observe the swollen base clearly you may have to dig up the mushroom as it's usually under the ground. The base of the stem of edible mushrooms is narrow or not thick like the rest of the stalk. On the other hand, many poisonous mushrooms usually have a noticeably swollen base. The Amanita muscaria, for instance, has a bulbous base.

d. Spore print

A spore print is an important diagnostic trait for identifying mushrooms. Identifying the color of the spore print can be very helpful as it helps you distinguish the different mushroom varieties. The color of mushroom spore can range from white to black and many other shades depending on the mushroom species. Some of the common poisonous mushrooms such as Amanita have white-colored spore prints.You can easily obtain a spore print for color-testing by removing the stem and putting the mushroom gills on a dark or white piece of paper for several hours. Once you know the color of the spore refer to a mushroom guide to know the exact species and its edibility.

e. Gills

Another distinctive feature is the size and color of the mushroom's gills. You will find most of the edible mushrooms with gills attached to the cap and not to the stalk. This means that the gills will stay attached to the cap even when the stalk is removed from the mushroom's base. The poisonous mushroom's gills, however, are attached to the stalk and will remain there even after you've removed it from the base. The gills on the cap of a young edible mushroom cap are usually pink in colour. However, the pink colour changes as the mushroom mature to brown or black. On the contrary, poisonous mushrooms have white gills that do not change colour throughout their entire lifecycle.

f. False Morel

A false morel is a mushroom that has an irregular shape and wrinkled structure. It has a wrinkled cap and a wrinkled stem. This type of mushroom is easy to spot because of its structure. It's also one of the common types of mushroom that you'll encounter.

What you need to know is that there is what we call a true and a false morel. A true morel is edible while a false morel can be both edible and not edible. This is because not all false morel is poisonous. However, just to be safe, pick up only a true morel.

There are a number of ways to identify a false morel from a true morel. And one of which is that a true morel has a hollow interior. While a false morel has a solid interior from the cap and the stem. Another reason to avoid morels is that some people have allergies to this type of mushroom.

g. Black Mushrooms

Your instincts might tell you already that black mushrooms are a no go when it comes to edibility. But just to be sure, we'll put it on this list. Black mushrooms are understandably dangerous as the color black is associated with poison.

There are numerous reasons why black mushrooms are dangerous. The first reason is that the black color represents decay. Most discoloration on mushrooms. Signifies that the mushroom is already undergoing some chemical process.

h. Decaying and Shrunken Mushrooms

Never eat a decaying mushroom. It's as simple as that, but some people still dare to take the risk. What some people don't understand is that, when a mushroom undergoes the process of decay. The mushroom releases a chemical that's deadly to the body.

To distinguish, just go for fresh and healthy mushrooms. You don't have to be an expert to know what a decaying mushroom looks like from a fresh one. But for those who can't seem to tell the difference, here's what you need to look for.

First of all, check the color of the mushroom. Compare side by side two mushrooms of the same kind and look for differences in their appearance. This is the easiest way on how you can identify a decaying mushroom from a fresh one.

i. *Smell*

Another common difference between poisonous and edible mushrooms is their smell. Some mushrooms have distinct smells or a unique smell which can help you to distinguish species that are visually similar. Some of the edible mushrooms, for instance, the Chanterelles have a distinctive fruity smell like apricots. Some of the poisonous species such as Agaricus xanthodermus, commonly known as the yellow-staining mushroom are known for their almond scent. When you are testing for odors, crush a part of the mushroom's cap for best results. Many mushrooms lack a smell, while others have quite a distinctive odor; thus, make sure you have a local mushroom guidebook to cross-reference. Also, you need to keep in mind that not all mushrooms with odors give a certain smell of something as most of them have vague descriptions like "farinaceous," meaning consisting of or containing starch.

How to Avoid Poisoning

To prevent mushroom poisoning you must be knowledgeable in the various mushroom identification methods when collecting mushrooms. Remember that there is no simple cut-and-dry method or set identifiable features to distinguish poisonous mushrooms from edible ones; thus, once you collect mushrooms, never mix the two species, and only consume the edible mushrooms that are healthy and in good condition.

Always preserve your edible mushrooms by properly refrigerating them, and discard any mushroom you are in doubt about whether it is edible or non-edible. Although there are numerous poisonous species, knowing how to properly identify the various mushrooms species will help to keep you from getting sick and even to enjoy your new mushroom foraging hobby.

Activity 3.1

1. Visit nearby vegetable venders, malls and big fresh vegetable outlets and collect information on different types of fresh mushroom available there. Collect information about mushrooms available in cans or as dried. Also collect information about different mushroom products available in the market.

Project Works

i. Prepare a brief report by observing the mushroom farming area around you.
ii. Make a list of mushrooms found in Nepal, write down their potential and characteristics on cardboard and paste them in the classroom.
iii. Prepare a model of the mushroom from thread or other domestic material and present it in the classroom.
iv. Produce mushrooms using the method of cultivating straw mulch at school or home.

Exercise

A. Mark the correct (✓) answers to the questions below:–

i. Mushroom is:
a. Saprophytic fungus
b. Autotrophic Algae
c. Heterotrophic fungus
d. None of the above

ii. Mycellium produces white or colored umbrella shaped fruiting bodies called:
a. Haphae
b. Basidiocarp
c. Annalus
d. Seta

iii. Mushroom cultivation is not useful in
a. recycling in agricultural waste
b. biogas production
c. biological control of crop production
d. preventing cancer

iv. Edible part of Mushroom is
a. Basidiocarp
b. Primary mycelium
c. Basidospores
d. Fungal hyphae

v. Mushrooms are very nutritious, rich in proteins, fiber and have ....
a. citric acid
b. amino acid
c. uric acid
d. folic acid

vi. Mushrooms are excellent source of
a. vitamin
b. carbohydrate
c. protein
d. minerals

B. State True or False

i. Fungi exist as microscopic threads in soil or on wood.
ii. Mushrooms are fruiting body of fungi.
iii. All fungi are mushrooms.
iv. All fungi are useful.
v. Cultivation technology is same for all mushrooms.
vi. Amount of spawn required for cultivation of different mushrooms is the same.

C. Fill in the blanks

i. Common name of Agaricus bisporus is.................
ii. The material left after growing mushrooms, commonly referred as.................
iii. Mushroom cultivation utilizes................. Space.
iv. Mushrooms are considered................. protein producers per unit area per unit time.
v. Mushroom cultivation is commonly described as generation of wealth from the.................
vi. Vitamin..........and vitamin.......... commonly found in animals, is also found in mushrooms.

vii. Mushroom is suitable for patients having high blood pressure as these have................. sodium and................. potassium.
viii. Mushroom is low calorie food and hence considered delight of the ....
ix. Seed of mushroom is called.................
x. Process of putting a layer of soil after spread of mycelium is called.................

D. Give reasons

i. Mushrooms are called saprophytes.
ii. Mushrooms are considered to be beneficial.
iii. People with high blood pressure, diabetes and heart disease are encouraged to consume mushrooms.
iv. Caution should be exercised when using wild mushrooms.

E. Write differences:–

i. edible mushroom and poisonous mushroom
ii. primary and secondary mycelium
iii. annulus and gills

F. Answer the following questions

i. Presently which mushroom is world's number one mushroom in terms of production?
ii. How many types of mushrooms are cultivated in Nepal?
iii. Which is the most popular mushroom in Nepal?
iv. Which mushroom is having maximum production in our country?
v. Why mushrooms cannot make their own food?
vi. Name the six most important mushrooms cultivated in the world.
vii. What are the two main advantages of growing mushrooms?
viii. Write down the medicinal and nutritional value of mushrooms.
ix. What are mushrooms' health benefits?
x. Are mushrooms classified as a fruit or vegetable? Why?
xi. Make a list of mushroom products.
xii. Describe the method of making mushroom pickles.
xiii. Write down the characteristics of poisonous mushrooms.
xiv. Draw a picture of the mushroom and name the different parts.
xv. Describe the lifecycle of the mushroom with pictures
xvi. Given below are pictures of some mushrooms. These are Shiitake, Pink oyster mushroom, Oyster mushroom, Button mushroom, Wood ear mushroom, Paddy straw mushroom, King oyster and Milky mushroom. Write correct name below each mushroom (Hint: 2. Milky mushroom).

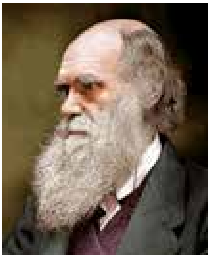
Unit 4

Evolution

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- give the concept of evolution and to describe the evidence related to it.
- explain Lamark's concept of evolution theory.
- explain Hugo de Vries' theory of mutation.
- explore the importance of variation and mutation in evolution.
- explain Darwin's concept of evolution theory



Charles Darwin, in full **Charles Robert Darwin**, (1809-1882) Downe, Kent), English naturalist whose scientific theory of evolution by natural selection became the foundation of modern evolutionary studies. Darwin formulated his bold theory in private in 1837–39, after returning from a voyage around the world aboard HMS Beagle, but it was not until two decades later that he finally gave it full public expression in *On the Origin of Species* (1859), a book that has deeply influenced modern Western society and thought. Darwin is often called the 'Father Of Evolution', but there was much more to the man than just his scientific papers and literary works.

4.1 Introduction to Evolution

The Earth consists of many plants and animals. They are different from each other in different groups on the basis of their similarities and dissimilarities. *For example* frog, bird, whale, and cow are different from each other but they have similarities i,e., they have backbone. According to modern beliefs, the most advanced organisms (mammals and flowering plants) on the earth so far have evolved from very simple micro-organisms (amoeba, euglena etc.). It means that simple forms of organisms were evolved first and gradually they modified into complex ones.

Fig 4.1

As the Earth's environment changed, the bodies of living things also changed accordingly. Based on various evidences of evolution, organisms with complex bodies evolved from simple organisms. Thus, the origin of various types of complex organism from simple organism is known as **evolution**.

According to principle of evolution, changes on living organisms which occurred years and years ago still exist and it will continue in near future. Some of the developed living organisms extinct while some of them are still surviving. In developmental process, origin of new plants and animals will take million of year. In nature, simple organism gives rise to complex organism. In similar way, principle of evolution focuses on origin of flowering and non-flowering plants, origin of vertebrates like fish, ape, reptiles, birds and mammals after the origin of invertebrates.

Evolution refers to change through time as species become modified and diverge to produce multiple descendant species. Evolution and natural selection are often conflated, but evolution is the historical occurrence of change, and natural selection is one mechanism—in most cases the most important—that can cause it. Recent years have seen a flowering in the field of evolutionary biology, and much has been learned about the causes and consequences of evolution. The two main pillars of our knowledge of evolution come from knowledge of the historical record of evolutionary change, deduced directly from the fossil record and inferred from examination of phylogeny, and from study of the process of evolutionary change, particularly the effect of natural selection. It is now apparent that when selection is strong, evolution can proceed considerably more rapidly than was generally envisioned by Darwin. As a result, scientists are realizing that it is possible to conduct evolutionary experiments in real time. Recent developments in many areas, including molecular and developmental biology, have greatly expanded our knowledge and reaffirmed evolution's central place in the understanding of biological diversity.

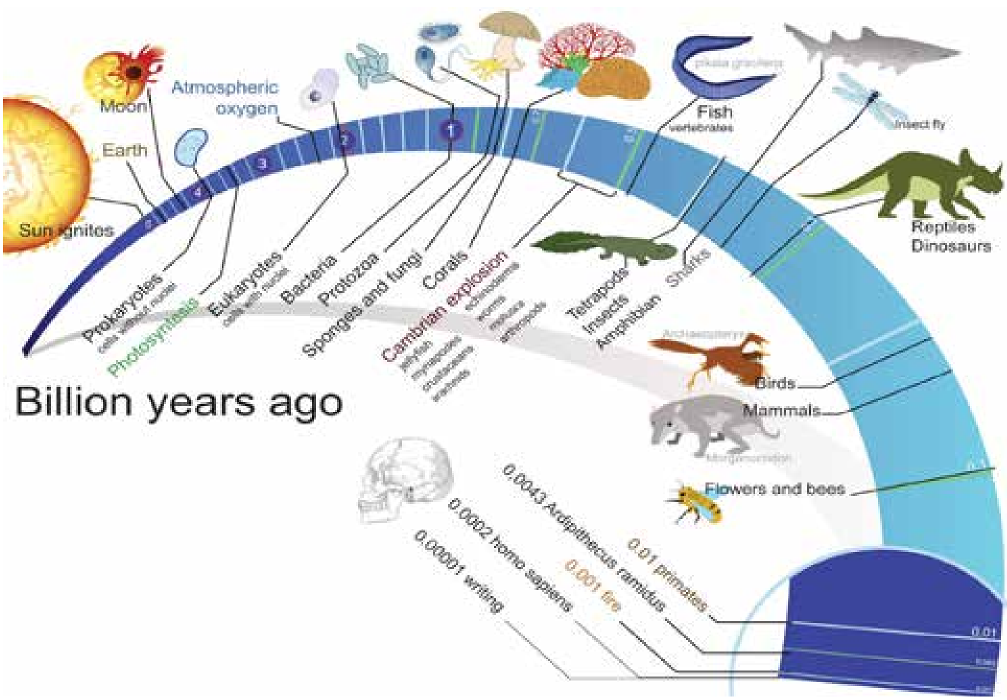


Fig 4.2

Evolution descent with modification; transformation of species through time, including both changes that occur within species, as well as the origin of new species. Evolution is the change in the characteristics of a species over several generations and relies on the process of natural selection. The theory of evolution is based on the idea that all species are related and gradually change over time. Evolution relies on there being genetic variation in a population which affects the physical characteristics (phenotype) of an organism. Some of these characteristics may give the individual an advantage over other individuals which they can then pass on to their offspring. There are three types of evolution : Convergent evolution, Co-evolution and Adaptive radiation. When the same adaptations evolve independently, under similar selection pressure e.i, **Convergent evolution**. For example, flying insects, birds and bats have all evolved the ability to fly, but independently of each other. When two species or groups of species have evolved alongside each other where one adapts to changes in the other e.i, **Co-evolution.** For example, flowering plants and pollinating insects such as bees. When a species splits into a number of new forms when a change in the environment makes new resources available or creates new environmental challenges, e.i., **Adaptive radiation**. For example, finches on the Galapagos Islands have developed different shaped beaks to take advantage of the different kinds of food available on different islands.

Natural Selection, the process in which individuals with a particular trait tend to leave more offspring in the next generation than do individuals with a different trait.

The branch of life science for the study of 'origin of life' and evolution of different forms of life on earth was called **bioevolution or evolutionary biology** by Mayer (1970). The word evolution means to unfold or unroll or to reveal hidden potentialities. Evolution simply means an orderly change from one condition to another. Evolution is a slow but continuous process which never stops.

Origin of life is the process by which living organisms developed from inanimate matter (which is generally thought to have occurred on Earth between 3800 - 4200 millions years ago). First life evolved about. 3800-4200 million years back. There are several theories about the origin of life, like big bang theory, theory of special creation, theory of eternity, cosmozoic theory etc.

4.2 Evidences of Organic Evolution

The term '**Organic Evolution'** consists of two words 'Organic' meaning 'living species' and 'evolution', meaning 'unfold. The organic evolution is the unfolding of the creation cycle of different forms of organisms. As we know there are millions of different animal and plant species around us. All these types of life came into being from very basic unicellular species, including the blue-green algae produced in the oceans. These single-celled organisms have evolved over time to adapt to changing environments. And hence, we say that, organic evolution is the process of gradual and orderly changes in organism from one form to another. It occurs countinuously but is very slow process. There are various evidences of evolution. They are :

1. Evidences from fossil or palaeontological evidences
2. Evidences from comparative morphology and anatomy
    a. Evidences from homologous and analogous organs
    b. Evidences from vestigial organs
3. Evidences from bridge animals
4. Evidences from embryo

1. Evidences from fossil or palaeontological evidences

The traces and preserved remnant of dead animals and plants are called fossils. The study of fossil is known as palaeontology. Palaeontological evidence is considered as the strongest evidence of organic evolution because scientists have been able to trace the phylogeny (evolution history) of animals such as horses, camels, dogs and elephants by studying fossils.

Palaeontological studies revealed the following points on the basis of which we can say that how living organisms evolved.

i. There were some living organisms in the past however, they are no more now.
ii. The living organisms which existed in the past were different from the present day forms.
iii. Some living organisms were dominant in one period, e.g. dinosaurs were dominant during mesozoic era, but later cretaceous period of the mesozoic era dinosaurs became extinct.
iv. The organisms which existed in the past link one group of living organisms to another groups. For example, Archaeopteryx is an extinct animals which links between reptiles and birds.
v. Palaeontological evidence shows the gradual progress from simple to complex forms throughout the geological time scale i.e. the older forms were comparatively simpler.

Note : Age of fossils is measured by carbon dating and uranium dating.

2. Evidences from comparative morphology and anatomy

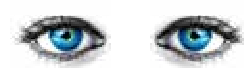
Every group of animals and plants has its pattern of body formation and it possesses a common set of characteristics that suggests, they have a common ancestry.

Morphology is the study of form of organisms and anatomy is the study of internal structure. Evidences from morphology and anatomy can be studied in following two heads :

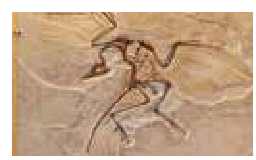
a. Homology and Analogy b. Vestigial organs

Interesting Facts about Evolution !

Most people had brown eyes until about 10,000 years ago when a single genetic mutation from the Black Sea switched the eyes from brown to blue. Approximately 8% of the world's population now has blue eyes.



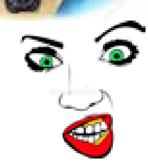
In 1861, the fossil of a primitive bird named Archaeopteryx ("first bird") was found in Germany. It has impressions of feathers and a long, bony tail. Scientist believe this fossil links birds and reptiles and was the first solid evidence to support Darwin's theory of evolution.



The discovery of DNA (strands of hereditary material) provides the strongest proof for biological evolution. By comparing genomes of different living things and observing the changes in the coding of genes, scientists can figure out how closely different species are related to each other and identify how long ago a common ancestor lived.

The platypus is the earliest mammal offshoot from the reptiles. It lays eggs but produces milk like other mammals. It also has evolved the ability to produce venom independently of its reptile ancestors.

Lip twitching when angry is an evolutionary leftover. It is the first part of baring teeth at an intruder and can also be seen in wolves, bears, and chimpanzees.



Homology

The similarity based on common origin, similar basic plan of organization and embryonic development is called **homology**. Similarity in appearance and function is not necessary. The organs which have common origin, embryonic development and the same basic structure but perform different functions are called homologous organs. Examples of homologous organs are:–

- ## Forelimbs of mammals

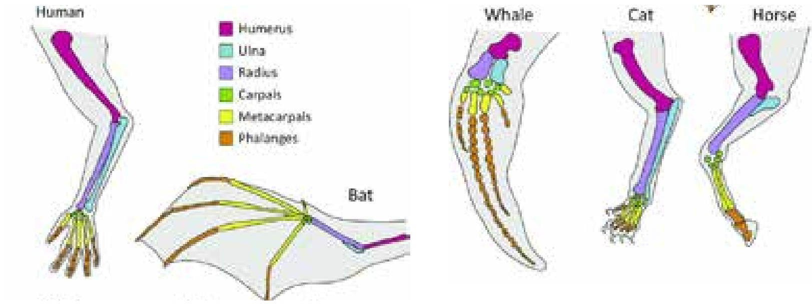


Fig 4.3

	Horse	Bat	Whale	Seal	Man
Appearence	Foot	Wings	Paddle	Flipper	Hand
Function	Running	Flying	Swimming	Swimming	Holding

In their forelimbs, similar bones are present like –humerus, radius, ulna, carpals, metacarpals and phalanges.

- ## Legs of invertebrates

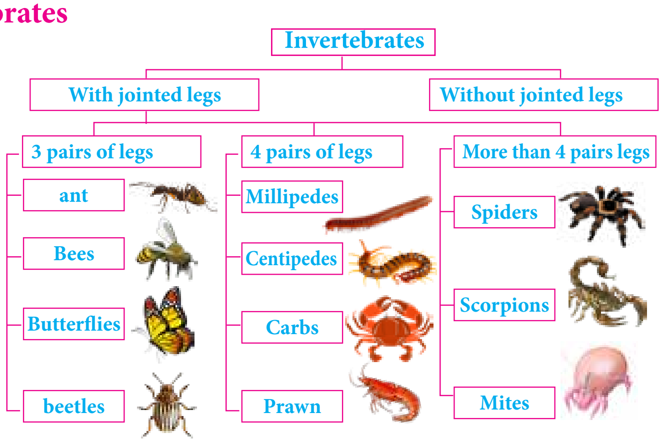


Fig 4.4

Cockroach	Honey bee
Walking	Collecting of pollens

In both cockroach and honey bee, segmented legs are present and segments are same like coxa, trochanter, femur, tibia and 1-5 jointed tarsus.

Cockroach Legs **Honey Bee Legs**

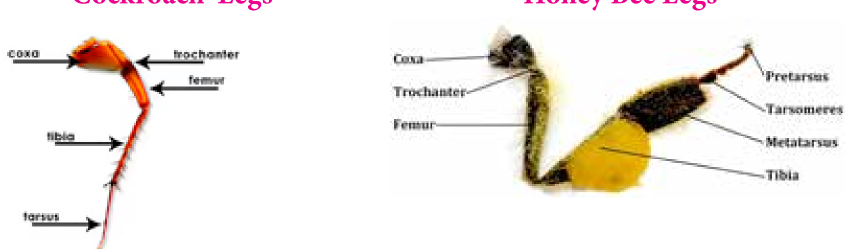


Fig 4.5

- ## Mouth parts of insects

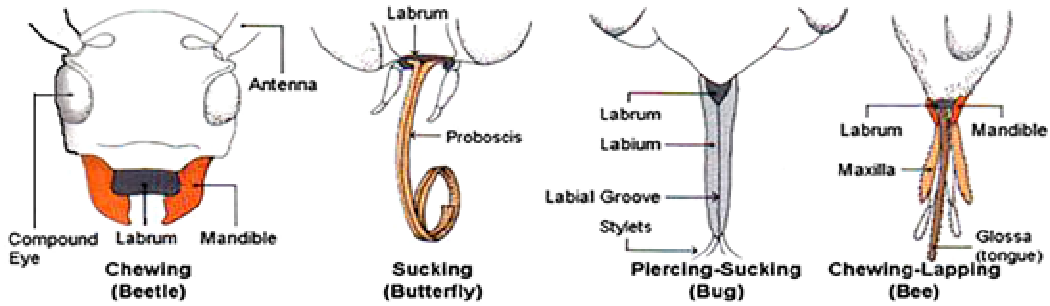


Fig 4.6

Cockroach	Honey Bee	Mosquito
Biting and chewing	Chewing and lapping	Piercing and sucking

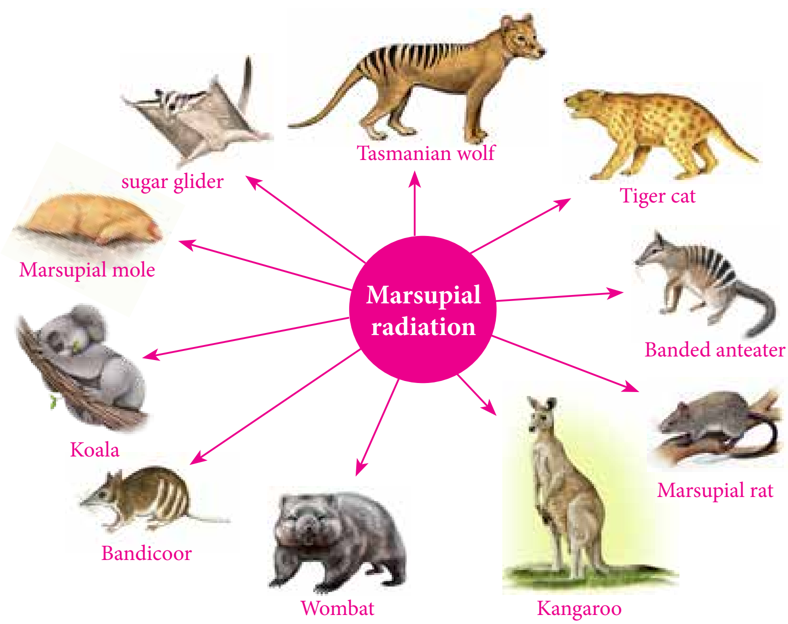


Fig 4.7

In each of these insects, the mouth parts comprises labrum, mandibles and maxillae.

- Homology is also seen in the skeleton, heart, blood vessels and excretory system of different vertebrates
- Thorn of Bougainvillea and tendril of Cucurbita (modification of axillary bud)
- Wings of sparrow and pectoral fins of fish
- Hind limb of mammals
- Homology is also seen amongst the molecules. This is called **molecular homology.** For e.g., the proteins found in the blood of man and apes are similar.
- Testes in male and ovaries in female develop from the same embryonic tissue.
- Pectoral fins of fish and flipper of Seal.
- Flipper of Penguin (bird) and Dolphin (mammal).

Homology found in different animals indicate their evolution from common ancestors. The process in which species which have diverged after origin from common ancestor giving rise to new species adapted to new habitats and ways of life is called **adaptive radiation,** exhibit large number of homologous organs. Homology shows **divergent evolution.** For e.g., Adaptive radiation gave rise to a variety of marsupials in Australia.

Analogy

It is similarity in organs based on similar function. Organs which have different origin and dissimilar fundamental structure but have similar functions are called **analogous organs.**

Examples of Analogous organs are–

- Wings of bat & birds are analogous to wings of insects.
- Pelvic fins of fish, flipper of seal.
- Sting of bee and scorpion.
- Phylloclade of Ruscus and leaf.
- Chloragogen cell of Pheretima and liver of vertebrate.
- Hands of man and trunk of elephants.
- Potato and sweet potato.
- Eyes of octopus and eyes of mammals (different in their retinal position).
- Dog fish and whale.

Analogy in the wings

Development of similar adaptive functional structures in unrelated groups of organisms is called **convergent evolution.** For e.g., Some of the marsupials of Australia resemble equivalent placental mammals that live in similar habitats of other continents. When adaptive convergence is found in closely related species, it is called parallel evolution. Analogous organs **do not show common ancestry** but they show evolution.

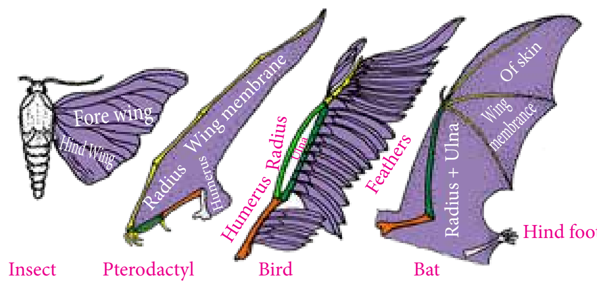


Fig 4.8

b. Vestigial organs

The organs which are present in reduced form and do not perform any function in the body but correspond to the fully developed functional organs of related animals are called **vestigial organs.** These are remnants of organs which were complete and functional in their ancestors. Human body possess about **180 vestigial organs.** Some of these are - nictitating membrane; muscles of pinna (auricular muscles); vermiform appendix; coccyx; canine teeth; third molars (wisdom teeth); segmental muscles of abdomen; caecum; body hairs; nipples in male and ear pinna. These organs prove about evolution as they are well developed in other lower forms.

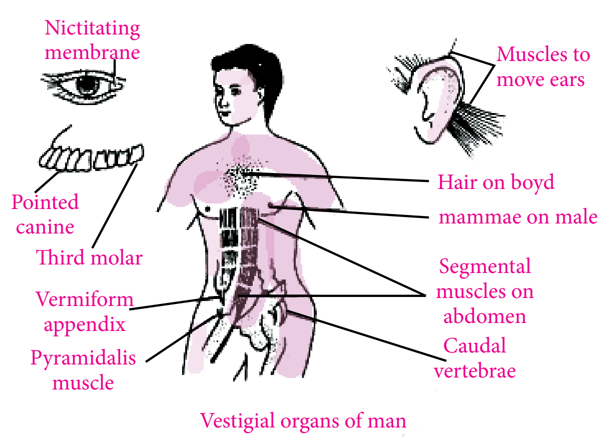


Fig 4.9

Examples of Vestigial Structures

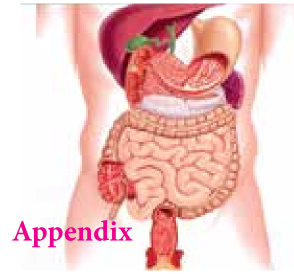


Fig 4.10

The animal kingdom is ripe with vestigial structures in their skeletons and bodies.

- Snakes descended from lizards, with their legs growing smaller and smaller until all that was left is a small bump (leg bones buried in muscle) at the back of some of the largest snakes, such as pythons and boa constrictors.
- Blind fish and salamanders who live in caves still have eye structures. One explanation, in the case of the fish, is that mutations in the genes that increase taste buds degrade the eyes.
- Cockroaches have wings, though the ones on the females aren't developed enough for them to fly.
- The whale shark is a filter feeder and its rows of teeth couldn't bite anything if they tried.
- The Galapagos cormorant has vestigial wings that don't help it to fly or swim, though the birds still dry them off in the sun after they get wet, just as if they would if they still could use them to fly. This species diverged into a flightless bird about 2 million years ago.

3. Evidences from bridge animals

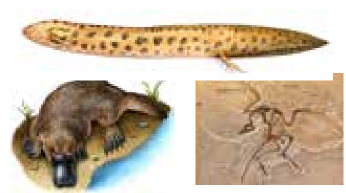


Fig 4.11

Some animals and plants possess characters of two separate groups – one being primitive and the other is advanced group. These species act as a bridge between two taxonomic groups. Such organisms are called **connecting links** or **bridge animal. Platypus** is a connecting link between birds and mammals. It has mammary gland and hair a beak like a bird. **Peripatus** is a living connecting link between arthropods and annelids. Its arthropods characters are claws, jaws, hemocoel, tracheae and dorshal tubular heart. The annelidan characters are continuous muscle layers in the body wall, unjoined legs and nephridia. **Archaeopteryx** is a connecting link between reptiles and bird. **Protopterus** (Lungfish) is a connecting link between fishes and amphibians. Like other fish they have paired fine, dermal scales, gills, segmented trunk, tail muscles and ears represented by internal ear only. They resemble amphibians in having internal nostrils, a lung, and the heart with imperfectly divided auricle. Connecting links provide good example of organic evolution and common ancestry. Examples –

1	Virus	Between living and non living.
2	Englena	Between plants and animals.
3	Proterospongia	Between protozoa and porifera.
4	Neopilina	Between mollusca and annelida
5	Peripatus	Between annelida and arthropoda.
6	Arfchaeopteryx	Between reptiles and birds.
7	Balanoglossus	Between non chordates and chordates.
8	Chimera	Between cartilaginuos fish and bony fish.
9	Lung fish (Protopterus)	Between fishes and amphibia.
10	Platypus	Between reptiles and mammals.
11	Echidina	Between reptiles and mammals.

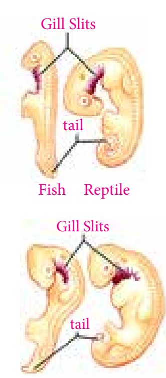


Fig 4.12

d. Evidences for embryo

When the embryos of different species of animals are compared, it is found that they resemble with one another.They develop gradually and differ with each other. Later on, accordingto their hereditary characters, they develop into different organisms.

Fig 4.13

Embryology is the study of the development of the anatomy of an organism to its adult form. It provides evidence for evolution as embryo formation in widely-divergent groups of organisms tends to be conserved. Structures that are absent in the adults of some groups often appear in their embryonic forms, disappearing by the time the adult or juvenile form is reached. For example, all vertebrate embryos, including humans, exhibit gill slits and tails at some point in their early development. These disappear in the adults of terrestrial groups, but are maintained in adults of aquatic groups, such as fish and some amphibians. Great ape embryos, including humans, have a tail structure during their development that is lost by birth. Another example, all vertebrate embryos, from humans to chickens to fish, have a tail during early development, even if that tail does not appear in the fully developed organism. And hence it proves that evolution occured from simple to complex from.

4.3 Theory of Evolution

The theory of evolution encompasses the well established scientific view that organic life on our planet has changed over long periods of time and continues to change by a process known as natural selection.

The theory of evolution contains two parts, both of which are unnecessarily contentious. The first is the word 'theory', which means something slightly different in everyday speech than it does in science. The second contentious word is 'evolution', because some people argue that there is insufficient evidence to support the idea that species change over time. Proponents of the latter view rely on our dual uses of the word theory to confuse the issues.

Many scientists have contributed to the formulation of the theory of evolution. Jean Baptiste de Lamarck of France, Alfred Russel Wallace and Charles Darwin of England and Hugo De Vries of Holland brought forward the scientific explanation of the mechanism of evolution. Baptiste de Lamarck, Charles Darwin and Hugo De Vries's theory of evolution are mentioned here.

Lamarck's Theory or Lamarckism

Lamarck was a French philosopher and biologist who brought forward the theory of evolution for the first time (1809 AD) in his book *Philosophic Zoologique*. His theory can be explained in the following three points.

a. Direct environmental effect

According to his theory, it is believed that the changed environment influences the modification of the organs of an organism. These modification create new organs. For example yaks found in Himalayan region have thick fur due to influence of extreme cold climate, which helps them to keep their body warm.

b. Use and disuse of organs

Development of any organ is directly proportional to its use. Disuse of organs leads to the gradual weakening of that organ. A constant use and disuse of organs leads to modification in the form and less used structures are reduced and ultimately get lost. For example, a black smith develops strong muscles of the arm due to its constant use.

c. Inheritance of acquired characters

Organisms obtain characters from use and disuse of organs and influence of environment. These characters are inherited from one generation to another generation and a new species are created after a series of generation. Lamarck explained the long neck of giraffe as an example.

Criticism of Lamarckism

- No experimental proof for use and disuse of organs can modify organs.
- No possibility of developing organs according to the need and wish of an organism.
- All the acquired characters are not inherited into new generation.

Darwin's Theory or Darwinism

The theory of evolution by natural selection, first formulated in Darwin's book "On the Origin of Species" in 1859, is the process by which organisms change over time as a result of changes in heritable physical or behavioral traits. Changes that allow an organism to better adapt to its environment will help it survive and have more offspring. Evolution by natural selection is one of the best substantiated theories in the history of science, supported by evidence from a wide variety of scientific disciplines, including paleontology, geology, genetics and developmental biology.

Main features of Darwinism are explained here under.

a. Enormous fertility

All organisms possess enormous fertility. They multiply in geometric ratio. If all the offsprings's survive and reproduce, they would soon overcrowd the Earth. Some examples are cited below:

- Insects lay hundreds of eggs. A cod-fish lays several hundred eggs at a time. A female rabbit gives birth to six young ones in one litter and produces four litters in a year. Six-month-old rabbit is capable of reproduction. If all the rabbits survived and multiplied at this rate, their number would be very large after some time.
- Each pair of mice produces dozens of young ones. They have a gestating period of 19 to 21 days. A female mouse gets pregnant about 5 to 10 times each year and can give birth to a litter of 3 to 14 pups. On average, the litter size ranges from 6 to 8 pups. On average, you are looking at least 32 to 56 pups each year from one female mouse.The mice reproduce each year, and the mother can mate immediately after giving birth. So you could be looking at a new litter within 25 days.
- It is assumed that elephant is the slowest breeder, which matures at the age of 30 years and lives for about 90 years. A single female reproduces on an average 6 young ones during its lifetime. If all the young ones of a pair survive, there would be 19000000 descendants at the end of 750 years.

Thus some organisms (living beings) produce more offspring and others produce fewer offspring. This is called differential reproduction.

b. Struggle for existence

The population size will increase to the higher extent if all the population that are born will survive. It will create scarcity of food and shelter. Despite of this, organisms have to struggle for food, shelter, fertility, disease and environment in order to survive. Those species which succeed in adapting themselves will exist and those unable to adapt will extinct from environment. Darwin defined it as struggle for existence.

The struggle for existence can be of three types.

(i) Intraspecific Struggle:

It is the struggle between the individuals of the same species because their requirements like food, shelter, breeding places, etc. are similar. Many human wars are the examples of intraspecific struggle. Cannibalism (eating the individuals of its own species) is another example of this type of struggle.

(ii) Interspecific Struggle:

It is the struggle between the members of different species. This struggle is normally for food and shelter. For example, a fox hunts out a rabbit, while the fox is preyed upon by a tiger.

(iii) Environmental Struggle:

It is the struggle between the organisms and the environmental factors, such as drought, heavy rains, extreme heat or cold, earthquakes, diseases, etc. Thus, climate and other natural factors also help in restricting the number of individuals of particular species.

c. Variations and heredity

We have seen that reproductive processes give rise to new individuals that are similar, but subtly different. We have discussed how some amount of variation is produced even during asexual reproduction. And the number of successful variations are maximised by the process of sexual reproduction. If we observe a field of sugarcane we find very little variations among the individual plants. But in a number of animals including human beings, which reproduce sexually, quite distinct variations are visible among different individuals.

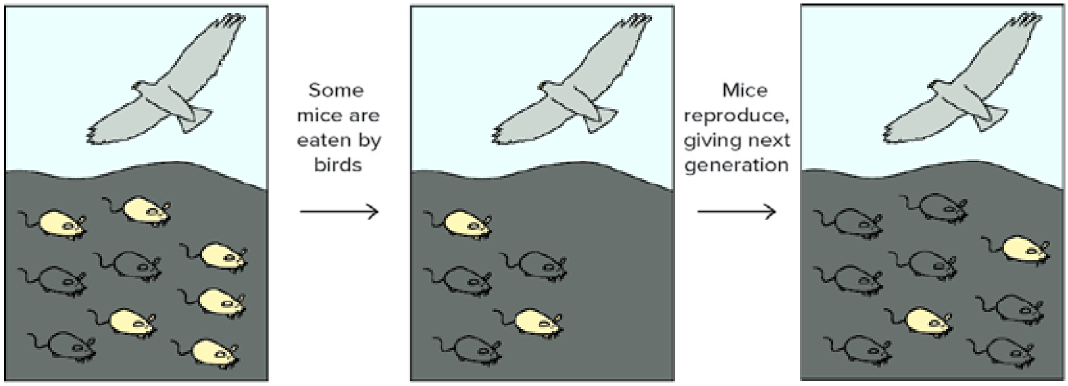
Offsprings of species are similar, however some of the characteristics differ. In this way, difference in shape and characteristics is known as variation. All organism does not possess variation according to environment. Thus, species whose variation occur according to environment will survive. But those species whose variation occur against environment will not survive.

d. Natural selection

There are two major components of the theory. The first is the mechanism of natural selection, which was proposed independently by Charles Darwin. In the same way artificial selection occurs when breeders choose seeds or studs that will improve their stock in the next generation, natural selection is the process of sorting living things according to how well adapted they are to their environment.

In the case of artificial selection, humans choose which traits are desirable. In the case of natural selection, traits that increase the likelihood of survival and reproduction will become more common within a population or species over time.

In the past, natural selection has been misrepresented by calling it the survival of the fittest. This statement oversimplifies the mechanism by making it sound like a tautology: the survival of those who survive. The truth is that individuals never survive. What survives is the process for making another individual, and this resides in genes found in populations.



A population of mice has moved into a new area where the rocks are very dark. Due to natural genetic variation, some mice are black, while others are tan.

Tan mice are more visible to predatory birds than black mice. Thus, tan mice are eaten at higher frequency than black mice. Only the surviving mice reach reproductive age and leave offspring.

Because black mice had a higher chance of leaving offspring than tan mice, the next generation contains a higher fraction of black mice than the previous generation.

Fig 4.14

Natural selection has more to do with differential reproduction than survival, and what it selects are the genes that code for desirable traits or characteristics. The interaction of individuals with their environment provides a mechanism for sorting out which traits (not which individuals) will be passed on to the next generation.

Organisms which can adapt to their environment tends to survive longer than those which are unable to adapt. Nature itself selects the survival period of organisms. Organs or characteristics which serve the organisms during struggle for existence will get transferred to their offsprings. More effective development of such characters will occur in every off springs. After several years, succeeding generations will bear totally new characters. Thus, selection of progressive organism will occur. This is called as natural selection. Organisms able to overcome the struggle will survive.

Example: How does natural selection work?

To make natural selection more concrete, let's consider a simplified, hypothetical example. In this example, a group of mice with heritable variation in fur color (black vs. tan) has just moved into a new area where the rocks are black. This environment features hawks, which like to eat mice and can see the tan ones more easily than the black ones against the black rock.
Because the hawks can see and catch the tan mice more easily, a relatively large fraction of the tan mice are eaten, while a much smaller fraction of the black mice are eaten. If we look at the ratio of black mice to tan mice in the surviving ("not-eaten") group, it will be higher than in the starting population.

Fur color is a heritable trait (one that can be passed from parent to child). So, the increased fraction of black mice in the surviving group means an increased fraction of black baby mice in the next generation. After several generations of selection, the population might be made up almost entirely of black mice. This change in the heritable features of the population is an example of evolution.

Key points about natural selection

When I was first learning about natural selection, I had some questions (and misconceptions!) about how it worked. Here are explanations about some potentially confusing points, which may help you get a better sense of how, when, and why natural selection takes place.

- ***Natural selection depends on the environment***
  Natural selection doesn't favor traits that are somehow inherently superior. Instead, it favors traits that are be neficial (that is, help an organism survive and reproduce more effectively than its peers) in a specific environment. Traits that are helpful in one environment might actually be harmful in another.
- ***Natural selection acts on existing heritable variation***
  Natural selection needs some starting material, and that starting material is heritable variation. For natural selection to act on a feature, there must already be variation (differences among individuals) for that feature. Also, the differences have to be heritable, determined by the organisms' genes.
- ***Heritable variation comes from random mutations***
  The original source of the new gene variants that produce new heritable traits, such as fur colors, is random mutation (changes in DNA sequence). Random mutations that are passed on to offspring typically occur in the germline, or sperm and egg cell lineage, of organisms. Sexual reproduction "mixes and matches" gene variants to make more variation.

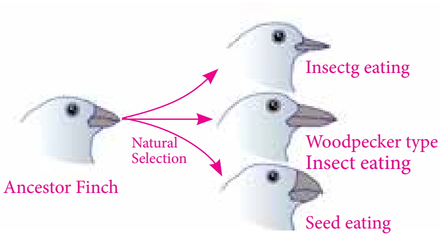


Fig 4.15

Natural selection and the evolution of species

Let's take a step back and consider how natural selection fits in with Darwin's broader vision of evolution, one in which all living things share a common ancestor and are descended from that ancestor in a huge, branching tree. What is happening at each of those branch points?

In the example of Darwin's finches, we saw that groups in a single population may become isolated from one another by geographical barriers, such as ocean surrounding islands, or by other mechanisms. Once isolated, the groups can no longer interbreed and are exposed to different environments. In each environment, natural selection is likely to favor different traits (and other evolutionary forces, such as random drift, may also operate separately on the groups). Over many generations, differences in heritable traits can accumulate between the groups, to the extent that they are considered separate species.

Based on various lines of evidence, scientists think that this type of process has repeated many, many times during the history of life on Earth. Evolution by natural selection and other mechanisms underlies the incredible diversity of present-day life forms, and the action of natural selection can explain the fit between present-day organisms and their environments.

e. Origin of new species

Organisms which struggle for their survival eventually become able to survive. Such favorable characteristics which helps in survival are also transferred into their offsprings. In such way, characteristics oforganisms which are able to survive an changed environment will be transferred into their off springs. After many years, offsprings develop into new organism. Two or more than two species originate from same ancestors.

Criticism of Darwinism

i. Natural selection does not explain the origin of variations (arrival of the fittest). It explains only the presence of variations (survival of the fittest). Why Darwin was unable to explain the origin of variations? Because he did not know about genes.
ii. Darwin believed that the variations help in competition. At the beginning the wings in birds are in primordial state. Then how they fly to protect from enemies? Likewise in Torpedo [electric ray], the protective electric organ was in rudimentary stage at the beginning. Then how the Torpedo was protected before the full development of electric organ?
iii. Darwin was unable to explain the presence of vestigial organs.
iv. Darwin did not explain the overgrowth of antlers in Irish deer and tusks in Jefferson's Mammoths.

Variation and mutation

Variation, is any difference between cell, individual organisms, or groups of organisms of any species caused either by genetic differences (genotypic variation) or by the effect of environmental factors on the expression of the genetic potentials (phenotypic variation). Variation may be shown in physical appearance, metabolism, fertility, mode of reproduction, behaviour, learning and mental ability, and other obvious or measurable characters.

Genotypic variations are caused by differences in number or structure of chromosomes or by differences in the genes carried by the chromosomes. **Phenotypic** variations also include stages in an organism's life cycle and seasonal variations in an individual. These variations do not involve any hereditary alteration and in general are not transmitted to future generations; consequently, they are not significant in the process of evolution.

All people are human. They belong to the same species. Your friends and classmates may have different eye and hair colour. Some are boys and some are girls. Some are tall and some are short. The presence of differences between living things of the same species is called variation.

Variation between different species is usually greater than the variation within a species. Some variation within a species is inherited, and some variation is due to the environment.

Variation in a characteristic that is a result of genetic information from the parents is called inherited variation. Such variations arise in the germ cells of the organisms and have no external influence. These heritable variations are also known as blastogenic variatons.

Children usually look a little like their father, and a little like their mother, but they will not be identical to either of their parents. This is because they get half of their DNA and inherited features from each parent.

Each egg cell and each sperm cell contains half of the genetic information needed for an individual. When they meet at fertilisation, a new cell is formed with all the genetic information needed for an individual.

Here are some examples of inherited variation in humans:

- eye colour
- hair colour
- skin colour
- lobed or lobeless ears
- ability to roll your tongue

Sex is inherited variation too, because whether you are biologically male or female is a result of the genes you inherited from your parents.

Environmental causes of variation

The variations due to the influences of the environment are called **somatogenic variations**. These variations are not inherited from the parents to offsprings. For example: Development of muscles in an athlete, loss of leg in an accident, etc.These variations are not heritable and not transmitted to the offspring and are lost with the organism death.

Characteristics of animal and plant species can be affected by factors such as:

- climate
- diet
- accidents
- culture
- lifestyle

For example, you will become heavier if you eat too much food, and you will become lighter if you eat too little. A plant in the shade of a big tree will grow taller as it tries to reach more light.

Variation caused by the surroundings is called **environmental variation**. Here are some other examples of features that show environmental variation:

- your language
- your religion
- flower colour in hydrangeas (these plants produce blue flowers in acidic soil and pink flowers in alkaline soil)

Inherited and environmental causes

Some features vary because of a mixture of inherited causes and environmental causes. For example, identical twins inherit exactly the same features from their parents. However, if you take a pair of twins, and twin 'A' is given more to eat than twin 'B', twin 'A' is likely to end up heavier. Weight and height are common examples of characteristics that are influenced by both genetic and environmental factors.

Continuous and discontinuous variation

Some of the features of the different organisms in a species show continuous variation, and some features show discontinuous variation.

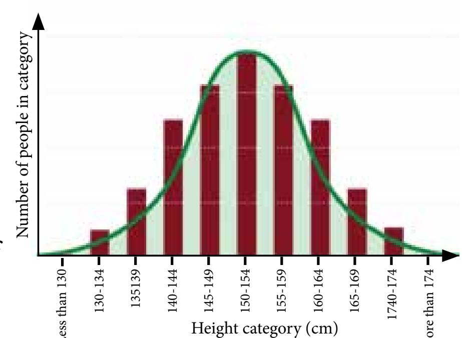
Continuous variation

Human height is an example of continuous variation. It ranges from that of the shortest person in the world to that of the tallest person. Any height is possible between these values. So, it is continuous variation.

For any species a characteristic that changes gradually over a range of values shows continuous variation. Examples of such characteristics are:

- height
- weight

If you record the heights of a group of people and draw a graph of your results, it usually looks something like this:



a bar chart to represent variotion in height

Fig 4.16

The more people you measure, and the smaller the categories you use, the closer the results will be to the curved line. This shape of graph is typical of a feature with continuous variation. Weight would give a graph similar in shape to this.

Discontinuous variation

A characteristic of any species with only a limited number of possible values shows discontinuous variation. Human blood group is an example of discontinuous variation. In the ABO blood group system, only four blood groups are possible (A, B, AB or O). There are no values in between, so this is discontinuous variation.

Here are some examples:

- blood group
- sex
- eye colour

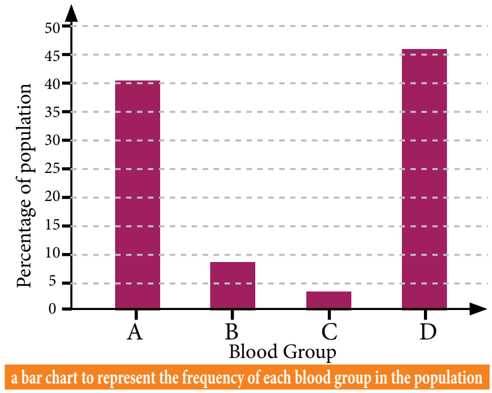


Fig 4.17

The role of variation in evolution

Variations refer to the changes that are seen in the case of the genetic makeup of an organism. Variations in organisms arise due to the sexual reproduction and ensure the natural selection of the individual and in turn make the organism better adapted to the environment. Variations pose many advantages to the population, some of the advantages are given below:

i. Variations enable better adaptation of an organism in the changing environmental condition.
ii. In the case of plants and animals, they help in disease resistance.
iii. Variations improve the chances of survival of a particular species on the onset of unfavorable conditions.
iv. Variations in organisms give rise to the development of new and better fit species in the environment, when two species mate with one another and show interspecific hybridization, they further give rise to genetic variation and hence the formation of new individuals.
v. Variation is the major source of species and environmental evolution wherein the more fit organisms replace the less fit organism from the environment they were earlier sharing.

It should be noted that variations have a lot of advantages on the population but these advantages are only based on the principle of natural selection and survival of the fittest in the environment. The variations enable the organisms to survive the changing environment and are hence considered to be important.

Mutation

Mutation is a change in a gene or chromosome. It is a rare, random change in the genetic material and it can be inherited. Mutation can be spontaneous (it just happens). It can also happen because of:

- ionising radiation
- chemical mutagens - such as tar from cigarette smoke

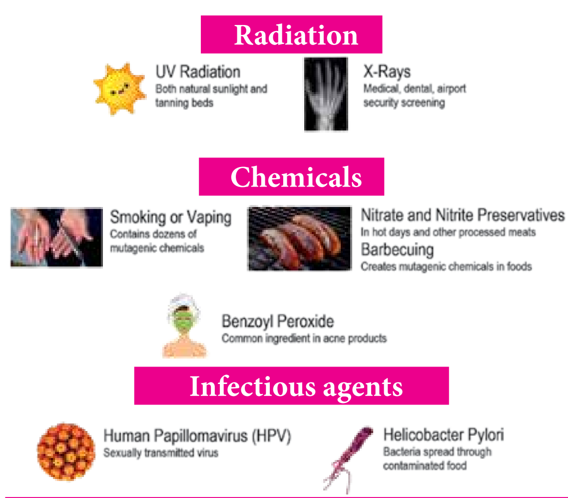
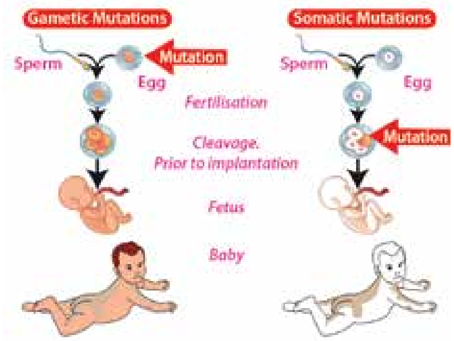


Fig 4.18

Anything in the environment that can cause a mutation is known as a **mutagen**. Ionising radiation includes gamma rays, X-rays and ultraviolet rays. The greater the dose of radiation a cell gets, the greater the chance of a mutation. A mutation may be neutral and have no effect. For example, the protein that a mutated gene produces may work just as well as the protein from the non-mutated gene. A mutation may sometimes be beneficial. For example, people who are carriers (heterozygous) for the sickle cell allele are more resistant to malaria (a tropical disease) than people who are homozygous for the gene. Black patch on the body, a cut at lip, six–fingered limbs etc are some other examples of mutation in human body.

Location of Mutation

- The location of a mutation determines whether or not it will be inherited.
  - Most mutations occur in **somatic cells** and are **not inherited.**
  - **Gametic mutations** occur in the cells or the **gonads** (which produce sperm and eggs) and may be inherited.



Gametic mutations are inherited and occur in the testes of males and the ovaries of females.

Somatic mutations occur in body cells. They are not inherited but may affect the person during their lifetime.

Effect of mutagens on DNA

- After exposure to UV light (a potent mutagen) adjacent thymine bases in DNA become cross-linked to form a 'thymine dimer'.
- This disrupts the normal base pairing and throws the controlling gene's instructions into chaos.

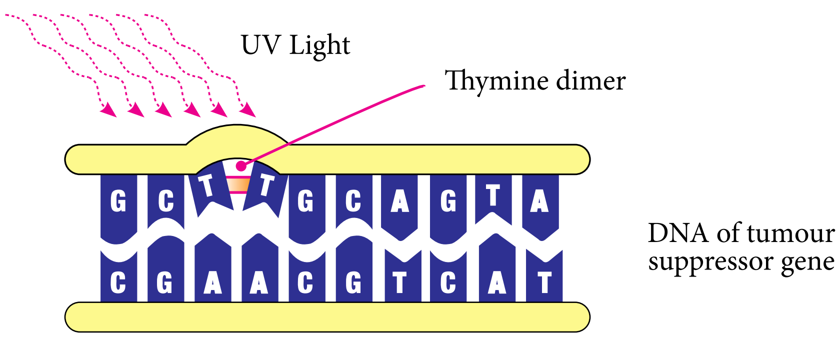


Fig 4.19

Hugo De Vries Mutation Theory

The mutation theory of evolution was proposed by a Dutch botanist, Hugo de Vries (1848-1935 A.D.). According to him, new species are not formed by continuous variations but by sudden appearance of variations, which he named as mutations. Hugo de Vries stated that mutations are heritable and persist in successive generations. He conducted his experiments on *Oenothera Lamarckian,* (Evening Primrose) and found several aberrant types. When *O. Lamarckian* was self-pollinated and its seeds were allowed to grow, majority of first filial generation (parental generation) plants were similar to the parents, but a few were different plants.

The different plants were also self-pollinated and when their seeds were sown, the majority of the plants were similar to the parents while a few were still more different plants and this continued generation after generation. During the study, he found that the plant should have 14 chromosomes, but found 15, 16, 20, 22 chromosomes in its species. These plants appeared to be new species, Hugo de Vries suggested from his experiments that new types of inherited characteristics may appear suddenly without any previous indication of their presence in the race. According to him, the theories of mutation are as follow :

Fig 4.20

i. The evolution is a discontinuous process and occurs by mutations (L. mutate = to change; sudden and inheritable large differences from the normal and are not connected to normal by intermediate forms). Individuals with mutations are called mutants.

ii. Elementary species are produced in large number to increase chances of selection by nature.

iii. Mutations are recurring so that the same mutants appear again and again. This increases the chances of their selection by nature.

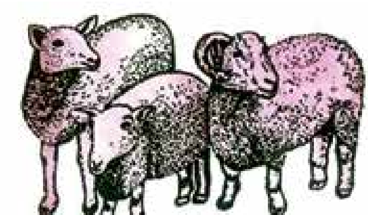
iv. Mutations occur in all directions so may cause gain or loss of any character.

Evidences in favour of Mutation theory:

i. Appearance of a short-legged sheep variety, Ancon sheep, from long-legged parents in a single generation in 1791 A.D.

ii. De Vries observations have been experimentally confirmed by McDougal and Shull in America and Gates in England.

iii. It can explain the inheritance of vestigial and over-specialized organs.



Ancon sheep with its normal parents.
Fig 4.21

Criticism of Hugo De Vries's Mutation Theory :

i. It is not able to explain the phenomena of mimicry and protective colouration.
ii. Rate of mutation is very low, i.e. one per million or one per several million genes.
iii. *Oenothera lamarckiana* is a hybrid plant and contains anamolous type of chromosome behaviour.
iv. Chromosomal numerical changes as reported by de Vries are unstable.
v. Mutation theory alone could not explain evolution. It, however, provided raw material for other forces to act upon it and bring about evolutionary changes.

Effects of Mutation on Evolution

Since all cells in our body contain DNA, there are lots of places for mutations to occur; however, some mutations cannot be passed on to offspring and do not matter for evolution. Somatic mutation occur in non-reproductive cells and won't be passed onto offspring. For example, the golden color on half of this Red Delicious apple was caused by a somatic mutation. Its seeds will not carry the mutation.

The only mutations that matter to large-scale evolution are those that can be passed on to offspring. These occur in reproductive cells like eggs and sperm and are called germ line mutations. Some mutations don't have any noticeable effect on the phenotype of an organism. This can happen in many situations: perhaps the mutation occurs in a stretch of DNA with no function, or perhaps the mutation occurs in a protein-coding region, but ends up not affecting the amino acid sequence of the protien.

Fig 4.22

A single mutation caused this cat's ears to curl backwards slightly. Some really important phenotypic changes, like DDT resistance in insects are sometimes caused by single mutations. A single mutation can also have strong negative effects for the organism. Mutations that cause the death of an organism are called lethals — and it doesn't get more negative than that. Mutations are often the victims of bad press — unfairly stereotyped as unimportant or as a cause of genetic disease. While many mutations do indeed have small or negative effects, another sort of mutation gets less airtime. Mutations to control genes can have major (and sometimes positive) effects.

The effects of mutation on evolution can also be mentioned as follows :

a. Neutral Mutation

Neutral mutations are changes in DNA sequence that are neither beneficial nor detrimental to the ability of an organism to survive and reproduce. In population genetics, mutations in which natural selection does not affect the spread of the mutation in a species are termed neutral mutations. Neutral mutations that are inheritable and not linked to any genes under selection will either be lost or will replace all other alleles of the gene. This loss or fixation of the gene proceeds based on random sampling known as genetic drift. A neutral mutation that is in linkage disequilibrium with other alleles that are under selection may proceed to loss or fixation via genetic hitchhiking and/or background selection.Examples include silent point mutations, which are neutral because they do not change the amino acids in the proteins they encode. Many other mutations have no effects on the organism because they are repaired before protein synthesis occurs.

Natural Mutations

- Does NOT affect the survival of the organism
- Simply alters appearance or structure
- Most frequently observed type of genetic mutation

For example:

- Red hair in humans
- Heterochromia iridium (condition in which the eyes are different colours)
- patches of irregular fur colour

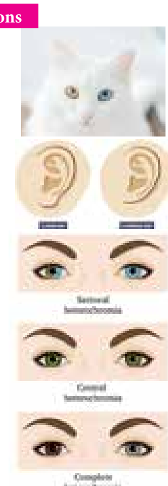


Fig 4.23

b. Beneficial Mutation

Some mutations-known as **beneficial mutations**- have a positive effect on the organism in which they occur. They generally code for new versions of proteins that help organisms adapt to their environment. If they increase an organism's chances of surviving or reproducing, the mutations are likely to become more common over time. There are several well-known examples of beneficial mutations. Here are two such examples:

- Mutations have occurred in bacteria that allow the bacteria to survive in the presence of antibiotic drugs, leading to the evolution of antibiotic-resistant strains of bacteria.

Examples of beneficial mutations in humans

1. Super immunity
2. Super Strength
3. Super sleeplessness
4. Super pain tollerance
5. Super flexibility
6. Super-dense bones
7. Super vision

Table 4.1

- A unique mutation is found in people in Limone, a small town in Italy. The mutation protects them from developing atherosclerosis, which is the dangerous buildup of fatty materials in blood vessels despite a high-fat diet. The individual in which this mutation first appeared has even been identified and many of his descendants carry this gene.

1. Example of beneficial mutation

Tolerance to high cholesterol levels in humans

- In the small village of Limone, about 4 villagers have extraordinarily high levels of blood cholesterol, with no apparent harmful effects on their coronary arteries.
- The village has population of 98 inhabidants and was, until recently, largely isolated from the rest of the world, with sheer cliffs behind the village, the lake in front of them, and no road access.

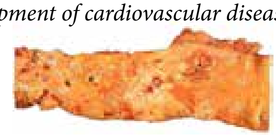
The village of Limone, on the shore of Lake Garda, Italy

2. Example of beneficial mutation

The 40 villagers possess a point mutation which alters the protein produced by just one amino acid. This protein in then times more effective at mopping up excess cholesterol.

- No matter how much excess cholesterol is ingested, it can always be disposed of.
- All carriers of the mutation are related and have descended from one couple who arrived in Limone in 1636
- Generally, the people of Limone live longer and show a high resistance to heart disease.

High blood cholesterol and dietary fat are implicated in the formation of plaques in the coronary arteries and in the development of cardiovascular disease.



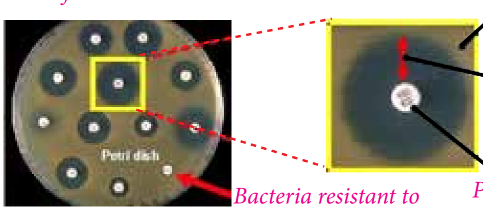
Antibiotic resistance

Antibiotics are drugs that inhibit bacterial growth.

- With increased antibiotic use after WWII, bacterial quickly developed resistance
- A survey in five European countries showed that around 4% of hospital samples contained at least one antibiotic resistant strain.
- Resistant becteria include: Klebsiella, Enterococcus, E. coli, Staphylococcus, aureus, Enterobacter, Pseudomonas, and Mycobacterium tuberculosis.

Agar plate (nutrient growth medium) with bacterial colonies spread uniformly across its surface.

Colonies of bacterial are distributed evenly across the agar plate surface.



Zone of inhibition where there is little or no bacterial growth.

Bacteria resistant to this antibiotic

Paper disc saturated with antibiotic.

C. Harmful Mutation

Imagine making a random change in a complicated machine, such as a car engine. There is a chance that the random change would result in a car that does not run well — or perhaps does not run at all. By the same token, a random change in a gene's DNA may result in the production of a protein that does not function normally or may not function at all. Such mutations are likely to be harmful. **Harmful mutations** may cause genetic disorders or cancer.

A **genetic disorder** is a disease, syndrome, or other abnormal condition caused by a mutation in one or more genes, or by a chromosomal alteration. An example of a genetic disorder is cystic fibrosis. A mutation in a single gene causes the body to produce thick, sticky mucus that clogs the lungs and blocks ducts in digestive organs.

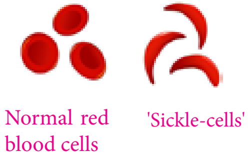
- **Cancer** is a disease in which cells grow out of control and form abnormal masses of cells (called tumors). It is generally caused by mutations in genes that regulate the cell cycle. Because of the mutations, cells with damaged DNA are allowed to divide without restriction.

Harmful Mutation

There are many examples of harmful mutation resulting from alterations to the DNA base sequence.

- Examples in humans include:
  - Skickle-cell disease
  - cystic fibrosis
  - thalassemias
- An example in animals is albinism, which increases susceptibility to predation and disease (e.g. cancers)
- These mutations are harmful because by altering the DNA sequence, they upset the structure and function of the protein they code for.

Sickle cell lesion



Project Works

i. A collection of various images related to evolution evidence from the Internet or other sources. Paste the collected pictures on chart paper and discuss it in class.

ii. Observation of a man with six fingers on his hand, or a man who is small in height, or a five-legged animal, or any other sudden change in your surrounding community, school, and neighborhood . Find out the causes of these mutations and the benefits and disadvantages of these mutations. Prepare a report by collecting information and presenting it to the class.

iii. Collect pictures of mutation examples from the internet and display those pictures by pasting them on chart paper.

Exercise

A. Choose the correct one and put the tick mark(√)

1. Which of the following is process of origin of complex organism from simple ones?

i. Lamarkism　　ii. Darwinism

iii. Evolution　　iv. All of above

2. **Who had given the theory of evolution of species by natural selection?**
   i. Darwin ii. Mendel
   iii. Dalton iv. Morgan
3. **Which of the following is strong evidence of Evolution?**
   i. Evidence from vestigial organ ii. Embryonic evidence
   iii. Evidence from distribution organisms iv. None of these
4. **What is the function of vermiform Appendix in herbivores?**
   i. Digestion of food ii. Excretion of useless materials
   iii. Functionless iv. All of above
5. **When did Charles Darwin publish "Origin of Species"?**
   i. 1857 A.D ii. 1859 A.D
   iii. 1860 A.D iv. 1959 A.D
6. **Which of the following are the postulates of Darwin's theory of evolution?**
   i. Within any population, there is natural variation.
   ii. Even though all species produce a large number of offsprings, populations remain fairly constant naturally.
   iii. The struggle for survival within populations eliminates the unfit individuals.
   iv. All of the above are correct
7. **Over a period of years, the average rainfall in an area decreases, causing environmental changes. Most likely to survive these environmental changes is a population..... .**
   i. with a great amount of genetic variation.
   ii. with very little genetic variation.
   iii. that has been altered through artificial selection.
   iv. with the smallest population size.
8. **What was the basic principle of Lamarckism?**
   i. Inheritance of acquired characters
   ii. Natural selection
   iii. Survival of the filters
   iv. Variations
9. **According to Lamarck the giraffe has a long neck because.**
   i. God designed it that way
   ii. Catastrophes eliminated short necked forms
   iii. Its ancestors stretched their neck to get food
   iv. Ancestral giraffes with a slightly longer neck got more food than others and left more surviving offsprings

B. Give reasons to these statements.

i. Platypus is considered as a bridge animals
ii. In embryonic stage human, bird and fish are similar in many aspects.
iii. Wings of birds and flippers of whale are homologous organs.
iv. Sometimes a man is found to have six fingers instead of five fingers.
v. Vestigial organs support to organic evolution.

C. Differentiate between these paris.

i. Variation and Mutation
ii. Homologous organ and Vestigial organ
iii. Analogous organ and Homologous organ
iv. Neutral mutation and Beneficial mutation
v. Blastogenic variation and Somatogenic variation
vi. Darwin theory and De Vries Theory
vii. Lamarck's theory and Darwin's theroy.

D. Answer the following questions :

i. What are the theories of evolution?
ii. What is Lamarck's theory of evolution?
iii. What were the two main points of Lamarck's Theory of evolution
iv. What are the three theories of Lamarck?
v. Evidences from vestigial organs prove the principle of theory of evolution. Explain briefly.
vi. Explain in brief, Darwin's theory of "Struggle for existence" and " Variation and heredity."
vii. How does new organism originate according to Darwin? Explain briefly.
viii. Write down the three points for criticism of Darwinism.
ix. Write down the Hugo De Vries's theory of mutation. Write down the reason for its rejection.
x. How does embryonic study help in providing theory of evolution? Explain
xi. Study of fossils shows the origin of complex organisms occurs from simple organisms. Explain briefly
xii. Explain antibiotic resistance observed in bacteria in light of Darwinian selection theory.
xiii. Try to trace the various components of human evolution (hint: brain size and function, skeletal structure, dietary preference, etc.)
xiv. Find out through internet and popular science articles whether animals other than man has self-consciousness.
xv. List 10 modern-day animals and using the internet resources link it to a corresponding ancient fossil. Name both.
xvi. Using various resources such as your school Library or the internet and discussions with your teacher, trace the evolutionary stages of any one animal.
xvii. List the vestigial structures found in man and categorize them in homologous or analogous structures.
xviii. Describe and analyze examples of technology that have extended or modified the scientific understanding of evolution.
xix. Explain the theory of natural selection as proposed by Darwin.
xx. Evolutionary biologists studied both Lamarck and Darwin's theories very carefully. Darwin's theory has been supported by a lot of evidence. Lamarck's theory of inheritance of acquired characteristics has been disproved. Write a paragraph on why we should believe Darwin and disprove Lamarck. Give suitable examples to back your argument.

Unit 5
Physical Structure and Life Process

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- introduce the tissue
- describes the different types, parts and functions of plant and animal tissue
- explain the structure, function and interrelationship of different parts of the human nervous system
- identify the different parts of the human brain and to describe their function
- compare the glands on the basis of ducts and secretions by introducing the glandular system
- introduce human hormones and to describe their functions and effects
- introduce plant hormones and to use plant growth hormones

Marie-François-Xavier Bichat, (1771-1802), was a French anatomist and pathologist, known as the father of modern histology. Although he worked without a microscope, Bichat distinguished 21 types of elementary tissues from which the organs of the human body are composed. He was also 'the first to propose that tissue is a central element in human anatomy, and he considered organs as collections of often disparate tissues, rather than as entities in themselves'.

5.1 Introduction

Cell form the body of an organism. Cell is a very small transparent unit of life. The life of every organism starts from one cell. Cells function differently in unicellular and multicellular organisms. A unicellular organism depends upon just one cell for all of its functions while a multicellular organism has cells specialized to perform different functions that collectively support the organism. In multicellular organisms, cells are combined together inside the body to form a tissue. Tissue is a group of similar specialized cells which together performs certain special function. Each tissue consists of cell which are alike in size, shape and arrangement. Various types of tissues are combined together to form an organ.Organs are responsible to carry out one or more specific activities in a body. A group of organs form system a particular function in a body. Body of an organism functions due to interrelationship among cells, tissues, organs and systems.

Fig 5.1

The maintenance functions of living organisms must go on even when they are not doing anything particular. Even when we are just sitting in class, even if we are just asleep, this maintenance job has to go on. The processes which together perform this maintenance job are **life processes**.

5.1.1 Tissue

Tissue is a level of organization in multicellular organisms; it consists of a group of structurally and functionally similar cells and their intercellular material. By definition, tissues are absent from unicellular organisms. Even among the simplest multicellular species, such as sponges, tissues are lacking or are poorly differentiated. But multicellular animals and plants that are more advanced have specialized tissues that can organize and regulate an organism's response to its environment.

The body **tissue** is an aggregation of cells that function together and have a similar function. The cells of a multicellular organism do not usually function independently instead they are usually associated with other cells forming a tissue. Mostly, tissues are made up of several types of cells that cover different requirements of tissue function. The study of tissues is called *histology*. This science studies the anatomy of different tissues using microscopes. The microscopic biological science histology helps in the classification of tissues of both plant and animal tissue as well as identifying their detailed structure.

Tissues are mainly classified into two types:

i. Plant Tissues
ii. Animal Tissues

The definition of tissue in animals is a group of cells combined together to perform a certain function. There are four tissue types in animals, each type of tissue has its distinct structure and function. They are:epithelial tissues, connective tissues, muscular tissues, nervous tissues.

Plants do not move, i.e., they are stationary. Most of the tissues they have are supportive, which provides them with structural strength. Most of these tissues are dead, as they can provide better mechanical strength than the live ones, and need less maintenance. Some of the plant tissues keep on dividing throughout the plant life. These tissues are localised in certain regions.

Relation between cells, tissues, organs and systems

Cell is the structural and functional unit of life. Cell is the basic or fundamental unit of living organisms.

i.e. cells + cells → tissues + tissues → organs + organs → system + system → body.

The table given below shows the systems, their organs, tissues and functions in a human body.

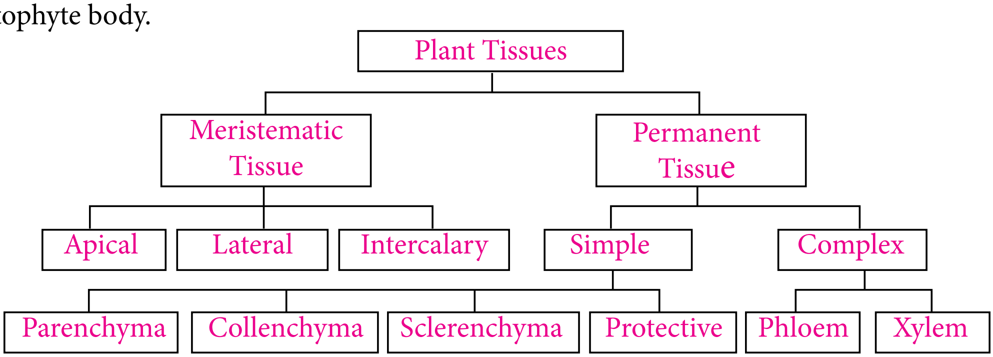
System	Organs of systems	Kinds of Tissues	Major functions
Digestive system	Mouth, Stomach Intestine, Liver Pancreas	Columnar epithelium, involuntary muscles	Grinding, digestion and absorption of food
Respiratory system	Nose, Trachea, Bronchi, Bronchiolus, Lungs	Cubical epithelium, pavement epithelium	Inhale oxygen and exhale carbon dioxide

Excretory system	Kidneys, Liver, Ureter, Gall bladder, Urinary bladder	cubical epithelium, pavement epithelium	Excretion of waste products
Circulatory system	Heart, Blood and Blood vessels	Cardiac muscle, connective tissue and pavement tissues	Supply of food and oxygen and protect body from diseases
Muscular system	Muscles and flesh	Muscular tissues	Give shape to body, movement and conduction of all life processes
Nervous system	Brain, spinal cord and nerves	Nervous tissues	Co-ordination and communication in a body
Skeletal system	Bones, Cartilage	Connective tissues	Give framework and helps in locomotion
Reproductive system	Testes, Ovaries, Vagina, Penis	Cubical epithelium, columnar epithelium.	Reproduction

Tabel 5.1

5.1.2 Plant Tissue

Bryophytes (liverworts, hornworts, and mosses) are nonvascular plants; i.e., they lack vascular tissues (phloem and xylem) as well as true leaves, stems, and roots. Instead bryophytes absorb water and nutrients directly through leaflike and stemlike structures or through cells comprising the gametophyte body.



Based on the dividing capacity of the tissues, various plant tissues can be classified as growing or meristematic tissue and permanent tissue which have further sub-divisions as explained below:

A. Merisematic tissue :

It is responsible for growth of plant. Meristematic tissue has the ability to divide and redivide to provide growth to plants. Generally, growth of plants occurs from specific region like root and shoot,nodes, girth of stem, leaf base etc. Therefore, meristematic tissue is present in these regions.Types of meristematic tissue are apical meristem, lateral meristem and intercalary mesistem.

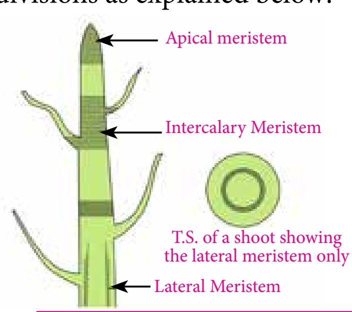


Fig 5.2

i. Apical meristem

Apical meristem is the region of cells capable of division and growth in the root and shoot tips in plants. Apical meristems give rise to the primary plant body and are responsible for the extension of the roots and shoots. Unlike most plants continue to grow throughout their entire life span because of the unlimited division of these and other meristems. As in other meristematic regions, the cells of the apical meristems are typically small and nearly spherical. They have a dense cytoplasm and relatively few small vacuoles (watery saclike enclosures). Some of these cells, known as initials, maintain the meristem as a continuing source of new cells and may undergo mitosis (cell division) many times before differentiating into the specific cells required for root or shoot growth. If apical meristem is damaged or removed from the plant, then the growth of the plant will stop. As this is required for the growth and the elongation of the roots, of the stem and increases the length of the plant. If it is cut, then the growth will gradually stop within the plant.

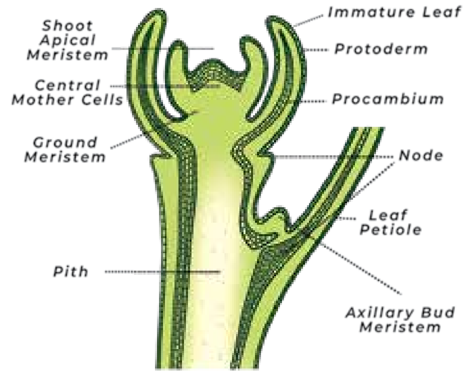


Fig 5.3

ii. Lateral meristem

The lateral meristems are present on the lateral side of the stem and root of a plant. These meristems help in increasing the thickness of the plants. The vascular cambium and the cork cambium are good examples of a lateral meristematic tissue. Both the vascular canbium and the cork cambium, if present, will begin to produce cells and tissues only after the primary tissues produced by the apical meristems have begun to mature. These divide preclinically or radially and give rise to secondary permanent tissues.

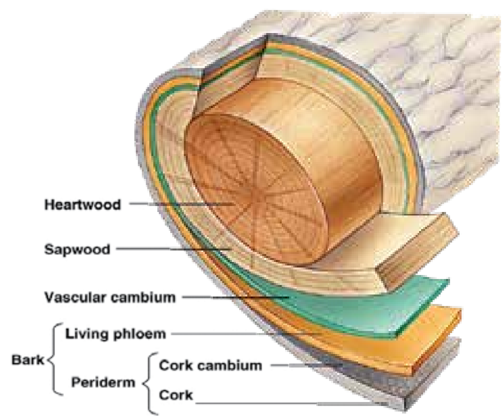
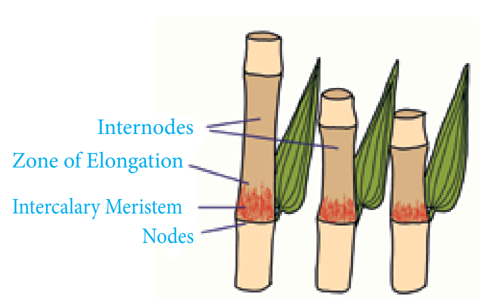


Fig 5.4

iii. Intercalary meistem :

These are located at the base of the nodes, internodes, leaves etc. Intercalary meristems are found in grasses and related plants that do not have a vascular cambium or a cork cambium, as they do not increase in girth. These plants do not have apical meristems and in areas of leaf attachment, called nodes, they have the third type of meristematic tissue. This meristem will also actively produce new cells and is responsible for increase in length.The intercalary meristem is responsible for the regrowth of cut grass.



Intercalary meristem
(only in monocot)

Fig 5.5

B. Permanent Tissue

Tissues that have become mature and do not have the ability to divide further are called permanent tissues. Generally, cell division does not occur in the cells found in permanent tissue. The cells found in this tissue are dead or living and cell wall is thick or thin. The cells in permanent tissues are fully grown, bigger in size, and have a certain shape. The metabolic rate is lower in the cells of permanent tissues. Permanent tissues are derived either from apical, lateral or intercalary meristems. Permanent tissues found in the plant are of three types:

i. Simple permanent tissue ii. Complex permanent tissue iii. Special permanent tissue

Tissues

- **Meristematic Tissue**
- **Permanent Tissue**
  - **Simple Tissue**
    - **Parenchyma**
    - **Collenchyma**
    - **Sclerenchyma**
      - **Sclerenchy-matous fibres**
      - **Stone Cells**
  - **Complex Tissue**
    - **Xylem (wood)**
      - **Tracheids**
      - **Vessels (Tracheae)**
      - **Xylem Fibres (Xylem Sclerenchyma)**
      - **(Xylem Parenchyma)**
    - **Pholem (bast)**
      - **Sieve Elements**
      - **Companion Cells**
      - **Phloem Fibres (Phloem Sclerenchyma)**
      - **Phloem Parenchyma**
  - **Special Tissue**
    - **Glandular Tissue**
    - **Laticiferous Tissue**

a) Simple Permanent Tissue

Simple permanent tissues are made up of similar cells and perform similar function. Thy are also known as homogenous tissues. Thay have **thin cell walls** made up of cellulose. Cells are loosely spaced in this tissue. So **intercellular** spaces between these cells are **large**. These are the basic packaging tissues in the plants generally found in few layers below epidermis. On the basis of structure of cells, these tissues are further cassified into three types:

i) Parenchyma
ii) Collenchyma
iii) Sclerenchyma

i) Parenchyma

Parenchymatous tissue is made up of thin walled living cells. Intercellular space is present in between the cells present in this tissue. Parenchyma is one of the three main types of ground, or fundamental, tissue in plants, together with sclerenchyma (dead support tissues with thick walls) and collenchyma (living support tissues with irregular walls). Parenchyma makes up the chloroplast–laden mesophyll (internal layers)

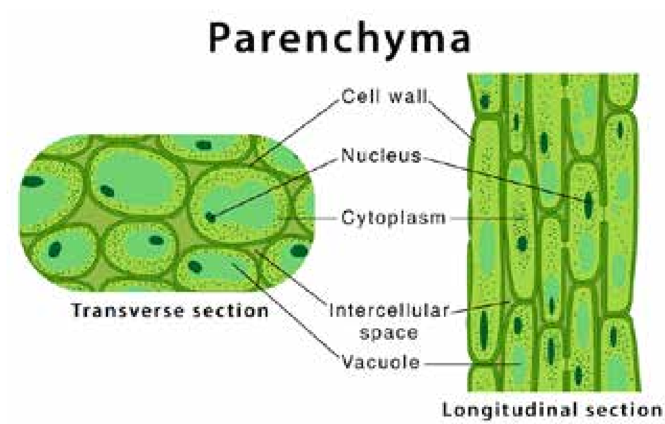


Fig 5.6

of leaves and the cortex (outer layers) and pith (innermost layers) of stems and roots. It also forms the soft tissues of fruits. Cells of this type are also present in xylem and phloem as transfer cells and as the bundle sheaths that surround the vascular strands. Parenchyma tissue may be compact or have extensive spaces between the cells.

ii) Collenchyma

Collenchymatous tissue is made up of the combination of elongated cells. The corners of these cells are thick due to the substances like cellulose and pectin. The cells present in this tissue are living cells. This tissue functions to strengthen the growing part of the plant and to prepare food. The collenchyma having thin cell wall helps in the growth of the cells, spreading of liquid substances and flexibility.

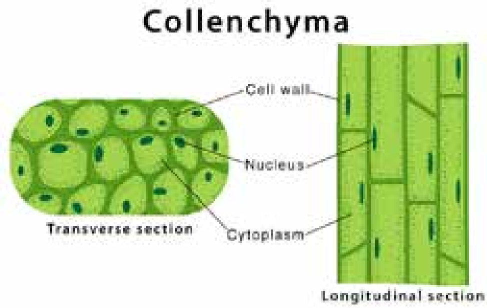


Fig 5.7

iii) Sclerenchyma

Sclerenchyma in plants, support tissue composed of any of various kinds of hard woody cells. Mature sclerenchyma cells are usually dead cells that have heavily thickened secondary walls containing lignin. The cells are rigid and nonstretchable and are usually found in nongrowing regions of plant bodies, such as the bark or mature stems. Generally, it is found in phloem, fruit walls, seeds and pulp of fruits. Sclerenchyma cells occur in many different shapes and sizes, but two main types are: fibres and sclereids. Average length of sclerenchyma is 1 to 3 mm but in some fibre-yielding plants, it is about 20 mm-550mm.

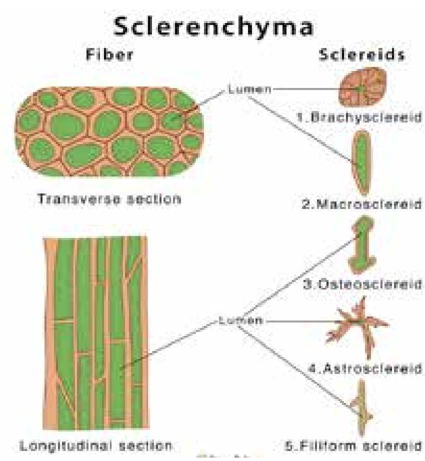


Fig 5.8

Complex permanent tissue

Complex permanent plant tissues are present in the vascular region of the plant. They help in the conduction of nutrients and water throughout the plant body. Complex permanent plant tissue consists of a group of multiple types of cells that have a common origin but perform different functions. It consists of both living and dead cells which coordinate together to perform the same specialized functions in the plant body. Based on its structure and function performed, complex permanent tissues are of two types – xylem and phloem.

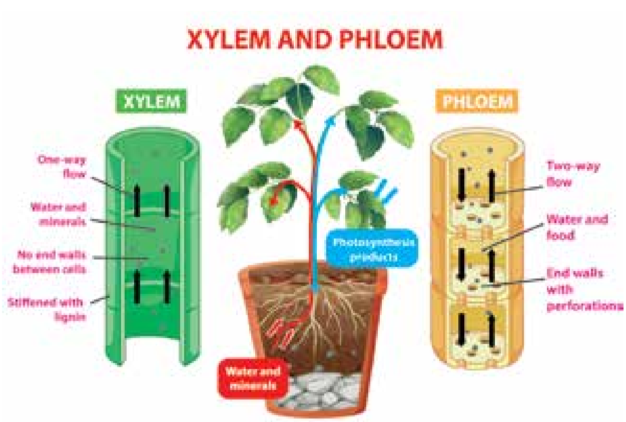


Fig 5.9

i. Xylem

Xylem is made up of dead cells**. It** is vascular tissue of plants that conveys water and dissolved minerals from the roots to the rest of the plant and also provides physical support. It consists of four types of cells. They are wood fibres, wood parenchyma, trachieds and vessels. Water-conducting cells are known as tracheary elements. The xylem tracheary elements consist of cells known as tracheids and vessel members, both of which are typically narrow, hollow, and elongated. Tracheids are less specialized than the vessel members and are the only type of water-conducting cells in most gymnosperms and seedless vascular plants. It is located in inner parts of roots, stem and leaves of plants. Except wood parenchyma , all other xylem elements are thick walled and dead. Xylem also provides mechanichal support to the plants body.

ii. Phloem

Phloem is made up of the group of living cells. This tissue is made up of different types of cells. They are; sieve tube, companion cell, phloem parenchyma and phloem fibre. It is found in all parts of plant like root, stem and leaf. It transports the prepared food in leaf to different parts of the body. ii. It stores food. iii. It provides mechanical support to the plant.

Special permanent tissue

The cells present in special tissue perform in excretion and secretion. This is modified for the special function. These tissues are also known as Secretory tissues and are specialized to secrete or excrete products. The tissues which are concerned with the secretion of materials such as gums, digestive juice, resin, oil nectar,latex and other similar substances are called special permanent tissues or secretory tissues. The secreted products may be useful or may not be useful for the plants.Special tissue is of two types. They are;

i. Glandular tissue

A gland is a specialised group of cells which have the capacity to secrete or excrete products. The products are secreted by the cytoplasm. They maybe stored in the cells or released outside. The cells which release the products outside have dense cytoplasm and prominent nuclei. The cells which store the products are larger in size and show big vacuoles. The cells are thin walled. The cell walls are made up of cellulose. They are living. The glands may be external or internal. External glands are found on the epidermis.They are formed from the epidermal cells or from sub-epidermal cells, they may be unicellular or multicellular. Internal glands are found as cavities within the plant body. Glandular tissue is made up of the layer of one cell or cells. secret various types of chemicals like digestive juice, resin, gum, etc. This type of tissues are found in plant like dhaturo, tulasi, salla.

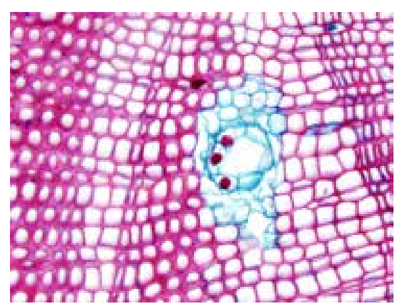


Fig 5.10

ii. Laticiferous tissue

Laticiferous tissue is composed of thin walled, elongated, branched and multinucleate tube like structures which contain colourless, milky juice called latex. The cells are distributed throughout the ground tissue of the plant body. They contain organic substances like starch, proteins, enzymes, alkaloids, tannins, mucilage, etc. Laticiferous tissue is found in plants belonging to (compositae) apocynaceae, asclepiadaceae, euphorbiacease, musaceae, etc. Laticiferous tissue is of two types:- latex cells and latex vessels. Lactiferous tissue is found in the plant like lalupate, pineapple etc.

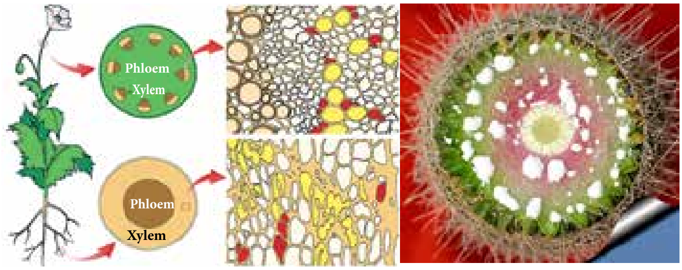


Fig 5.11

Animal Tissue

Animals move around in search of food and shelter. Animals consume more energy as compared to plants. Most of the animal tissues are living.

The structural organization of organ and organ system is more complex in animals. Animal tissues are divided into four types:-

a. Epithelial tissue
b. Muscular tissue
c. Connective tissue
d. Nervous tissue

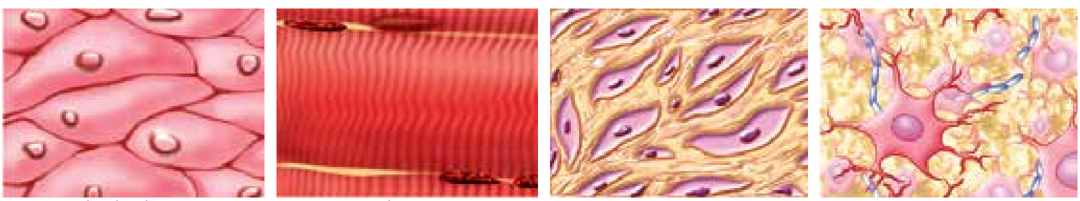


Fig 5.12

a. Epithelial tissue

Epithelial tissue consists of cells which form membranes. This membrane covers the body surface and the glands. The covering or protective tissues in the animal body are epithelial tissues. Epithelial tissues covers most organs and cavities within the body. It also forms a barrier to keep different body systems separate. The skin, the lining of the mouth, the lining of blood vessels, lung alveoli and kidney tubules are all made of epithelial tissue.The cells are tightly packed and form a continuous sheet. They have only a small amount of cementing material between them and almost no intercellular spaces. The function of epithelial tissue is protection, secretion, absorption, excretion etc.

i. Pavement epithelium

Pavement epithelium, also known as ***simple squamous epithelial tissue*** or **simple squamous epithelium**, is an epithelial tissue that is composed of a single layer of epithelial cells. The term 'pavement epithelium' comes from its tile- or brick-like appearance. The epithelial tissue is in direct contact with the basement membrane that separates it from the underlying connective tissue. These tissues are found in the heart, lungs, kidney etc. These tissues are involved in covering, protecting and secreting functions.

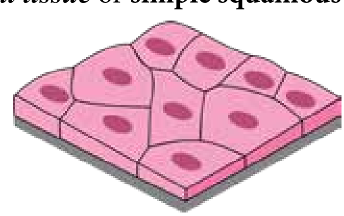


Fig 5.13

ii. Cubical epithelium

Cubical epithelium also known as **cuboidal epithelium**, is composed of epithelial cells that are distinctively cuboidal in shape. The cell comprising the cuboidal epithelium is approximately as wide as it is tall. It is therefore cube-like (thus, the name). When viewed from atop it appears square in shape. The nucleus is large and is usually found in the center of the cell. The cuboidal epithelium may also be classified according to the number of layers that make it up. For example, a simple cuboidal epithelium is a type of cubical epithelium made up of a single layer of cuboidal cells. A stratified cuboidal epithelium is comprised of more than one layer of cuboidal cells. Cuboidal epithelia can be found lining the collecting ducts of the kidney, the pancreas, the salivary gland, the sweat glands , and the mammary glands. They are also found covering the germinal linings of the ovary and the walls of the seminiferous tubules of the testes. This tissue is involved in secretory, absorptive, or excretory functions.

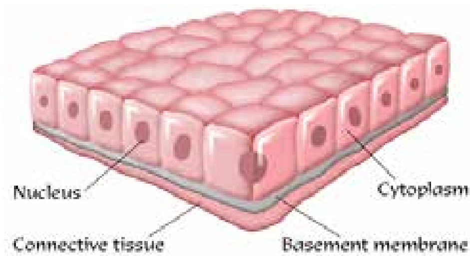


Fig 5.14

iii. Columnar epithelium

An epithelial tissue comprised of columnar epithelial cells, with or without cilia, and is involved primarily in secretory, absorptive, or excretory functions. The columnar epithelium is composed of epithelial cells that are column-shaped. The cell comprising the columnar epithelium is taller than it is wide. Its height is approximately four times its width. The nucleus in each cell is elongated and often found near the base. Some of them may have microvilli at the apical surface. When present, the microvilli increase the surface area (such as during absorption). Cilia may also be present. Ciliated columnar cells aid in the movement of mucus (as seen during mucociliary clearance). The columnar epithelium may be classified according to the number of layers that make it up. For example, a simple columnar epithelium is made up of a single layer of columnar epithelial cells. A stratified columnar epithelium is comprised of more than one layer of columnar epithelial cells. there is a special type of single columnar epithelium named pseudostratified epithelium. Its name is derived from its appearance. The cells are oriented in a way that they appear to be in multiple layers when in fact there is only one layer of epithelial cells. Examples of columnar epithelia are Goblet cells, those lining the pharynx, sex organs, respiratory tract, fallopian tubes, etc.

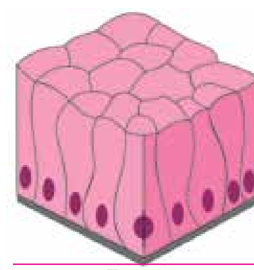


Fig 5.15

iv. Glandular epithelium

The glandular epithelium is a group of tissues, other than the covering and lining epithelium, which is specialized for the production and secretion of various macromolecules. Because of its primary function, the glandular epithelium is also called the secretory epithelium. This epithelium lies beneath the covering and lining epithelium and either consists of cells with specific functions or comprise specialized organs called glands. A gland consists of epithelium that secretes substances into ducts (tubes), onto a surface, or eventually into the blood in the absence of ducts. Some unicellular glands, comprised of specialized cells, might be interspersed between the simple cuboidal, simple columnar, and pseudostratified epithelia. The shape of the cells of the glandular epithelium can range from cuboidal to columnar as the squamous cells quite rare in the secretory epithelium. The glandular epithelium of the endocrine glands is rich in vascularization as well as innervation. The secretory cells in the glandular epithelium may synthesize, store, and release proteins (e.g., in the pancreas), lipids (e.g., adrenal, sebaceous glands), or complexes of **carbohydrates** and **proteins**. The cells of some glands (e.g., sweat glands) have little synthetic activity and secrete mostly water and electrolytes (ions) transferred from the blood. Examples of glandular epithelium include the epithelium of the endocrine glands like the pituitary gland at the base of the brain, the pineal gland in the brain, thyroid and parathyroid glands near the larynx (voice box), adrenal glands superior to kidneys, pancreas near the stomach, ovaries in the pelvic cavity, testes in the scrotum, thymus in the thoracic cavity. The exocrine glands include the sweat, sebaceous, and ceruminous glands of the skin and the digestive glands such as salivary glands and pancreas.

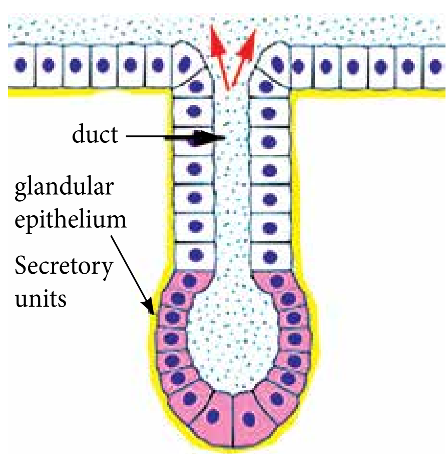


Fig 5.16

b. Muscular tissue

Muscular tissue is a specialized tissue in animals which applies forces to different parts of the body by contraction. It is made up of thin and elongated cells called muscle fibers. It controls the movement of an organism. The cytoplasm in the muscle fibers is called sarcoplasm. It contains a network of membrane called the sarcoplasmic reticulum. The membrane surrounding the muscle fibers is called sarcolemma. The muscular tissues are bundled together and surrounded by a tough connective tissue similar to cartilage known as epimysium. The bundle of nerve cells that run in long fibers called fascicles are surrounded by the epimysium. The fascicles are surrounded by a protective layer known as perimysium. It allows the flow of nerves and blood to the individual fibers. Another protective layer, the endomysium surrounds the fibers. These layers and muscles help in the contraction of different parts of the muscles. The different bundles slide past one another as they contract. The epimysium connects to the tendons attached to the periosteum connective tissue that surrounds the bones. This helps in the movement of the skeleton when the muscles contract. The epimysium connects to other connective tissues to produce a force on the organs and control everything from circulation to food processing.

The muscular tissues are connected to the same nerve bundles.The nerve impulse from the brain tells the muscles to contract. Each muscle cell contains the proteins actin and myosin. These proteins slide past one another when the signal is received for contraction. Muscular tissues help in the movement of bones, squeeze different organs, or compress chambers.

i. Skeletal muscular tissue

These muscles are attached to the skeleton and help in its movement. These muscles are also known as striated muscles because of the presence of alternate patterns of light and dark bands. These light and dark bands are sarcomeres which are highly organized structures of actin, myosin, and proteins. These add to the contractility and extensibility of the muscles. Skeletal muscles are voluntary muscles composed of muscle fibers. 40% of our body mass comprises skeletal muscles. Each skeletal tissue contains myofibrils. The cells of these tissues are multinucleated. These are provided with blood vessels and many elongated mitochondria and glycogen granules. They bring about the movement of the organs of the body.

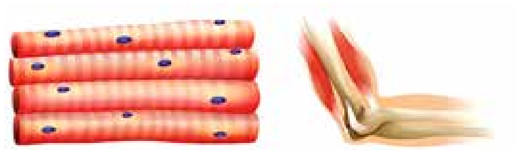


Fig 5.17

ii. Cardiac muscular tissue

These are found only in the heart.These are involuntary muscles and the heart pumps the blood through cardiac contractions. The cells of the cardiac muscles known as the cardiomyocytes are striated. They are single-celled and uninucleated. The ends of the cells are joined and the junctions are called intercalated discs. The cells are attached to each other by desmosomes.

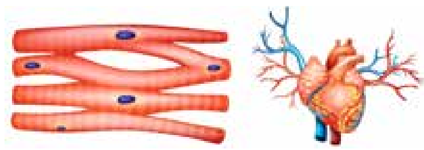


Fig 5.18

iii. Smooth muscular tissue

These are non-striated, involuntary muscles controlled by the Autonomous Nervous System. It stimulates the contractility of the digestive, urinary, reproductive systems, blood vessels, and airways. The actin and myosin filaments are very thin and arranged randomly, hence no striations. The cells are spindle-shaped with a single nucleus.

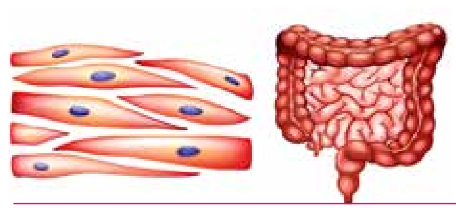


Fig 5.19

c. Connective tissue

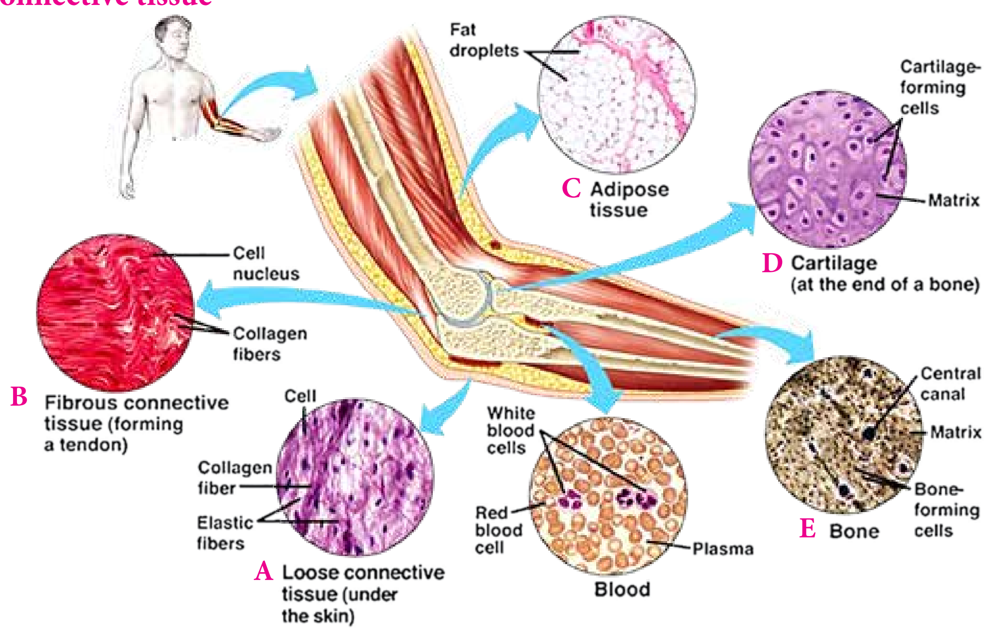


Fig 5.20

The connective tissue is an animal tissue that is predominantly composed of extracellular components (such as fibers and intercellular substances). The types of fibers that form the connective tissues are collagenous fibers, elastic fibers, and reticular fibers. Some connective tissues, though, are not as fibrous, e.g. adipose tissues and blood. The cellular elements also vary from one connective tissue to another. The connective tissue cells are cellular elements of the connective tissue. They include fibroblasts ,adipocytes, macrophages, mast cells, and leukocytes. The major functions of connective tissues are to connect, support, and surround tissues and organs It protects and supports the body.The cells are loosely spaced and embedded in an intercellular matrix. The matrix may be jelly like, fluid, dense or rigid. The nature of matrix differs in concordance with the function of the particular connective tissue. Connective tissues perform many functions in the body, but most importantly, they support and connect other tissues; from the connective tissue sheath that surrounds muscle cells, to the tendons that attach muscles to bones, and to the skeleton that supports the positions of the body. Protection is another major function of connective tissue, in the form of fibrous capsules and bones that protect delicate organs and, of course, the skeletal system. Specialized cells in connective tissue defend the body from microorganisms that enter the body. Transport of fluid, nutrients, waste, and chemical messengers is ensured by specialized fluid connective tissues, such as blood and lymph. Adipose cells store surplus energy in the form of fat and contribute to the thermal insulation of the body.

i. Loose connective tissue

The loose connective tissue is named after its *weave* appearance. The weave appearance is due to the loose, multidirectional interlace of extracellular fibers. The loose connective tissue is the most common type of connective tissue in humans and other vertebrates. It holds or binds the biological organs together. It binds the epithelial tissue to the adjacent tissues. It also surrounds the blood vessels and nerves. Another function of certain loose connective tissues is to serve as the major site of fluid and gas exchange between blood and adjacent tissues. Examples of loose connective tissue include areolar tissue and reticular connective tissue. There are two types of loose connective tissue :–

- **Adipose tissue**

  Adipose tissue is a specialized connective tissue consisting of lipid-rich cells called adipocytes. As it comprises about 20-25% of total body weight in healthy individuals, the main function of adipose tissue is to store energy in the form of lipids (fat). Based on its location, fat tissue is divided into parietal (under the skin) and visceral (surrounding organs). Depending on adipocyte morphology, there are two types of adipose tissue:

- **White adipose tissue** - mainly found in adults
- **Brown adipose tissue** - mainly found in newborns

  Besides energy storing, fat tissue has several other important functions in the human body. These include thermal isolation, cushioning the organs, an endocrine role, and production of numerous bioactive factors.

> Adipose tissue is fat tissue and it is used to maintain body temperature as well as to cushion internal organs. Animals such as polar bears bodies against the cold environment in which they live.

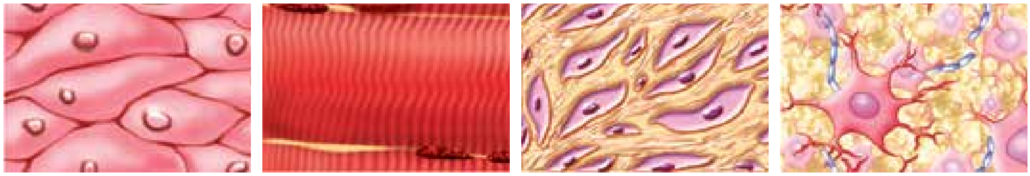


Fig 5.21

Fibrous connective tissue

Fibrous connective tissues contain large amounts of collagen fibers and few cells or matrix material. The fibers can be arranged irregularly or regularly with the strands lined up in parallel. Irregularly-arranged fibrous connective tissues are found in areas of the body where stress occurs from all directions, such as the dermis of the skin. Regular fibrous connective tissue is found in tendons (which connect muscles to bones) and ligaments (which connect bones to bones). Ligament possesses high elasticity and strength. It has a very little matrix.

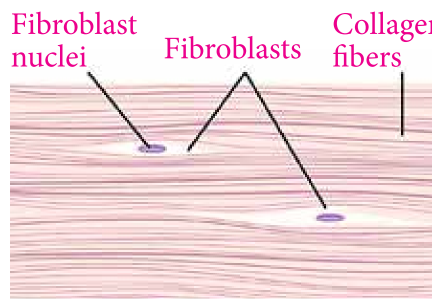


Fig 5.22

ii. **Supporting Connective Tissues**

The supporting connective tissue have a strong and durable framework that protects and supports the soft body tissues.The extracellular matrix in supporting connective tissue contains many protein fibers and a ground substance that ranges from semisolid to solid.Bones and cartilage are supporting connective tissue. The cartilage has a semisolid extracellular matrix, while bone has a solid extracellular matrix.

- **Bone**

  Bone is very strong, non-flexible tissue, porous,highly vascular, its matrix is made up of proteins, heavily coated with Phosphate (P), Ca and Mg salts. These minerals are responsible for hardness of the bone. It forms endoskeleton of human being and other vertebrates.It provide shape and support to body. It protects vital body organs. It serves as a storage site of Calcium(Ca) and Phosphate (P).

- **Cartilage**

  Cartilage is a flexible connective tissue connecting tissue connecting joints between bones, ribs cage, ear, nose etc. It acts like shock absorbent. Cartilaginous tissue is avascular, which means there are no blood vessels, thus all nutrients need to diffuse through the matrix to reach the chondrocytes. This is a factor contributing to the very slow healing of cartilaginous tissues. Cartilage gives shape, support, and structure to other body tissues. It also helps to cushion joints. Cartilage also smoothens the bone surfaces at the joints. It is essential for the development and growth of long bones

iii. Fluid Connective Tissue

Fluid connective tissue is **a connective tissue in which the matrix is liquid**. Blood and lymph are fluid connective tissues.

Blood

Cells circulate in a liquid extracellular matrix. The formed elements circulating in blood are all derived from hematopoietic stem cells located in bone marrow. Erythrocytes, red blood cells, transport oxygen and carbon dioxide. Leukocytes, white blood cells, are responsible for defending against potentially harmful microorganisms or molecules. Platelets are cell fragments involved in blood clotting. Some white blood cells have the ability to cross the endothelial layer that lines blood vessels and enter adjacent tissues. Nutrients, salts, and wastes are dissolved in the liquid matrix and transported through the body.

It is considered a connective tissue, because it consists of blood cells surrounded by a nonliving fluid matrix called **blood plasma**. It is the most atypical connective tissue: the fibers of blood are soluble protein molecules that become visible during blood clotting. It is found in blood vessels. Blood has three functions:

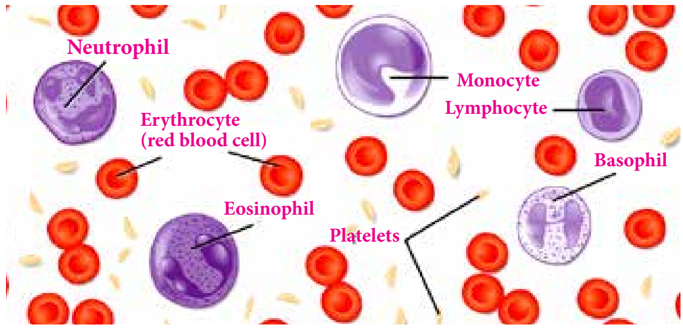


Fig 5.23

- **Transportation:** Blood delivers oxygen from the lungs and nutrient from the digestive tract to all body cells; it transports carbon dioxide to the lungs and nitrogenous waste to the kidney for removal from the body; it transports hormones from their endocrine glands to their target organs.
- **Regulation :** Blood helps regulate body temperature and pH in body tissues.
- **Protection :** Platelets and plasma proteins prevent blood loss by forming clots when blood vessels are damaged. Antibodies, complement proteins and white blood cells fight infection.

Lymph

Lymph contains a liquid matrix and white blood cells. Lymphatic capillaries are highly permeable, allowing larger molecules and excess fluid from interstitial spaces to enter the lymphatic vessels. Lymph vessels return molecules and fluid to the venous blood that could not otherwise directly enter the bloodstream. In this way, specialized lymphatic capillaries transport absorbed fats away from the intestine and deliver these molecules to the blood.

d. Nervous tissue

The cells of nervous tissue are highly specialized and the cells of this tissue are called nerve cells or neurons. Nervous tissue stimulates and transmits the stimulus very rapidly from one place to another within the body. The brain, spinal cord and nerves are composed of the nervous tissue.

Neuron

Neurons are the building blocks of the nervous system. They receive and transmit signals to different parts of the body. This is carried out in both physical and electrical forms. There are several different types of neurons that facilitate the transmission of information. The sensory neurons carry information from the sensory receptor cells present throughout the body to the brain. Whereas, the motor neurons transmit information from the brain to the muscles. The interneurons transmit information between different neurons in the body.

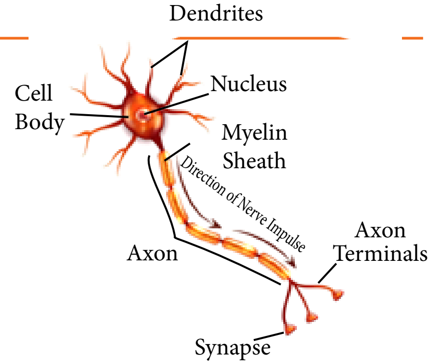
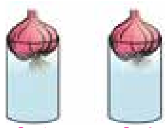


Fig 5.24

A neuron consists of a cell body which comprises of nucleus and cytoplasm, from which long thin hair-like parts arise. The neuron has a single long part, called the axon, which transmit the nerve impulse to body parts. The neuron has short, branched parts called dendrites. Many nerve fibers combine together by connective tissue and form a nerve. Nerve impulse enables animals to move rapidly in response to stimuli.

Activity 5.2

- Take two glass jars and fill them with water.
- Now, take two onion bulbs and place one on each jar, as shown in Figure
- Observe the growth of roots in both the bulbs for a few days.
- Measure the length of roots on day 1, 2 and 3.



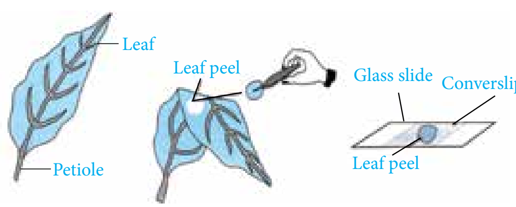
Length	Day 1	Day 2	Day 3	Day 4
Jar 1				
Jar 2				

From the above observations, answer the following questions:

i. Which of the two onions has longer roots? Why?
ii. Do the roots continue growing even after we have removed their tips?
iii. Why would the tips stop growing in jar 2 after we cut them?

Activity 5.3

- Take a freshly plucked leaf (Rheo or Tradescantia).
- Stretch and break it by applying pressure.
- While breaking it, keep it stretched gently so that some peel or skin projects out from the cut.
- Remove this peel and put it in a Petri dish filled with water.
- Add a few drops of safranin.
- Wait for a couple of minutes and then transfer it onto a slide. Gently place a cover slip over it.
- Observe under microscope.



Project Works

i. Observe the audio-visual material about the endocrine gland and fill in the following table and present it in your classroom.

Name of gland	Location	Hormones	Functions

Exercise

A. Choose the correct one and put the tick mark(√)

i. Connective tissue is made of which three essential components?

a. cells, ground substance, and carbohydrate fibers
b. cells, ground substance, and protein fibers
c. collagen, ground substance, and protein fibers
d. matrix, ground substance, and fluid

ii. Ligaments connect bones together and withstand a lot of stress. What type of connective tissue should you expect ligaments to contain?

a. areolar tissue b. adipose tissue
c. dense regular connective tissue d. dense irregular connective tissue

iii. Which connective tissue specializes in storage of fat?

a. tendon b. adipose tissue
c. reticular tissue d. dense connective tissue

iv. The flexibility in plants is due to a tissue called

a. chlorenchyma b. parenchyma
c. sclerenchyma d. collenchyma

v. The tissue present in the lining of kidney tubules and ducts of salivary glands is

a. squamous epithelium tissue b. glandular epithelium tissue
c. cuboidal epithelium tissue d. columar epithelium tissue

vi. The connective tissue that connects muscle to bone is called

a. ligament b. tendon
c. nervous tissue d. all of the above

vii. The tissue that helps in the movement of our body are

a. musclar tissue b. skeletal tissue
c. nervous tissue d. all of the above

viii. The size of the stem increases in the width due to

a. apical meristem b. intercalary meristem
c. primary meristem d. lateral meristem

ix. Cartilage and bone are types of

a. muscular tissue b. connective tissue
c. meristematic tissue d. epithelial tissue

x. Xylem and phloem are examples of

a. epidermal tissue b. simple tissue
c. protective tissue d. complex tissue

B. Critical Thinking Questions :

i. One of the main functions of connective tissue is to integrate organs and organ systems in the body. Discuss how blood fulfills this role.
ii. Why does an injury to cartilage, especially hyaline cartilage, heal much more slowly than a bone fracture?

C. Give reasons to these statements.

i. A cell is defined as the structural, functional, and biological unit of all organisms.
ii. Blood is considered a connective tissue .

iii. The growth of a plant stops if its apical part is cut.
iv. Bone dipped in hydrochloric acid becomes soft.
v. Simple diffusion will not meet the requirements of all the cells.
vi. Cartilage is a flexible connecting tissue.
vii. Neurons are the building blocks of the nervous system.

D. Differentiate between these paris:

i. Cells and Tissues
ii. Apical meristem and Lateral meristem
iii. Parenchyma and Collenchynma
iv. Xylem and Phloem
v. Glandular tissue and Laticiferous tissue
vi. Muscular tissue and Nervous tissue
vii. Axon and Dendrites

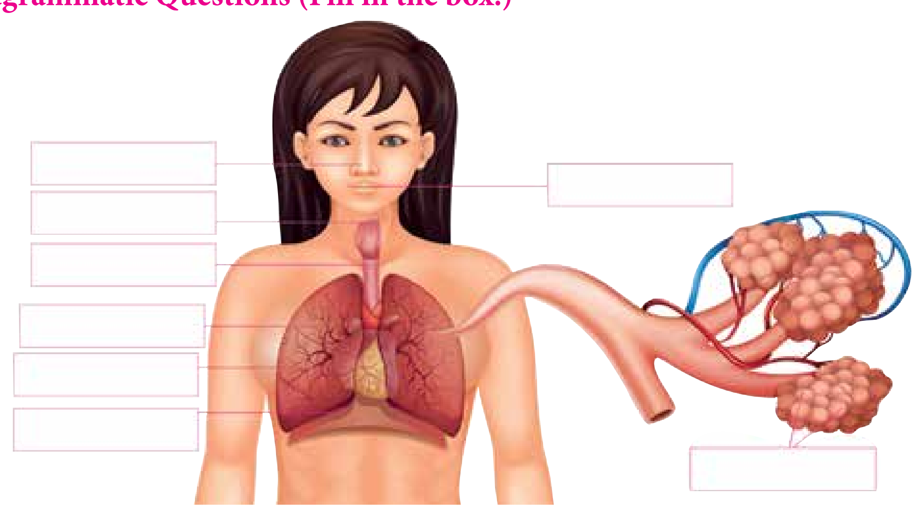
E. Answer the following questions :

i. Define the term 'tissue'.
ii. How many types of elements together make up the xylem tissue? Name them.
iii. How are simple tissues different from complex tissues in plants?
iv. Diagrammatically show the difference between the three types of muscle fibres.
v. What is the specific function of the cardiac muscle?
vi. Draw a labelled diagram of a neuron.
vii. Make a comparison and write down ways in which plant cells are different from animal cells.
viii. How is a prokaryotic cell different from a eukaryotic cell?

F. Name the following.

i. Tissue that forms the inner lining of our mouth.
ii. Tissue that connects muscle to bone in humans.
iii. Tissue that transports food in plants.
iv. Tissue that stores fat in our body.
v. Connective tissue with a fluid matrix.
vi. Tissue present in the brain.

G. Diagrammatic Questions (Fill in the box.)



5.2 Human Nervous System

How do we know about the effects and changes in the environment around us? Discuss how communication takes place in each organs of our body.

There are various environmental factors around us such as heat, light, sound, gravity, etc. All these factors to which the organ system responds and reacts are called stimuli. Living organisms are sensitive towards different stimuli. The reaction of the organisms to the stimulus is called response. Nerve cells, brain, spinal cord, hormones and different sense organs co-operate to perform the function of stimulation and reaction of the body. In animals too, nervous system plays an important role in stimulation and reaction.

Response is one of the fundamental characteristics of living things. For an instance, the leaflets of the *Mimosa pudica* collapse when touched. Similarly, the millipede curls up like a watch spring, when touched. The behaviour of the above organisms suggests that plants and animals are sensitive to external stimuli. Here, touch is the stimulus and closing of the leaflets and curling of the body are the responses or reactions. This type of responses for stimulation depends on the nature of the stimulus. The environmental change that brings about a response in the organism is called stimulus. The reaction of the organism to the stimulus is called response.

Most of the animals possess a nervous system. Therefore, they respond quickly to stimuli. Animals show the movement of their organs in response to stimuli. Animals also have another important system called endocrine system that controls the internal environment of the body. The stimuli like heat, touch, pressure, smell, sounds, etc. stimulate our body for reaction to them. This process is called stimulation. In this unit, we are going to study about the nervous system and the glandular system.

Nervous System

The system of the body comprising various organs that help in control and co- ordination of the body is called nervous system. It consists of brain, spinal cord and nerves. This system regulates and controls the activities of voluntary and involuntary muscles of our body. Nervous system is divided into three parts; central nervous system, peripheral nervous system, and autonomic nervous system.

A. Central Nervous System (CNS)
B. Peripheral Nervous System
C. Autonomic Nervous System

Human Nervous System
- Central Nervous System (CNS)
  - Brain
  - Spinal Cord
- Peripheral Nervous System (PNS)
  - Cranial Nerves
  - Spinal Nerves
- Autonomic Nervous System (ANS)
  - Sympathetic Nervous System
  - Para Sympathetic Nervous System

A. Central nervous System (CNS)

Central nervous system, includes brain and spinal cord. These are illustrated with labelled diagram in the following sub-sections.

i. Gray matter

Gray matter, named for its pinkish-gray color, is home to neural cell bodies, axon terminals, and dendrites, as well as all nerve synapses. This brain tissue is abundant in the cerebellum, cerebrum, and brain stem. It also forms a butterfly-shaped portion of the central spinal cord.

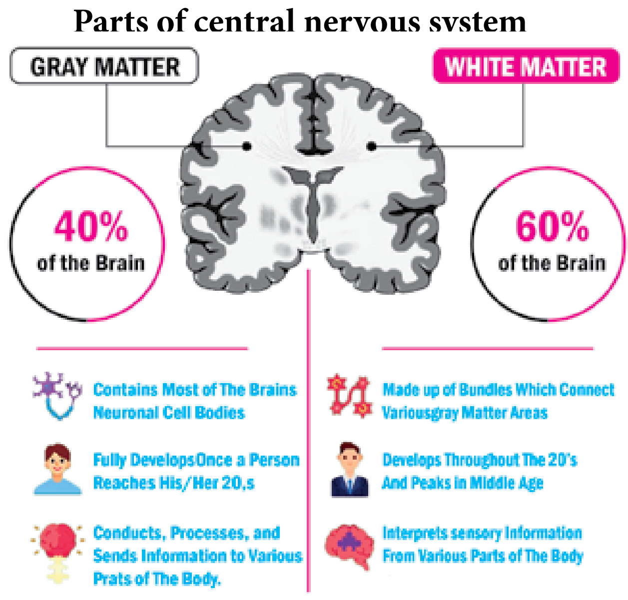


Fig 5.2.1

The back portion of this butterfly shape is known as the posterior, sometimes called the dorsal gray horn. This region passes sensory information via ascending nerve signals to the brain. The front part, which is sometimes called the ventral gray horn, sends descending nerve signals governing motor activities to your autonomic nerves. A problem with the dorsal gray horn may affect your brain's ability to interpret sensory information, while issues with the ventral gray horn interfere with your body's ability to receive motor information; paralysis, tingling, and muscle weakness are often the products of damage to the ventral gray horn.

ii. White matter

The white matter of your brain and spinal cord is composed of bundles of axons. These axons are coated with myelin, a mixture of proteins and lipids, that helps conduct nerve signals and protect the axons. White matter's job is to conduct, process, and send nerve signals up and down the spinal cord. Damage to the white matter of your brain or spinal cord can affect your ability to move, use your sensory faculties, or react appropriately to external stimuli. Some people with damaged white matter suffer deficits in reflexive reactions.

A. Brain

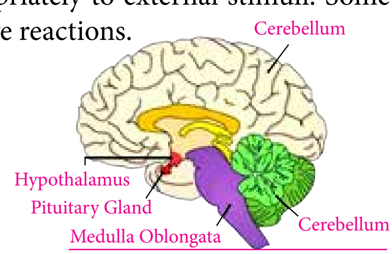


Fig 5.2.2

Brain is the largest and top most organ of central nervous system. It is highly developed and delicate organ in a human body. It is enclosed in a bony box called cranium. Brain is made up of nervous tissues. It is covered with three protective layers called meninges. The outer layer is duramater which is thick, tough that protects the brain from jerk. The middle layer is arachnoid mater. This layer is thin and soft. It contains blood vessels. The space between pia mater (inner layer) and arachnoid mater is filled with cerebrospinal fluid which protects the brain against shock and mechanical injuries.

Brain has three distinct parts- cerebrum,cerebellum and medulla oblongata.

i. Cerebrum is the centre of intelligence, memory, imagination and emotion.
ii. Cerebellum control the function of other parts of the brain.
iii. Medulla oblongata regulates involuntary activities of our body like heart beat, respiration

Meninges

The meninges refer to the membranous coverings of the brain and spinal cord. There are three layers of meninges, known as the dura mater, arachnoid mater and pia mater.These coverings have two major functions:

i. Provide a supportive framework for the cerebral and cranial vasculature.
ii. Acting with cerebrospinal fluid to protect the CNS from mechanical damage.

- **Dura mater**

The outermost of the three meninges is the dura mater (or pachymeninx), a strong, thick, and dense membrane. It is composed of dense fibrous tissue, and its inner surface is covered by flattened cells like those present on the surfaces of the pia mater and arachnoid. The dura mater is a sac that envelops the arachnoid and has been modified to serve several functions. The dura mater surrounds and supports the large venous channels (dural sinuses) carrying blood from the brain toward the heart.

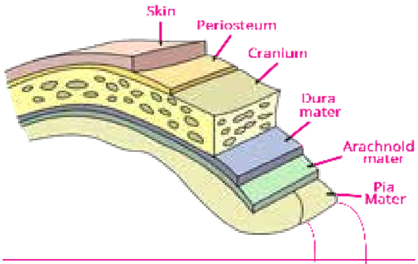


Fig 5.2.3

- **Arachnoid**

The arachnoid mater is the middle layer of the meninges, lying directly underneath the dura mater. It consists of layers of connective tissue, is **avascular**, and does not receive any innervation. Underneath the arachnoid is a space known as the **sub-arachnoid space**. It contains cerebrospinal fluid, which acts to cushion the brain. Small projections of arachnoid mater into the dura (known as **arachnoid granulations**) allow **Cerebrospinal fluid** to re-enter the circulation via the dural venous sinuses.

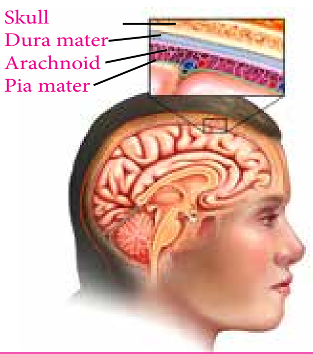


Fig 5.2.4

- **Pia mater**

The pia mater is located underneath the sub-arachnoid space. It is very thin, and **tightly adhered** to the surface of the brain and spinal cord. It is the only covering to follow the contours of the brain. Like the dura mater, it is highly vascularised, with blood vessels perforating through the membrane to supply the underlying neural tissue.

- **Cerebrospinal fluid (CSF)**

Cerebrospinal fluid (CSF) is clear, colourless liquid that fills and surrounds the brain and the spinal cord and provides a mechanical barrier against shock. Formed primarily in the ventricles of the brain, the cerebrospinal fluid supports the brain and provides lubrication between surrounding bones and the brain and spinal cord. When an individual suffers a head injury, the fluid acts as a cushion, dulling the force by distributing its impact. The fluid helps to maintain pressure within the cranium at a constant level. An increase in the volume of blood or brain tissue results in a corresponding decrease in the fluid. Conversely, if there is a decrease in the volume of matter within the cranium, as occurs in atrophy of the brain, the CSF compensates with an increase in volume.

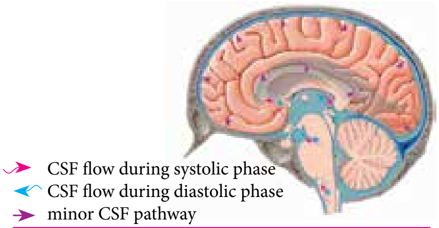


Fig 5.2.5

The fluid also transports metabolic waste products,antibodies, chemicals, and pathological products of disease away from the brain and spinal-cord tissue into the bloodstream. CSF is slightly alkaline and is about 99 percent water. There are about 100 to 150 ml of CSF in the normal adult human body.

The exact method of the formation of the CSF is uncertain. After originating in the ventricles of the brain, it is probably filtered through the nervous-system membranes (ependyma). The CSF is continually produced, and all of it is replaced every six to eight hours. The fluid is eventually absorbed into the veins; it leaves the cerebrospinal spaces in a variety of locations, including spaces around the spinal roots and the cranial nerves. Movement of the CSF is affected by the downward pull of gravity, the continual process of secretion and absorption, blood pulsations in continent tissue, respiration, pressure from the veins, and head and body movements. Examination of the CSF may diagnose a number of diseases. A CSF analysis may include tests to diagnose: **Infectious diseases of the brain and spinal cord,** including meningitis and encephalitis. CSF tests for infections look at white blood cells, bacteria, and other substances in the cerebrospinal fluid.

Medulla oblongata

It is the small posterior part of the brain.It connects the spinal cord with brain. It is the lowest part of the brain. Spinal cord arises from its lower part. Any kind of injury or damage in medulla oblongata causes instant death of human being.

i. Medulla oblongata receives and integrates signals from the spinal cord and sends the resulting impulses to the cerebrum and cerebellum.
ii. It regulates involuntary activities of our body like heart beat, respiration, blood circulation, sneezing, coughing, vomiting, salivation, swallowing etc.

- **Pons Varoli**

The **pons Varoli** is a part of the brain stem which connects the medulla oblongata and the cerebral cortex. It is the largest part of the brain stem, sitting superior to the **medulla oblongata** and inferior to the **midbrain**, connecting the two.

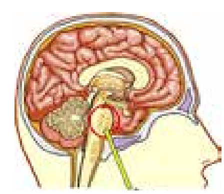


Fig 5.2.6

It is also anterior to the brain's **cerebellum** and posterior to the pituitary gland. The pons is approximately 27mm long and is made up of two areas: the ventral pons and the dorsal pons. The ventral part of the pons contains pontine nuclei, as well as corticopontine and corticospinal tracts traveling vertically along this portion. It also has fibers crossing transversely from the pontine nuclei to the opposite cerebellum.

A groove called the basilar sulcus runs down the middle of the ventral portion, which accommodates the basilar artery. The dorsal portion (AKA tegmentum) mainly contains the not-well-defined reticular formation which runs throughout the brain stem.

As the pons is, essentially, a large collection of different nerves and nuclei, it does not carry out one defined function – instead, it is **involved in several different functions** to do with both the central and peripheral nervous system.

For instance, several nerves originate from the pons, including nerves that control functions of the face such as the:

Trigeminal nerve – controls facial sensation and chewing
Abducens nerve – controls eye movement
Facial nerve – controls facial expressions and movement
Vestibulocochlear nerve – controls hearing and equilibrium maintenance

The pons also plays a role in:

- **Regulating breathing rate** (by assisting medulla oblongata)
- The **control of sleep cycles**
- The **regulation of deep sleep**
- **Inhibition of movement during sleep** (by activating inhibitory centers in the medulla)

The pons also helps to **connect some parts of the brain**. This aids in relaying sensory information from one place to another.

B. Spinal Cord

The spinal cord is the most important structure between the body and the brain. The spinal cord extends from the foramen magnum where it is continuous with the medulla to the level of the first or second lumbar vertebrae. It is a vital link between the brain and the body, and from the body to the brain. The spinal cord is 40 to 50 cm long and 1 cm to 1.5 cm in diameter. Two consecutive rows of nerve roots emerge on each of its sides. These nerve roots join distally to form 31 pairs of spinal nerves. The spinal cord is a cylindrical structure of nervous tissue composed of white and gray matter, is uniformly organized and is divided into four regions: cervical (C), thoracic (T), lumbar (L) and sacral (S), (see in figure), each of which is comprised of several segments. The spinal nerve contains motor and sensory nerve fibers to and from all parts of the body. Each spinal cord segment innervates a dermatome (see Figure 3.5).

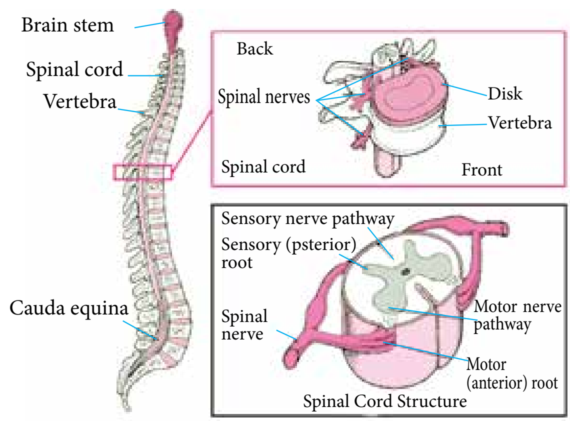


Fig 5.2.7

General Features of Spinal Cord

1. Similar cross-sectional structures at all spinal cord levels
2. It carries sensory information (sensations) from the body and some from the head to the central nervous system (CNS) via afferent fibers, and it performs the initial processing of this information.

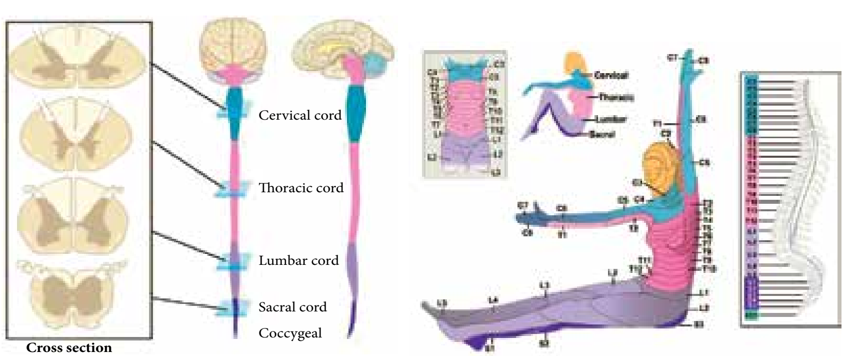


Fig 5.2.8

3. Motor neurons in the ventral horn project their axons into the periphery to innervate skeletal and smooth muscles that mediate voluntary and involuntary reflexes.
4. It contains neurons whose descending axons mediate autonomic control for most of the visceral functions.
5. It is of great clinical importance because it is a major site of traumatic injury and the locus for many disease processes.

Although the spinal cord constitutes only about 2% of the central nervous system (CNS), its functions are vital. *Knowledge of spinal cord functional anatomy makes it possible to diagnose the nature and location of cord damage and many cord diseases.*

Nerve fibers

A nerve contains bundles of nerve fibers, either axons or dendrites, surrounded by connective tissue. Sensory nerves contain only afferent fibers, long dendrites of sensory neurons. Motor nerves have only efferent fibers, long axons of motor neurons. Mixed nerves contain both types of fibers.

A connective tissue sheath called the epineurium surrounds each nerve. Each bundle of nerve fibers is called a fasciculus and is surrounded by a layer of connective tissue called the perineurium. Within the fasciculus, each individual nerve fiber, with its myelin and neurilemma, is surrounded by connective tissue called the endoneurium. A nerve may also have blood vessels enclosed in its connective tissue wrappings.

Parts of Neuron

Neuron is the structural and functional unit of nervous system. There are about 10 billions nerve cells in human body. These nerve cells are scattered throughout the body to form a complex network. Neurons help to communicate different parts of body with brain. A neuron has three main parts: cell body, axon and dendrites.

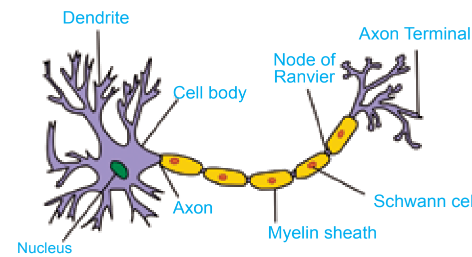


Fig 5.2.9

A cell body is central round part of neuron. It has nucleus centrally located on it. Fine branches arise from a cell body. Among the branches, one branch is longer which is called axon and other shorter are called dendrites. A number of cell bodies outside the center nervous system unite to form a ganglia.

Types of Nerve fibers

a. **Afferent or sensary nerve**
   They carry impulses from receptors to brain or spinal cord.
b. **Efferent or motor nerve**
   They carry impulse from brain or spinal cord to different parts of the body (muscles/glands).
c. **Inter neuron**
   The type of neurons that transmit impulses involving other neurons, particularly as a part of the reflex arc are called interneurons. Interneurons are also documented with different names such as

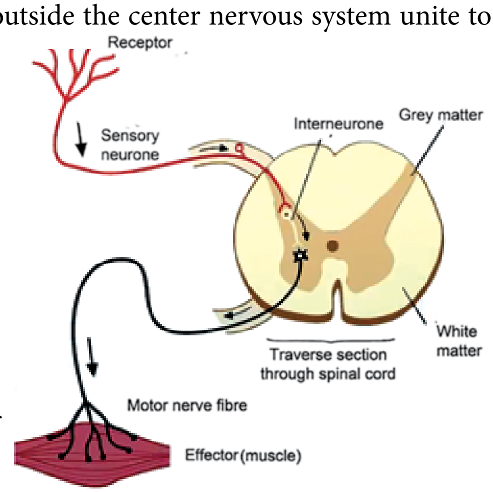


Fig 5.2.10

relay neurons, connector neurons, internuncial neurons, association neurons, or local circuit neurons. Interneurons are the central nodes of circuits. The main function of the interneurons is to receive information from either sensory or motor neurons and transmit it to a motor or sensory neurons.Interneurons are of diverse types. They are actively involved in handling and processing information. Interneurons are a part of both simple reflex circuits and compound neural networks of the brain. A combination of interneuron networks in the brain behaves like a decision-maker of the brain which is stored in the brain for future use. Example: Once a burning candle is touched, the information that 'it is not good to touch a burning candle' is retained in the brain.

Peripheral nervous System

The peripheral nervous system consists of the nerves that branch out from the brain and and spinal cord. These nerves form the communication network between the CNS and the body parts.

a. Cranial nerve

Twelve pairs of cranial nerves emerge from the inferior surface of the brain. All of these nerves, except the vagus nerve, pass through foramina of the skull to innervate structures in the head,neck and facial region.

The cranial nerves are designated both by name and by Roman numerals, according to the order in which they appear on the inferior surface of the brain. Most of the nerves have both sensory and motor components. Three of the nerves are associated with the special senses of smell, vision, hearing, and equilibrium and have only sensory fibers. Five other nerves are primarily motor in function but do have some sensory fibers for proprioception. The remaining four nerves consist of significant amounts of both sensory and motor fibers.

Acoustic neuromas are benign fibrous growths that arise from the balance nerve, also called the eighth cranial nerve or vestibulocochlear nerve. These tumors are non-malignant, meaning that they do not spread or metastasize to other parts of the body. The location of these tumors is deep inside the skull, adjacent to vital brain centers in the brain stem. As the tumors enlarge, they involve surrounding structures which have to do with vital functions. In the majority of cases, these tumors grow slowly over a period of years. In other cases, the growth rate is more rapid and patients develop symptoms at a faster pace. Usually, the symptoms are mild and many patients are not diagnosed until some time after their tumor has developed. Many patients also exhibit no tumor growth over a number of years when followed by yearly MRI scans.

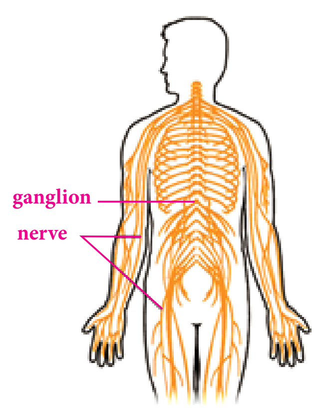


Fig 5.2.11

b. Spinal nerve

Thirty-one pairs of spinal nerves emerge laterally from the spinal cord. Each pair of nerves corresponds to a segment of the cord and they are named accordingly. This means there are 8 cervical nerves, 12 thoracic nerves, 5 lumbar nerves, 5 sacral nerves, and 1 coccygeal nerve.

Each spinal nerve is connected to the spinal cord by a dorsal root and a ventral root. The cell bodies of the sensory neurons are in the dorsal root ganglion, but the motor neuron cell bodies are in the gray matter. The two roots join to form the spinal nerve just before the nerve leaves the vertebral column. Because all spinal nerves have both sensory and motor components, they are all mixed nerves.

Reflex action

Reflex action is a quick automatic and mechanical response produced to a stimulus. Brain does not involve in reflex action. It is judged by spinal cord. Blinking of eye, watering of mouth on seeing food, shivering in cold, jerking of hand when touched a hot object, etc. are some examples of reflex action.

Reflex arc is a pathway in which the nerve impulses travel along sensory and motor nerves in the reflex action. It consists of five parts: receptor organ (skin), sensory nerve (afferent), interneuron, motor nerves (efferent), and effector organ (muscle). When the receptor receives the stimulus it is transmitted to the spinal cord through sensory nerve. In the spinal cord impulses are passed onto relay neuron. Then motor nerve conducts the impulse of instruction to the effector (muscle) which shows the response.

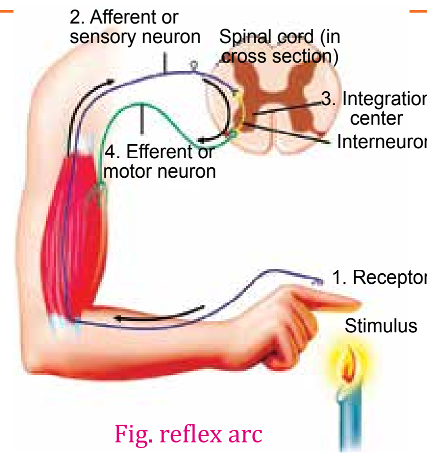


Fig 5.2.12

Receptor organ skin: It receives the stimulus and initiates a sensory nerve impulse e.g. skin and other sense organs.
Sensory or afferent nerve: It conducts impulses from the receptor to the spinal cord.
Interneuron: It acts as a modulator and changes the sensory impulse into the motor impulse. It is also called relay neuron.
Motor or efferent nerve : It conducts impulses from the interneuron (spinal cord) to the effector organ (muscle or gland).
Effector organ/ muscles: It responds to the impulses received by muscles and glands with effectors.
A reflex action follows this general sequence and does not involve the conscious part of the brain. This is why the response is so fast.

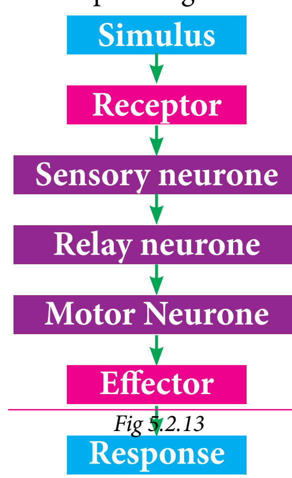


Fig 5.2.13

Reflex arc

The nerve pathway followed by a reflex action is called a reflex arc. For example, a simple reflex arc happens if we accidentally touch something hot.

- **Receptor** in the skin detects a stimulus (the change in temperature).
- **Sensory neuron** sends electrical impulses to a relay neuron, which is located in the spinal cord of the CNS. Relay neurons **connect** sensory neurons to motor neurons.

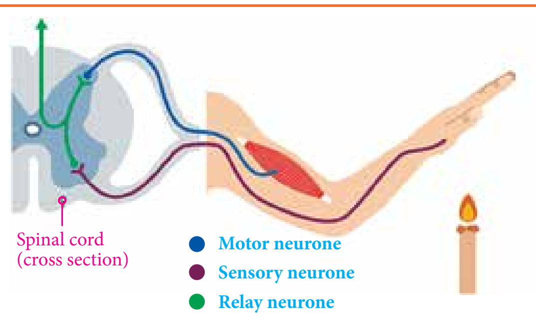


Fig 5.2.14

- **Motor neuron** sends electrical impulses to an effector.
- Effector produces a response (muscle contracts to move hand away).

Organisms are able to modify a reflex action and overcome it, but this uses the brain and has to be learnt. For example, holding of a hot object requires a nerve impulse to be sent to the motor neuron of the reflex arc to interfere with the normal reflex action to drop the object.

c. Autonomic nervous System

This is the part of nervous system that control the activities of involuntary muscles of the body. Autonomic nervous system controls working of heart, lungs, kidneys, urethra, etc. whether we are awake or asleep. This system is of two types sympathetic nervous system and parasympathetic nervous system.

Sympathetic and parasympathetic nervous system have opposite effect on the functions that they regulate. Sympathetic nervous system is responsible for helping the body to get ready for action during stressful situations, considerable fright. Parasympathetic nervous system is responsible for stimulation of rest and digest or feed and breed activities that occur when the body is at rest. Sympathetic nervous system causes increase in heartbeat, blood pressure, respiration during emergency. When the emergency is over parasympathetic nervous system acts opposite and brings normality of the body organ.

a. Sympatheric nervous system

It is a nice, sunny day...you are taking a nice walk in the park. Suddenly, an angry bear appears in your path. Do you stay and fight OR do you turn and run away? These are “Fight or Flight” responses. In these types of situations, your sympathetic nervous system is called into action - it uses energy - your blood pressure increases, your heart beats faster, and digestion slows down.

b. Parasympatheric nervous system

It is a nice, sunny day...you are taking a nice walk in the park. This time, however, you decide to relax in comfortable chair that you have brought along. This calls for “Rest and Digest” responses. Now is the time for the parasympathetic nervous to work to save energy. This is when blood pressure can decrease, pulse rate can slow, and digestion can start.

Structure	Sympathetic Stimulation	Parasympathetic timulation
Iris (eye muscle)	Pupil dilation	Pupil constriction
Salivary Glands	Saliva production reduced	Saliva production increased
Oral/Nasal Mucosa	Mucus production reduced	Mucus production increased
Heart	Heart rate and force increased	Heart rate and force decreased
Lung	Bronchial muscle relaxed	Bronchial muscle contracted
Stomach	Peristalsis reduced	Gastric juice secreted; motility increased
Small Intestine	Motility reduced	Digestion increased

Large Intestine	Motility reduced	Secretions and motility increased
Liver	Increased conversion of glycogen to glucose	
Kidney	Decreased urine secretion	Increased urine secretion
Adrenal medulla	Norepinephrine and epinephrine secreted	
Bladder	Wall relaxed Sphincter closed	Wall contracted Sphincter relaxed

Table 5.2.1

It should be noted that the autonomic nervous system is always working. It is NOT only active during "fight or flight" or "rest and digest" situations. Rather, the autonomic nervous system acts to maintain normal internal functions and works with the somatic nervous system.

Activity

How do you know when your hand touches something? How do you know if something brushes against your shoulder?, Do you think you need the same number of nerves in every part of your body? Think about your fingertip, arm and back. In which of these places might your nerves be closer together? Make your predictions and see for yourself in the experiment below:

Hypothesis Explain which part of your body (fingertip, arm or shoulder) will be most sensitive and explain why: If____

then____

because____

Materials

1 ruler with centimeters , 1 Paperclip, Paper and a pencil

Procedures

- Open your paper clip. Spread the ends and use the ruler to measure the distance between them. Adjust them until they are exactly 4cm apart.
- Touch both ends of the paper clip to your finger tip. A gentle touch is all that is required. If you feel both ends, write a "2" in the first square in the chart as shown in the example above. If you only feel one paper clip end, that means both ends of the paper clip are touching the same neuron. If this happens, write a "1" in the appropriate square in your table.
- Repeat this on your upper arm and back, and record your results in your table. (Hint: If you have a hard time reaching your back, ask a partner for help.)
- Using your ruler, push the paper clip ends 1/2 centimeter closer together. Repeat steps 2 and 3, bringing the paper clip ends closer each time until they are touching.

Experiment Overview

Use the table below to record your results.

Distance between paperclip ends	Fingertip	Upper arm	Back
4 cm			
3.5 cm			
3 cm			
2.5 cm			
2 cm			
1.5 cm			
1 cm			
0.5 cm			
ends touching			

Analysis and Conclusions:

1. What was the independent variable in this experiment? How do you know?
2. What was the dependent variable in this experiment? How do you know?
3. What patterns did you see in your data?
4. Which part of the body was least sensitive?
5. Which part of the body is most sensitive? Why do you think that is?
6. Was your hypothesis supported? Why or why not? Use your data to explain your answer.
7. What further questions does this experiment raise, and what could you do to investigate the answers to those questions?

Exercise

A. Choose the correct one and put the tick mark(√)

i. The nervous system consists of:

a. Brain, Spinal Cord
b. Brain,Spinal Cord, Nerves, Digestive system
c. Brain, Spinal Cord, Nerves, Sensory Organs
d. Brain, Spinal Cord, Vertebrae, Nerves

ii. The main control system consisting of Brain and Spinal Cord is.....

a. Central Nervous System   b. Peripheral Nevous System
c.. Autonomic System   d. Sensory Nervous System

iii. This part of the brain is responsible for balance, posture, as well as muscle tone and learning while using muscles.

a. Cerebellum   b. Thalamus
c. Medulla Oblongata   d. Cerebrum

vi. Which nerves are attached to the brain and emerge from the skull?

a. Cranial Nerves   a. Spinal Nerves
c. Thoracic Nerves   d. Sacral Nerves

vii. What is the unit of Nervous system?

a. Brain b. Spinal Cord
c. Neuron d. Nerves

viii. In our body involuntary actions are controlled by:

a. Medulla in Hindbrain b. Medulla in Forebrain
c. Medulla in Spinal Cord d. Medulla in Midbrain

ix. Those reflex actions which involve brain are called:

a. Stimulus b. Cerebral reflexes
c. Spinal reflexes d. Reflex arc

x. Pons, cerebellum and medulla are part of which brain?

a. Forebrain b Midbrain
c. Hindbrain d. None of the above

xi. Spinal Cord originates from which part of the brain?

a. Cerebellum b. Medulla
c. Pons d. Cerebrum

B. Give reasons to these statements.

i. Cerebrum has a grey upper surface but upper surface of spinal cord is white.
ii. A person jumps up when he/she steps on soft loose things unknowingly.
iii. When cerebrum is injured, a person becomes unconscious.
iv. When cerebellum is injured, the body becomes unbalanced.
v. Spinal cord is said to be the center of reflex action.
vi Playing a harmonium by striking a particular key on seeing a music note is an example of conditioned reflex.

C. Differentiate between these pairs

i. Central nervous system and Peripheral nervous system
ii. Gray matter and white matter
iii. Cerebrum and cerebellum
iv. Afferent and efferent nerve
v. Cranial nerve and spinal nerve
vi. Reflex action and reflex arc
vii. Sympathetic nerve and parasympathetic nerve

D. Answer the following questions :

i. Name the parts of the hind brain.
ii. What are the structures involved in the protection of brain? Define reflex arc.
iii. With a neat labelled diagram explain the structure of a neuron.
iv. Illustrate the structure and functions of brain.
v. What will you do if someone pricks your hand with a needle? Elucidate the pathway of response with a neat labelled diagram.
vi. Describe the structure of spinal cord.
vii. How nerve impulses are transferred from one neuron to next neuron?
viii. 'M' is a cylindrical structure that begins from the lower end of medulla and extend downwards. It is enclosed in bony cage 'N' and covered by membranes 'O'. As many as 'P' pairs of nerves arise from the structure 'M'.

a. What is M?

b. Name (a) bony cage 'N' and (b) membranes 'O'
c. How much is 'P'?

ix. Our body contains a large number of cells 'L' which are the longest cells in the body. 'L' has long and short branch called as 'M' and 'N' respectively. There is a gap 'O' between two 'L' cells, through which nerve impulse transfer by release of chemical substance 'P'.
a. Name the cells 'L'
b. What are 'M' and 'N'?
c. What is the gap 'O'?
d. Name the chemical substance 'P'.

E. Complete the two lists in the table below to show the different activities and functions of the sympathetic and parasympathetic divisions of the autonomic nervous systems on some key organs of the human body.

Sympathetic nervous system	Organ	Parasympathetic nervous system
	Eye muscles	
	Salivary glands	
	Heart	
	Respiratory system	
	Stomach	
	Intestines	
	Pancreas	
	Gall bladder	
	Urinary bladder	

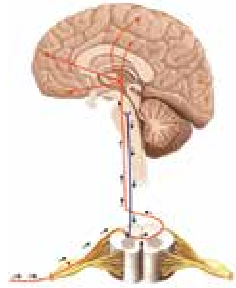
F. Critical Thinking Questions:

i. Imagine. By accident, your finger touches the fire flame of a candle. *So, what you will do?* Obviously, you will instantly pull back your hand to protect your finger from burning. Have you ever given a thought, only your finger has burned, but how the whole body knows about it? And, why you instantly react and pull your whole hand back?

ii. How are neurons similar to other cells? How are they unique?

iii. Scientists have suggested that the autonomic nervous system is not well-adapted to modern human life. How is the sympathetic nervous system an ineffective response to the everyday challenges faced by modern humans?

G. Diagrammatic Questions:



i. Draw neat diagram of human brain and label on it the following parts :
Midbrain, Pituitary gland, cerebellum.

ii. Label the diagram of the pain pathway (below) to show the route taken by impulses when sensory endings are stimulated and the brain perceives pain. Write short note s about each stage of the process.

5.3 Glandular System

Gland is an organ which secretes particular chemical substances required for human body. The group of glands in our body forms the glandular system. There are various glands in our body. These glands are divided into two types:

a. **Exocrine gland :** A gland that secrets enzymes and releases them through a duct or opening to a body surface is known as exocrine gland. Liver, salivary gland, tear gland, gastric gland, etc. are the examples of exocrine gland.

b. **Endocrine gland :** A gland that secrets hormones that are released directly into the blood is known as endocrine gland. Hormones are mixed into blood directly. Pituitary, thyroid, adrenal, etc. are some of the examples of endocrine glands. Pancreas secretes both enzyme and hormone. So, it is also called mixed gland or heterocrine gland.

5.3.1 Human Hormone

Hormones are secreted by endocrine glands. Hormones are also known as chemical messengers because they regulate, control, co-ordinate and integrate various activities of the body. There must be right amount of hormones secretion in the body. A small change in the amount of hormones may causes big disorder in the body such as dwarfism, tallness, sterility, etc.

Functions of Hormones

- Hormones serve as chemical messengers in the body and help maintain **homeostasis**.
- Hormones are released into bodily fluids, like blood, which carry them to target cells.
- Target cells respond to a hormone when they express a specific receptor for that hormone.
- Hormones also play a role in the regulation of cell death, the immune system, reproductive development, mood swings, and hunger cravings.
- In the adrenal gland, epinephrine and norepinephrine regulate responses to stress; in the thyroid gland, thyroid hormones regulates metabolic rates.
- Hormones affect nearly every process in your body, including growth and development, emotions and mood, fertility and sexual function, sleep and blood pressure.

Table of endocrine gland

Exocrine gland	Endocrine gland
i. It is ducted gland.	It is ductless gland.
ii. It secretes enzymes.	It secretes hormones.
iii. Enzymes produced are transported by duct to the related part of the body.	Hormones are mixed in the blood stream directly and carried to related parts of body.
iv. The gland and the site of a action of enzymes are closer.	The gland and the site of action of hormone are far.

Table 5.3.1

The endocrine gland, the location of the gland, the hormones produced and the functions can be seen in the table below:

Glands	Location	Hormones	Functions
Pituitary	Brain	Growth hormone	• Regulates growth • Controls the functioning of endocrine glands
Thyroid	Throat	Thyroxine	• Controls the metabolism rate • It also brings about balanced growth
Parathyroid	Near thyroid gland	Parathormone	• Controls calcium balance of the body
Adrenal	Attached to kidneys	Adrenaline	• Prepares body for emergency
Pancreas	Abdomen	Insulin	• Controls glucose level of the blood
Testes	Scrotum	Testosterone	• Controls growth and development of male reproductive stystem
Overies	Lower abdomen	Oestrogen, progesterone	• Controls growth and development of female reproductive system

Table 5.3.2

Pituitary Gland

It is a small pea seed size endocrine gland. It lies at the base of the brain. This gland is also known as master gland because it controls activities of other glands. It secretes mainly growth hormones and stimulation hormones. Right amount of secretion of growth hormones causes normal growth of bone and body. Its over secretion leads to gigantism and under secretion leads to dwarfism.

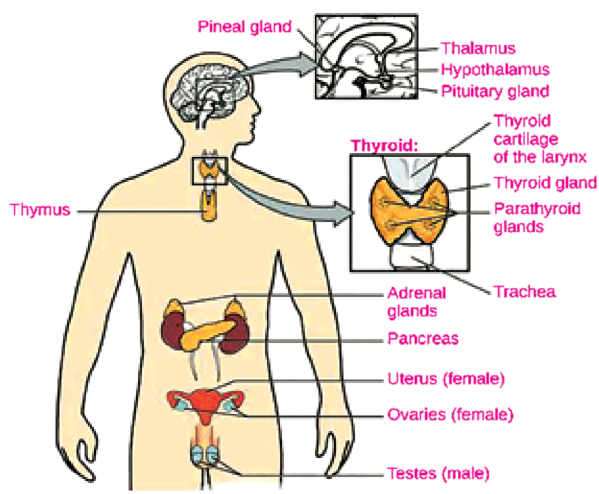


Fig. 5.3.1

Thyroid gland

This gland lies in the neck. It secretes thyroxin hormone. It helps to increase the rate of metabolism. Thyroxin contains iodine. Deficiency of thyroxin in a young child leads to retardation of physical and mental growth, less sweating, low pulse rate, dry skin, etc. Lack of iodine in food may cause increase in size of thyroid gland. This condition is called goitre. This gland also helps to deposit calcium in the bone and decrease the calcium level in blood.

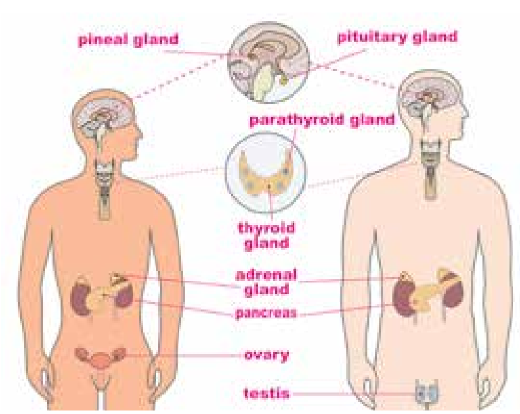


Fig. 5.3.2

Parathyroid gland

There are four minute yellowish parathyroid glands. They are located on thyroid gland. So, they are called parathyroid glands. They produce parathyroxin (parathormone) hormone. Over secretion of parathoromone makes bones and teeth weak and soft. Under secretion of this hormone causes muscle spasms due to low concentration of calcium in blood. It may cause stones in the kidneys.

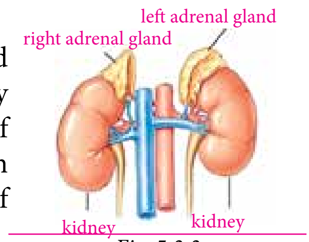


Fig. 5.3.3

Andrenal gland

It is situated at the top of each kidney. It secretes adrenalin hormone. This hormone prepares the body to face emergency conditions. So, these glands are also known as emergency gland. Excessive secretion of the hormone causes hypertonic and may cause death too. Low secretion of it causes weakness, low blood pressure, low sugar in blood, vomiting, etc.

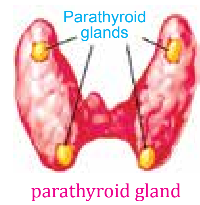


Fig. 5.3.4

Pancrease

It is located at the loop of the duodenum. It produces pancreatic juice enzymes and insulin hormone. So, it is also known as mixed gland. Insulin helps to control sugar in blood. Over secretion of insulin causes low sugar level in blood and may lead to unconsciousness. Under secretion of insulin causes diabetes mellitus. The symptoms of diabetes are, increase sugar level in blood, thirst, hunger, loss of body weight, tiredness, frequent urination and delay in healing of wound.

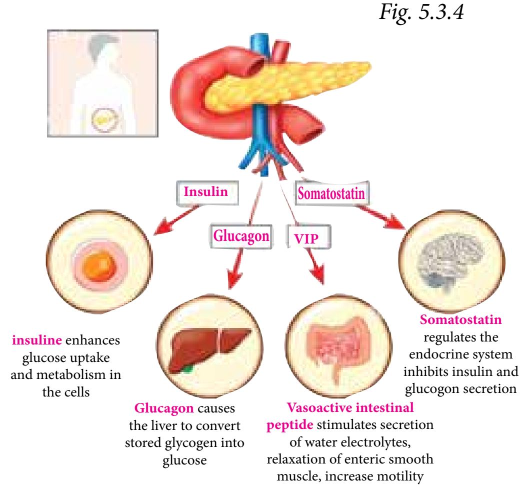


Fig. 5.3.5

Gonads

Testes of male and ovaries of female are called gonads. These are heterocrine glands. Testes are located in scrotum and secrets male sex hormones called testosterone and sperms. The hormone stimulates for the development of secondary sex characters in male like beards, change in voice, sexual desire, etc.

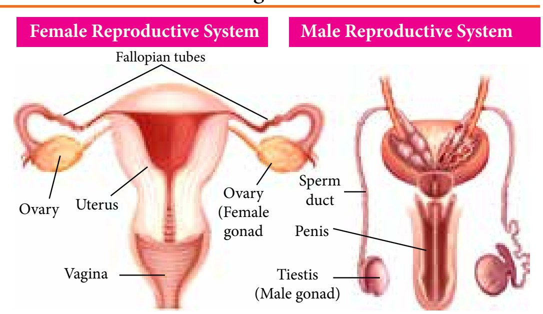


Fig. 5.3.6

In female there are oval shaped ovaries located inside the lower abdominal cavity of the body. Overies produce hormones : estrogen and progesterone. They also produce secondary sexual characters in female like enlargement of breasts, widening of pelvis, soft skin, growth of pubic hair, onset of menstrual cycle, etc.

a. Testes

The testes - also called testicles - are two oval - shaped organs in the male reproduction system.

b. Ovary

The ovary is an organ found in the female reproductive system that produces an ovum.

5.4 Plant Hormone

Among the substances which markedly influence the reactions and metabolism of the animal body are those internally-produced compounds called hormones. Many of the hormones of the higher animals are secreted by the ductless glands; examples are adrenalin, thyroxin, and insulin. Within the last decade or two convincing evidence has accumulated that hormone-like substances also occur in plants. Those compounds are called **growth substances, hormones, growth hormones**, or **phytohormones**. Like animal hormones plant hormones quite commonly affect parts of the organism other than those in which they are produced. It is a characteristic of both plant and animal hormones that they usually exert their physiological effects while present in minute concentrations; it is principally on this basis that they differ from compounds ordinarily classified as foods.

Plants need sunlight, water, oxygen, minerals for their growth and development. These are external factors. Apart from these, there are some intrinsic factors that regulate the growth and development of plants. These are called plant hormones or **"Phytohormones".** Plant hormones are chemical compounds present in very low concentration in plants. They are derivatives of indole (**auxins**), terpenes (**Gibberellins**), adenine (**Cytokinins**), carotenoids (**Abscisic acid**) and gases (**Ethylene**). These hormones are produced in almost all parts of the plant and are transmitted to various parts of the plant.They may act synergistically or individually. Roles of different hormones can be complementary or antagonistic. Hormones play an important role in the processes like vernalisation, phototropism, seed germination, dormancy etc. along with extrinsic factors. Synthetic plant hormones are exogenously applied for controlled crop production. Charles Darwin first observed the phototropism in the coleoptiles of canary grass and F.W. Went first isolated auxin from the coleoptiles of oat seedlings.

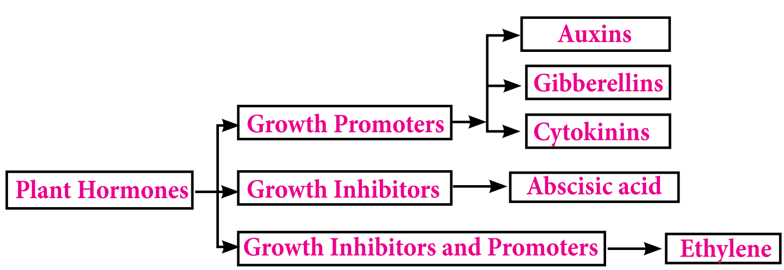


Fig. 5.3.7

Plant hormones are chemical messengers that affect a plant's ability to respond to its environment. Hormones are organic compounds that are effective at very low concentrations; they are usually synthesized in one part of the plant and are transported to another location. They interact with specific target tissues to cause physiological responses, such as growth or fruit ripening. Each response is often the result of two or more hormones acting together.

Auxins are hormones involved in plant-cell elongation, apical dominance, and rooting. A well known natural auxin is indoleacetic acid (IAA) which is produced in the apical meristem of the shoot. Developing seeds produce IAA, which stimulates the development of fleshy fruit. For example, the removal of seeds from a strawberry prevents the fruit from enlarging. The application of IAA after removing the seeds causes the fruit to enlarge normally. IAA is produced in actively growing shoot tips and developing fruit, and it is involved in elongation. Before a cell can elongate, the cell wall must become less rigid so that it can expand. IAA triggers an increase in the plasticity, or stretchability, of cell walls, allowing elongation to occur.

Characteristics of Phytohormones

i. Unlike animals, plants do not have any specific hormonal glands. Plant hormones can be produced from any part of the body.
ii. These molecules transmit through all parts of the vascular tissues called phloem and xylem and by plasmodesmata from cell to cell.
iii. These hormones can act both individually or synergistically. Moreover, their roles can also be either antagonistic or complementary.
iv. Every life process of plants, along with external factors, is controlled by these chemical messengers.
v. Synthetic phytohormones are used exogenously for customised crop production.

Functions of growth hormone

- Cytokinins promote cell division in plants. Produced in the developing shoots, roots, fruits, and seeds of a plant, cytokinins are very important in the culturing of plant tissues in the laboratory. A high ratio of auxins to cytokinins in a tissue-culture medium stimulates root formation. A low ratio promotes shoot formation. Cytokinins are also used to promote lateral bud growth in flowering plants.
- Plant Hormones control plant growth and development by affecting division, elongation, and cell differentiation.. Hormonal signal is amplified by gene expression, enzyme activity, or membrane properties.
- Gibberellins are a class of hormones that have important commercial applications. Almost all seedless grapes are sprayed with gibberellins to increase the size of the fruit and the distance between fruits on the stems. Beer makers use gibberellins to increase the alcohol content of beer by increasing the amount of sugar produced in the malting process. Gibberellins are also used to treat seeds of some food crops because they will break seed dormancy and promote uniform germination.

	Germination	Growth to Maturity	Flowering	Fruit Development	Abscission	Seed Dormancy
Gibberellin	✓	✓	✓	✓	✗	✗
Auxin	✗	✓	✓	✓	✗	✗
Cytokinins	✗	✓	✓	✓	✗	✗
Ethylene	✗	✗	✓	✓	✓	✗
Abscisic Acid	✗	✗	✗	✗	✓	✓

Fig. 5.3.8

- **Auxins** are hormones produced in immature parts of plants that stimulate growth. Auxins stimulate cell differentiation, which means this hormone helps decide if a cell will become ground tissue or vascular tissue or protective tissue. Auxins also help stimulate stem elongation, which is what primary stem growth is all about. Without auxins, fruits are often too small. Some produce farmers will spray artificial auxins on plants - such as apples or pears - in order to increase the size of the fruits.
- The hormone **ethylene** is responsible for the ripening of fruits. Unlike the other four classes of plant hormones, ethylene is a gas at room temperature. Ethylene gas diffuses easily through the air from one plant to another. The saying 'One bad apple spoils the barrel' has its basis in the effects of ethylene gas. One rotting apple will produce ethylene gas, which stimulates nearby apples to ripen and eventually spoil because of over-ripening.
- Ethylene is usually applied in a solution of ethephon, a synthetic chemical that breaks down and releases ethylene gas. It is used to ripen bananas, honeydew melons, and tomatoes. Oranges, lemons, and grapefruits often remain green when they are ripe. Although the fruit tastes good, consumers often will not buy them, because oranges are supposed to be orange, right? The application of ethylene to green citrus fruit causes the development of desirable citrus colors, such as orange and yellow. In some plant species, ethylene promotes abscission, which is the detachment of leaves, flowers, or fruits from a plant. Cherries and walnuts are harvested with mechanical tree shakers. Ethylene treatment increases the number of fruits that fall to the ground when the trees are shaken.

Utilities of plant growth hormones

- The use of plant growth hormone in horticulture is a trend with great advantages. The approach of the application of plant growth regulators in horticulture shows good results. Plant growth hormone is used in tissue culture. Auxin and cytokinin hormones are artificially mixed during tissue culture. Auxin helps in root growth. The cytokinin hormone helps in stem growth. When these two hormones are kept in balance, the growth and development of plants is accelerated.
- These hormones also play an important role in producing quality fruits and vegetables, as well as non-seasonal vegetables.
- Plant hormones such as auxins, gibberellins and ethene can be used commercially. Selective weed killers contain auxins. The weed plants compete with crops for water and minerals. If the crops are narrow-leaved and the weed is broadleaved, then auxins are used. Auxins stimulate growth of shoots and so when the weeds absorb more auxins, they grow too quickly and die.
- Gardeners take cuttings of plants that grow into new plants. They dip the ends of these into rooting powder which contains auxins that cause the stalk to produce roots quickly. This helps the cuttings grow.
- Gibberellins stimulate germination of seeds which increases crop yields. They also stimulate the production of flower and fruit so yield is again increased. Gibberellins stimulate stem elongation. If done on crops like sugar cane, yield is increased!

- Gibberellins sprayed on to flowers can stop seeds from developing in the fruits. They also make the fruits larger. People prefer larger, seedless fruits so they are worth more money.
- Ethene is a gas released by some ripe fruits such as bananas. This ethene gas acts as a ripening hormone on other fruits. Unripe bananas release very little or none of this gas.

Project Work

Visit a nearby horticultural or agricultural research area and prepare a report by collecting data on the use of plant hormones, their uses and its benefits with the help of relevant experts.

Exercise

A. Choose the correct one and put the tick mark(√)

i. A gland having endocrine as well as exocrine function

a. Pituitary b. Thyroid
c. Pancreas d. adrenal

ii. Exophthalmic goiter is caused due to the overactivity of

a. thymus b. thyroid
c. parathyroid d. adrenal cortex

iii. What are the hormones that control the amount of sugar in the blood?

a. Thyroxine b. Parathyroid
c. Insulin d. Estrogen

iv. Which hormone works to ripen the fruit?

a. Ethylene b. Gibberlins
c. Cytokinin d. Auxin

v. Which hormone causes apical dominance?

a. Ethylene b. Gibberlins
c. Cytokinin d. Auxin

vi. Which gland is called Master gland?

a. Thyroid gland b. Tear gland
c. Pituitary gland d. Adrenal gland

vii. What are the hormones that develop and control masculinity?

a. Progesterone, b. Thyroxine
c. Testosterone d. Estrogen

viii. Which of these is true of the endocrine system?

a. secretes hormones that are transported to target cells by blood
b. causes changes in metabolic activities
c. effects are prolonged
d. All of above are true.

ix. **Name the gland that is located at the base of the throat, just inferior to the laryngeal prominence.**

a. Pituitary — b. Pineal gland

c. Hypothalamus — d. Thyroid

x. **What gland is located just superior to the kidneys?**

a. Pituitary — b. Adrenal

c. Pancreas — d. ovaries

xi. **How do hormones from the thyroid and parathyroid regulate the calcium concentration of the blood?**

a. Calcitonin lowers blood calcium; parathyroid hormone raises blood calcium.
b. Parathyroid hormone lowers blood calcium; calcitonin raises blood calcium.
c. Thyroxine and triiodothyronine together regulate calcium levels, as needs dictate.
d. Both parathroid hormone and the three thyroid hormones function to regulate blood calcium levels.

xii. **The secretions from which of these glands differs between males and females?**

a. Adrenal. — b. Parathyroid.

c. Gonadal. — d. Pancreas.

B. Name the following:

a. The hormone produced by adrenal medulla.
b. The condition caused by the over secretion of insulin.
c. The hormone secreted by beta cells of the islets of Langerhans.
d. The interconnection between the two lobes of thyroid gland (technical term).
e. The hormone whose under secretion causes more urine formation.
f. The hormone which stimulates the entire sympathetic nervous system.

C. Mention the name of diseases based on the clues/ symptoms given below:

a. Urine is loaded with sugar.
b. Swelling in the neck.
c. Dwarfism and mental retardation in children.
d. Eyes are protruded.
e. Excessive growth of bones in the face, hands and feet.

D. Write the main function of each of the following hormones.

Hormones	Functions
a. Thyroxine	....
b. Adrenaline	....
c. Insulin	....
d. Glucagon	....
e. Vasopressin	....

E. Complete the following table by filling in the blanks numbered 1 to 7.

Gland	Hormone secreted	Effect on body
(1) -----------	(2) -------	Regulates basal metabolism
Pancreas ("beta" cells)	(3) -------	Controls blood sugar
(4) ------------	(5) --------	Increases heart beat
(6) ------------	Thyroid stimulating hormone	(7) ------------

F. Give reasons to these statements.

a. Adrenaline is often described as the emergency hormone.

b. Pituitary is popularly called as the master gland.

c. People living in the low Himalayan hilly regions often suffer from goitre.

d. Simple goitre can be prevented by using iodised salt in food.

e. Hormones are called chemical agents.

f. Glucagon and insulin work against each other.

G. Differentiate between these pairs.

a. Exocrine and endocrine glands (manner of secretion)

b. Enzymes and hormones (chemical composition and mode of action)

c. Nervous control and hormonal control (transmission and effect)

d. Diabetes mellitus and diabetes insipidus (cause and symptoms)

H. Answer the following questions :

i. What is a gland? Present its type in the chart with examples.

ii. What would a child suffer from, if there was hypo secretion from his thyroid?

iii. Do you agree with the statement- "All hormones are chemical signals"? Yes/No. Justify your answer.

iv. Mention three important differences between the action of hormones and that of nerves in the regulatory mechanism of our body.

v. Compare the hormonal response with the nervous response with respect to their speed, transmission and general nature of changes brought about.

vi. What are plants hormones?

vii. Make a list of plant hormones.

viii. Define the following terms:

  a. Endocrine system

  b. Hormones

ix. Draw a picture showing the various endocrine glands found in the human body.

x. What is the effect on the body if more hormones are produced than required? Describe with examples.

I. Critical Thinking Questions :

i. If you stand to make your maiden speech before a large audience, your mouth dries up and heart rate increases. What brings about these changes?

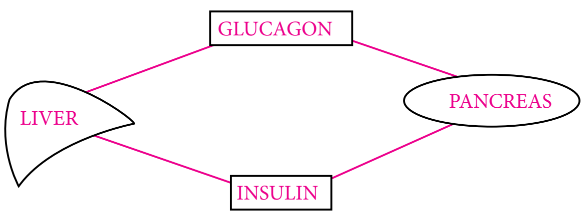
ii. The parents of a 14 year old Monika are concerned about her height because she is only 4 feet tall and they are both close to 6 feet tall. After tests by their doctor, certain hormones are prescribed for the girl. What hormones are prescribed and explain why the girl might expect to reach normal height?

iii. Dipika and her mother went out to eat at a resturant that had a self–serve soda fountain. During the evening Dipika drank 5 cokes. Later on she found herself visiting the restroom on a more than regular basis. Explain why she is experiencing excessive urination.

iv. Sabita has just been brought into the emergency rooms of Bir Hospital. She is perspiring profusely and is breathing rapidly and irregularly. Her breath smells like acetone (sweet and fruity) and her blood glucose test out at 650mg/100ml of blood. She is in acidosis. Normal blood glucose levels should be less than 140mg/100ml of blood. What hormone should be administered and why?

J. Diagrammatic Questions

i. Study the diagram given below and then answer the questions that follow:



a. Name the cells of the pancreas that produce (1) glucagon (2) insulin.

b. State the main function of (1) glucagon and (2) insulin.

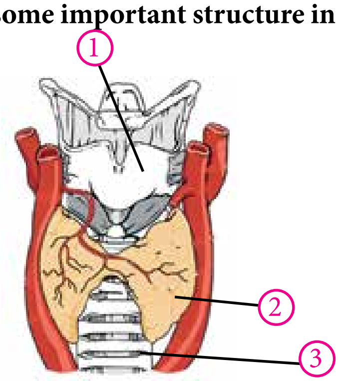
c. Why is the pancreas referred to as an exo-endocrine gland?

d. Why is insulin not given orally but is injected into the body?

e. What is the technical term for the cells of the pancreas that produce endocrine hormones?

f. Where in the body is the pancreas located?

ii. Given below is a portion from the human body showing some important structure in ventral (front) view.



a. Where is this portion located in the body?

b. Name the structures numbered 1-3.

c. State one main function of each of the structures named above.

d. Is there any duct to carry the secretions from the structure numbered 2? If so, give its name.

Unit 6 Nature and Environment

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- explain the interrelationship of biotic and abiotic factors in aquatic and terrestrial ecosystems.
- introduce food chain and food webs in ecosystems and demonstrate organism interdependence.
- describe the various types of interrelationships that exist between organisms in ecosystems.

The term **'ecosystem'** was first proposed in 1935 by the British ecologist **Sir Arthur George Tansley** (1871-1955). He was a pioneer in the science of ecology in Britain. He presented the notion that ecologists needed to consider 'the whole system', including both organisms and physical factors, and that these components could not be separated or viewed in isolation, by suggesting that ecosystems are dynamic, interacting systems.

Study the diagrams given below and then answer the questions that follow:

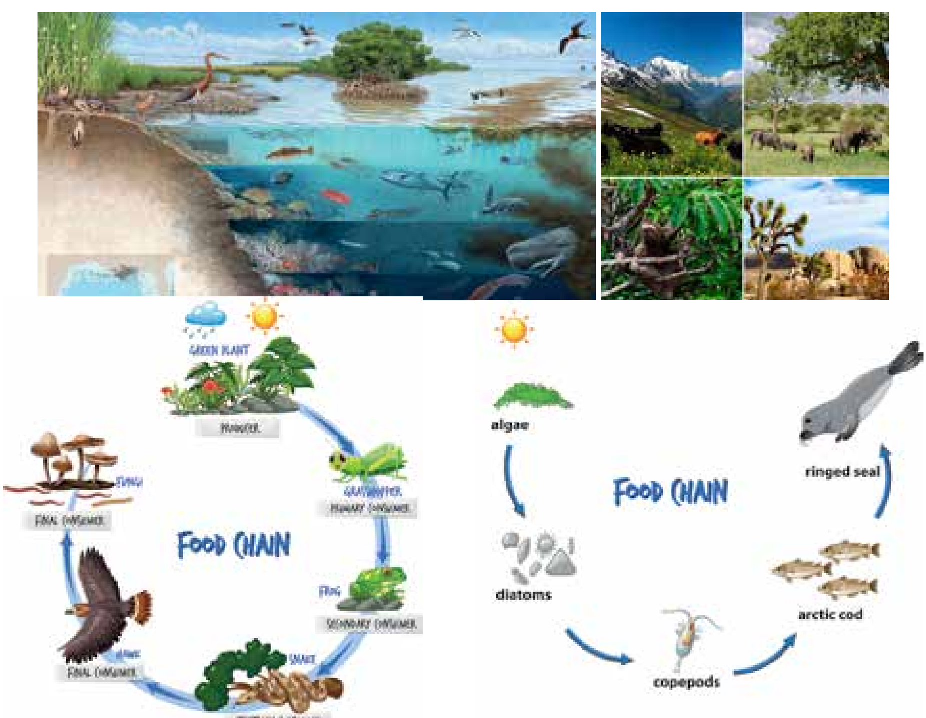


Fig. 6.1

a. What are the ecosystems of the places shown in the pictures?
b. Identify two of the four pictures above that are related to each other. What are the reasons for their association?
c. Make a list of biotic and abiotic factors in both of these ecosystems.
d. What is the difference between these two ecosystems?

6.1 Introduction

We all live in incredibly rich ecosystems, whether or not we're aware of the environmental diversity around us. Even in the largest cities you can find sparrows surviving on seeds, bees circling around flowers, and squirrels snacking on berries, all participating in the same network of energy, co-dependence, and survival.

Ecosystem, the complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space. An ecosystem can be categorized into its abiotic constituents, including minerals, climate, soil, water, sunlight, and all other nonliving elements, and its biotic constituents, consisting of all its living members. Linking these constituents together are two major forces: the flow of energy through the ecosystem and the cycling of nutrients within the ecosystem. Ecosystems vary in size: some are small enough to be contained within single water droplets while others are large enough to encompass entire landscapes and regions.

You should know all about ecology and how living things are adapted to their way of life. The questions you should ask yourself are :

a. What is ecology?
b. What are the major parts of an ecosystem?
c. How do organisms interact with each other and the non-living surroundings?
d. How are living things organized in the ecosystem?
e. How have living things adapted to their way of life?

6.1.1 Ecosystem

Various factors of physical world have direct or indirect effect on life of living beings. There exist deep relationship between various factors of physical environment and living beings. Substances like food, water, oxygen, carbon dioxide, minerals etc. are constantly obtained by living organisms from physical environment. If the factors of physical environment like air, light, temperature, soil etc. deteriorate, then it will have adverse effect. Living organisms present in environment depend on each other and they live in the same environment. This is known as **community**. There is continuous regulation of such interrelationship between complete ecosystem and physical environment. Eventually it forms ecosystem.

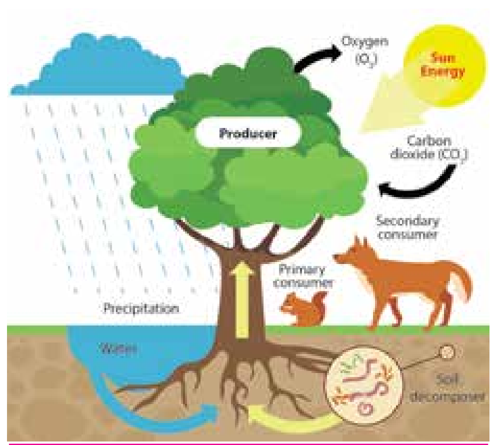


Fig. 6.2

The basic unit of study in ecology is an ecosystem. The ecosystem is the structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment. In other words, an ecosystem is a chain of interaction between organisms and their environment. Scientists use the term ecosystem to describe a particular environment and all the living things that are supported by it. It can also be described as a collection of living and non-living parts of the environment, which interact with each other to function as a whole. Other parts of the ecosystem are affected when one part of the ecosystem changes or does not function well. Another way of thinking of an ecosystem is all the biotic and abiotic factors in an area.

The particular place where an organism can be found is its distribution. For an organism to live in an area, all the resources it requires must be present. The relationships between living things and their surroundings are often complicated and the people who study them are called ecologists.

You should know all about how ecosystems work. The questions you should ask yourself are :

- How can we classify organisms according to the different roles they play in the ecosystem?
- Where do organisms get the energy to survive?
- How is energy transferred between organisms?
- How are materials being constantly reused?

Activity 6.1

Walk around the school grounds, or through a nearby garden or park, and make a list of all the different animals you see: birds, insects, mammals, lizards. What each animal eats and how it might be connected to other animals, to trees, and to humans. You think about how outdoor cats and dogs participate in the ecosystem too. Prepare a report and present in your classroom.

Structure of the Ecosystem

An ecosystem's structure mainly refers to the description of both biotic and abiotic components in their organization's environment. In particular, it involves the distribution of energy in the environment. Furthermore, it includes various climatic conditions prevailing in that specific environment. Both biotic and abiotic components are interconnected and form an open system in which energy is transferred from one particular component to another.

Ecology Community

How does the depth of a lake influence the complexity of the community living within it? Why do some places contain more species than others? Is there competition in nature?

Community ecology seeks to answer these and other questions about communities. An ecological community is a group of actually or potentially interacting species living in the same location. Communities are bound together by a shared environment and a network of influence each species has on the other.

Community ecology is an expanding and rich subfield of ecology. Ecologists investigate the factors that influence biodiversity, community

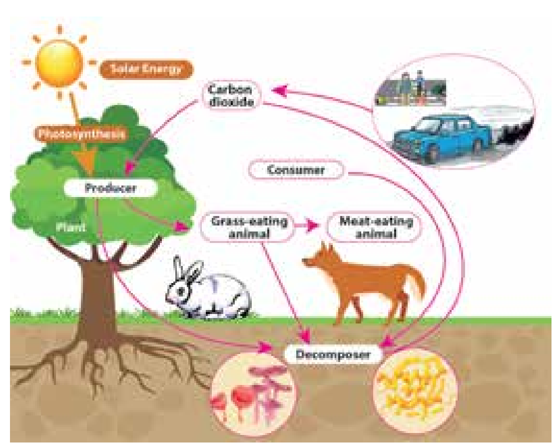


Fig. 6.3

structure, and the distribution and abundance of species. These factors include interactions with the abiotic world and the diverse array of interactions that occur between species. Species interactions, including competition, predation, herbivory, parasitism and mutualisms, are the basic for most of the research in community ecology. Questions of interest include: What are the feeding relationships among species? Who competes with whom and for what resources? Does the presence of some species benefit others?

Food webs are a graphical depiction of the interconnections among species based on feeding relationships, and are a core concept of the field. The role of keystone species in communities is another important tenet, and one of the best-known ideas in community ecology. Keystone species are those whose presence or absence profoundly affects other species in the community, disproportionately to its abundance.

The Functions of the Ecosystem

The ecosystem regulates the essential ecological processes, supports life systems and renders stability. It is also responsible for the cycling of nutrients between biotic and abiotic components. It maintains a balance among the various trophic levels in the ecosystem. It cycles the minerals through the biosphere. The abiotic components help in the synthesis of organic components that involves the exchange of energy.

Factors of Ecosystem

In ecology, biotic and abiotic factors encompass all the living and non-living parts of an ecosystem. Biotic factors pertain to living organisms and their relationships. Abiotic factors are the non-living components of the ecosystem, including sunlight, water, temperature, air, and nutrients.

Interactions between biotic and abiotic factors ripple through an ecosystem. Plants, for example, use sunlight, water, and carbon dioxide to produce energy and grow, releasing oxygen and—directly or indirectly—serving as a food source for other organisms. When they die, living organisms break back down into abiotic components. Changes in a biotic factor, such as a species population increase, or an abiotic factor, such as a decrease in precipitation, can therefore affect the entire ecosystem.

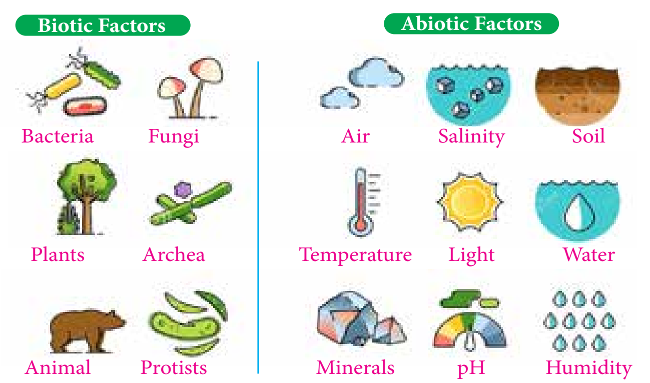


Fig. 6.4

Ecologists use biotic and abiotic factors to predict population changes and ecological events. By investigating how these factors interact, ecologists can gauge what is happening in an ecosystem over time. Ecologists may conduct population surveys to see whether the number or density of a given species is changing, how quickly it is changing, and why. By understanding the biotic and abiotic factors that impact the species, they can find explanations for population declines or increases. In addition, they may be able to predict ecological events like species die-offs, over-population, changes in growth rates, and disease outbreaks.

There are two main components of an ecosystem that are in constant communication with each other. They are the biotic factors and the abiotic factors.

Abiotic Factors

Abiotic factors come in all types and can vary among different ecosystems. For example, abiotic factors found in aquatic systems may be things like water depth, pH, sunlight, turbidity (amount of water cloudiness), salinity (salt concentration), available nutrients (nitrogen, phosphorous, etc.), and dissolved oxygen (amount of oxygen dissolved in the water). Abiotic variables found in terrestrial ecosystems can include things like rain, wind, temperature, altitude, soil, pollution, nutrients, pH, types of soil, and sunlight.

The boundaries of an individual abiotic factor can be just as unclear as the boundaries of an ecosystem. Climate is an abiotic factor - think about how many individual abiotic factors make up something as large as a climate. Natural disasters, such as earthquakes, volcanoes, and forest fires, are also abiotic factors. These types of abiotic factors certainly have drastic effects on the ecosystems they encounter.

A special type of abiotic factor is called a **limiting factor**. Limiting factors keep populations within an ecosystem at a certain level. They may also limit the types of organisms that inhabit that ecosystem. Food, shelter, water, and sunlight are just a few examples of limiting abiotic factors that limit the size of populations. In a desert environment, these resources are even scarcer, and only organisms that can tolerate such tough conditions survive there. Below is a list of some of the most significant abiotic factors.

Air

The layer of air surrounding earth is atmosphere. Various gases like Nitrogen, Oxygen, Carbon dioxide, Helium, Neon etc. are present in atmosphere. Water droplet and water vapor are also available in atmosphere. Plants prepare their own food by photosynthesis process. During photosynthesis process, plants take carbon dioxide gas and liberate oxygen gas. Human as well as other animals inhale oxygen and exhale carbon dioxide gas during respiration. Pollination in plants and transfer of seeds of plants are also assisted by air.

Wind is moving air. It increases the rate of water loss from the organisms, therefore affecting their distribution. Wind is also important in formation of rain. In deserts winds form sand dunes which can be habitats for other organisms. Wind causes wave formation in lakes and ocean, which enhance aeration of water in this water bodies. Trees in areas experiencing a strong winds may have stunted growth and distorted growth. Wind also disperses spores and seeds hence influence disposal and migration of flying animals.Wind wafts scent hence determines the positioning of hinting animals with respect to their prey in a habitat. A wind vane or windsock is used to determine the direction of prevailing wind.Anemoter is used to measure the speed of wind.

Solar energy

The sun is the main source of energy to all life on earth. It provide us light and heat, which is essential for living beings. Sunlight plays an essential role in most ecosystems. Green plants and photosynthetic bacteria need light to manufacture their food. Animals depend on plants for food. Light affects living things in terms of intensity, quality and duration. Some places have adequate solar energy while its availability is inadequate in some places. The major reason for unequal distribution is the geographical structure of earth. Due to this the climate of different places, rainfall, production of food etc. also differ. Thus, it results in diversity between plants and animals of different places.

And hence, light intensity and quality affects photosynthesis, flowering and germination of plants while in animals affects migration, hibernation and reproduction. A photographic light meter is used to measure light intensity while the seechi disc measures light penetration in water.

Water

Water is essential factor for life cycle of both plants and animals. It is necessary for building up of living being's life. Plants absorb water from land for photosynthesis process. Man including other birds and animals use water from river, lakes, ponds, springs, sea etc for their livelihood.

In terrestrial (land) ecosystems where water is scarce, such as deserts, organisms develop traits and behaviors that help them survive by harvesting and storing water efficiently. This can sometimes create a water source for other species as well. In ecosystems like rainforests where the abundance of water depletes soil nutrients, many plants have special traits that let them collect nutrients before water washes them away. Water also contains nutrients, gases, and food sources that aquatic and marine species depend on, and it facilitates movement and other life functions.

Soil

Soil is formed from small particles of rocks, minerals etc. Structure of soil varies from place to place. The color of soil varies from one place to another due to the presence of mineral particles. The quality of soil increases when degraded materials, rotten food and dead bodies get mixed into soil. Soil consist, of minerals, organic matters, organisms and chemical factors like Nitrogen, Potassium, phosphorous, Calcium etc. These factors are highly important for plants. Composed of both biotic and abiotic components, soil is an interesting case. Soil filters and stores water and anchors the roots of plants. It contains nutrient minerals and gases, as well as millions of microorganisms like bacteria, fungi, and single-celled organisms called archaea. These are important decomposers, the planet's indispensable recyclers. Disorder in the composition of soil has direct and adverse effect on plants and animals.

Temperature

Biochemical processes of most organisms function effectively within a narrow range of temperature. Temperature varies due to seasons, altitude, latitude and also diurnally especially in hot deserts. This therefore affects the distribution of organisms in a habitat. Temperature variations influence the distribution of organisms more in terrestrial habitats than aquatic habitats. Living organisms must develop necessary physiological and behavioral adaptations to cope with extremes of temperatures.

Humidity

It refers to the amount of water vapour in the atmosphere. When humidity is high there is much water vapour and vice versa. Humidity affects the rate at which water evaporates from the surface of organisms such as in transpiration or sweating. This in turn affects their distribution on earth. Paper Hydrometer is used to measure a wet and dry bulb hydrometer.

Salinity

It refers to the salt concentration of water, causing a division of the aquatic environment into marine, estuarine and fresh water. Saline conditions immediately outside the body of organism pose the problem of water loss from the body to the environment. Only animals with suitable osmoregulation adaptations can occupy such habitats.Salinity can be determined by calculating percentage of of salts on water or by the acid-base titration method.

p^H (Hydrogen ion Concentration)

pH is is the measure of how acidic or alkaline water is in aquatic animals or soil solution. It influences the distribution of plants and animals in soil and fresh water ponds. Some plants drive well in acidic conditions while others in alkaline conditions. The pH of a soil can be altered by leaching fertilizers' applied or soil exhaustion.

Nutrients

Soil and water contain inorganic nutrients that organisms require to eat and grow. For example, minerals like phosphorous, potassium, and nitrogen found in soil are important for plant growth. Water contains many dissolved nutrients, and soil runoff can carry nutrients to aquatic and marine environments.

Biotic Factors

All living organisms are biotic factors. Living components of environment are interrelated and interconnected with each other. Biotic factors refer to ecosystem which include producers, consumers and decomposers. On the basis of flow of energy, biotic factors are classified as follows:–

Producers

Most producers use the sun's energy along with water and carbon dioxide in a process called photosynthesis. This results in energy that producers can feed on. In fact, producers are also called autotrophs, because they feed themselves. Plants with green pigments are producers. Autotrophs make use of abiotic factors to produce their own food.

Consumers

Most consumers are animals, and they do not make their own food. Instead, they consume producers or other consumers to obtain food energy. That's why consumers are also known as heterotrophs, because they obtain their nourishment from species other than themselves. On the basis of nutrition, consumers are categorized into primary, secondary, tertiary and quaternary

i. **Primary consumers:** The primary consumers are the consumers or the organisms that eat producers i.e. who make their own food. They are the next link in the food chain primary consumers, called herbivores can be as small as a grasshopper or as large as an elephant. Example of primary consumers are cow, buffalo, deer, goat, rabbit, squirrel, beetles etc. Similarly, herbivores of the aqutic ecosystem are crustaceans, tadpoles, mollus and protozoans. They feed on floating algae and phytoplanktons.

ii. **Secondary consumer:** The secondary consumer or the organisms that feed on the herbivores. These animals are carnivores or meat eaters. For example: larva of mosquitos, small fish, frog, sparrow, crow, dog etc feed on herbivores animals.

iii. **Tertiary consumers:** Living beings which depend upon primary and secondary consumers for food are known as tertiary consumers. Animals like primary and secondary consumers are carnivores while some of them are omnivores. Examples: snake, seal, jellyfish, turtles, sharks, whales, crocodiles etc.

iv. **Quaternary consumers:** Quaternary consumers are often top predators within the environment, and they eat the tertiary consumers. Examples of quaternary consumers include lions,tigers,wolves, polar bears, humans, eagles and hawks. Organisms may operate under different roles, such as a bear that eats fish but also berries.

Note : Man is both primary and quaternary consumer because a man eats plants like herbivorous and also eats animals like carnivorous.

Decomposers

Decomposers are the organisms that break down organic matter from dead plants and animals into the inorganic components, like carbon and nitrogen, that are necessary for life. The inorganic matter then returns to the soil and water as nutrients that can be used by producers anew, continuing the cycle. Decomposers are also called saprotrophs: from the Greek "saprós," or rotten, because they feed on rotting organic matter. Examples of decomposers include bacteria, fungi, earthworms, and some insects.

Decomposers, as well as scavengers, are the important part of the food cycle involved in the ecological recycling of nutrients and organic matter. However, the two-class of organisms differ in their mechanism of work. Essentially, scavengers are the initiators of the process of decomposition which is eventually taken over by the decomposers.

Factors Affecting Ecosystem

Directly or indirectly factors of ecosystem is depend on each other for their existence.

Availability of Food : It is considered to be the limiting factor. When there is a shortage of food, animals will die due to starvation. For eg: when the herbivores die, carnivores will also die due to starvation. The whole ecosystem will be disturbed.

Presence of Predator : In an ecosystem, to maintain balance, there must be a balance between prey and predator. When there is an increased number of predators but prey is few, in such condition, the prey will disappear. Suppose in a grassland, if the number of the cattle are more but grassland is few or suppose is deer are few in number/are less in number but tigers are more in number, then in such condition, grassland and deer will eventually disappear.

Presence of Parasites : Parasites are those organisms that harbor or live in other living organisms like plants and animals for their existence. We can take an example of the ectoparasites like lice which are normally present in the untidy hair of children. Endoparasites like roundworms, hookworms live in the intestine. Parasites obtain nutrition from the host. For eg, hookworm results in anemia as it causes the loss of blood. When parasites lodges inside the host, use the nutrition of the host and it will result in illness.

Competition between the species :

It's the law of nature, for their survival and existence, animals need to compete with each other. Only those species which has the capacity to obtain food will survive, they will adapt in nature whereas others will eventually die. Back to the theories of evolution, it suggested short neck giraffes got disappeared whereas only the long-necked giraffes existed, it's because of access to food.

Similarly, in our human body too, there is the presence of normal flora. Not all bacteria are harmful. Some good bacteria are also present in our body whose presence prevent the colonization of the pathogens. Such harmful organisms won't get access to our bodies.

There is always competition between the organism either it's about the microorganisms or the other animals.

All the biotic factors can't function solely. Directly or indirectly they are dependent upon one another. All the biotic factors are influenced or affected by the abiotic factor. As a result, their coordination, shape the ecosystem.

Types of Ecosystem

There are different types of ecosystems based on different climates, habitats, and life forms. This means that ecosystems can typically be divided into hundreds and thousands of smaller systems. However, all such types generally fall into one of the following two categories:

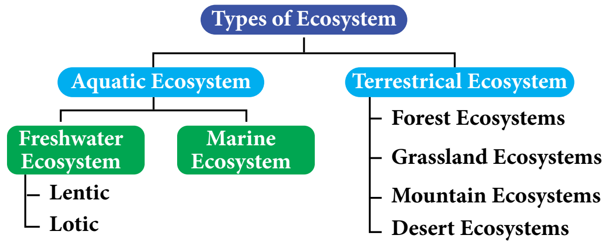


Fig. 6.5

a. Aquatic Ecosystem
b. Terrestrial Ecosystem

A. Terrestrial Ecosystem

Terrestrial ecosystem is a dominant ecosystem of landforms. Major terrestrial ecosystem are in specific biome and are found and found in tundra, taiga, temperate deciduous forest, tropical rainforest, grassland and desert. Terrestrial ecosystem is different from aquatic ecosystem with lower water availability. It comprises a community of organism and their environment that occurs on the landmasses of continents and islands.There are variations in composition and geographical variation in terrestrial communities. Terrestrial ecosystem occupy $(144,150,000 \text{ km})^2$ or 28% of earth's surface. First terrestrial ecosystem appeared some 425m years ago. Terrestrial ecosystem have been major site of adaptive radiation of both plants and animals. Various biotic and abiotic elements on land can be looked upon as different ecosystems based on difference in climate, natural vegetation and animal life.

Grassland ecosystem

Grassland occupy roughly 19% of the earth's surface. Grasslands occur in interior parts of the continents. As there is no leaching, soil is fertile. Grassland can be home to migrating animals (such as buffalo) as well as to birds, predators, insects and humans. Grassland may be found all over the world and it may change vastly with the seasons or stay much the same throughout the year.

Grasslands cover areas where rainfall is usually low and/or the soil depth and quality is poor. The low rainfall prevents the growth of a large number of trees and shrubs, but is sufficient to support the growth of grass cover during the monsoon. Many of the grasses and other small herbs become dry and the part above the ground dies during the summer months. In the next monsoon the grass cover grows back from the root stock and the seeds of the previous year. This change gives grasslands a highly seasonal appearance with periods of increased growth followed by a dormant phase. A variety of grasses, herbs, and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grass covered areas. These animals are able to live in conditions where food is plentiful after the rains, so that they can store this as fat that they use during the dry period when there is very little to eat. Man began to use these grasslands as pastures to feed his livestock when he began to domesticate animals and became a pastoralist in ancient times.

Grasslands are the grazing areas of many rural communities. Farmers who keep cattle or goats, as well as shepherds who keep sheep, are highly dependent on grasslands. Domestic animals are grazed in the 'common' land of the village. Fodder is collected and stored to feed cattle when there is no grass left for them to graze in summer. Grass is also used to thatch houses and farm sheds. The thorny bushes and branches of the few trees that are seen in grasslands are used as a major source of fuelwood. Overgrazing by huge herds of domestic livestock has degraded many grasslands. Grasslands have diverse species of insects that pollinate crops. There are also predators of these insects such as the small mammals like shrews, reptiles like lizards, birds of prey, and amphibia such as frogs and toads. All these carnivorous animals help to control insect pests in adjoining agricultural lands. What are the threats to grassland ecosys- What are the threats to grassland ecosystems?

I. Abiotic Factor

The abiotic components of a grassland ecosystem are the non-living features of the ecosystem that the living organisms depend on. Each abiotic component influences the number and variety of plants that grow in an ecosystem, which in turn has an influence on the variety of animals that live there. The four major abiotic components are: climate, parent material and soil, topography and natural disturbances.

Climate

Climate includes the rainfall, temperature and wind patterns that occur in an area, and is the most important abiotic component of a grassland ecosystem. Temperature, in tandem with precipitation, determines whether grasslands, forests, or some combination of these two, form. The amount and distribution of the rainfall an area receives in a year influences the types and productivity of grassland plants. The climate in our grassland ecosystems is usually hot and dry in the spring and summer growing season, and cool or cold in winter dormant season. Precipitation in the winter falls mostly as snow rather than rain. During the hottest months of the year (the height of summer) more water evaporates from parts of the grasslands than falls as rain, creating a moisture deficit.

Parent Material And Soil

Parent material is the geological material that lies on top of the bedrock and is the foundation on which soil has developed. Soil develops in the upper portion of the parent material and is a mixture of abiotic and biotic components: minerals, organic matter, water and air. The type of parent material in a particular area influences the texture of the soil, how well water flows through it, and hence the chemistry and nutrients of the soil. This combination of texture, water flow and chemistry determines the vegetation that grows in the area.

Grasslands have a rich layer of organic matter that forms the top surface of the soil. This layer has developed largely as a result of the breakdown of plant roots. Roots form as much as half the volume of a grass plant and up to 50% are replaced every year.

Topography

Topography is the variety of shapes found on the landscape determined by slopes, elevation and aspects. The topography of grassland ecosystems is a varied landscape of gently rolling hills and prairies, rock outcrops, cliffs, gullies, and low lying areas. Diverse topography is what gives incredible variety to grassland ecosystems. Aspect refers to the direction in which a piece of land is facing. Areas that face towards the south, or the sun, are hotter and drier than areas that face north, or away from the sun. The slope of an area is the angle at which the land lies. Slope is important in our grasslands as water may run downhill rather than soak into the ground where it is available for plants. An area that slopes with a southern aspect will be much drier and hotter than an area that slopes with a northern aspect. Elevation describes the height of land above sea level. Temperatures are generally cooler and rainfall is higher as elevation is gained.

Natural Disturbance

Natural disturbances change grasslands in many ways, adding to the diversity of these ecosystems. Some types of disturbance, such as annual flooding of riparian areas along rivers and streams, can be predicted while others, such as a fire after a lightning storm, happen unexpectedly. Flooding occurs every spring in the riparian areas along the large rivers and lakes in the grassland areas of the province. The water comes from melting snow in the surrounding hills and mountains. The amount of water that flows down from the mountains and hills may rise very suddenly if – the snow is deeper than normal, high temperatures cause the snow to melt very fast and there are heavy rainfalls on the snow. The flooding waters can alter stream and river banks and move soil, broken trees and shrubs downstream.

II. Biotic Factors

Green plants and living creatures found in grassland are biotic factors. Biotic factors of grassland ecosystem include following sub-component :

a. Producer

All green plants can produce their own food with the help of water, carbon dioxide, solar energy. Therefore, all green plants are called producers. They are also called autotrophs. Grass and other plants of grassland are examples of producer.

b. Consumer

They are organisms which consume other organisms or their products as their food. All animals belong to this category. The consumers depend upon producers for their food directly or indirectly. They get their food by eating other organisms or their products. For example, man, goat, deer, fish, lion, cow, buffalo, etc., are common consumers.

The consumers can be classified into the following types :

Primary consumer

These are organisms (animals) which get their food by eating the producers (or plant) directly. The primary consumers are also known as herbivores. They are also called first order consumers. Some common examples of herbivores are : earthworm, insects, deer, rabbit, cows, buffaloes, rat, squirrel, goat, cattle, monkey etc. **which feed on green plants in order to survive.**

Secondary consumer

These are organisms (animals) which consume other animals. They are also called carnivores. Carnivores feed on the flesh of herbivores. Some common examples are snakes, foxes, wild cats, jackals, frogs, some birds, fishes, etc.

Tertiary consumer

Voltures, hawks, eagles etc. constitute the tertiary consumer in the grassland ecosystem which preys upon the secondary and primary consumer.

Decomposer

After the death of producers and consumers, microorganisms like bacteria and fungi decompose their dead bodies and mix into soil. Green plants again absorb the nutrients from soil. Thus, close interrelationship between biotic and abiotic factors is maintained in grassland and the ecosystem is continued.

Functions of the Grassland Ecosystem

The functional aspects of the Grassland can be studied by two means:

i. **Food Chain in an ecosystem:** There is an important feature of the ecosystem that one level of an organism serves as food for another level of the organism. A series is formed which is known as Food Chain. In an ecosystem, the food chain does not follow the linear pattern, but an organism may feed upon more than one organism in the same food chain or upon organisms of different food chains. Thus interconnected food chain system is formed known as a food web.

ii. **Nutrient cycle in an ecosystem:**For any ecosystem to be successful, it is important that the constituent materials move in a cyclic manner. The producers (green plant) takes up the mineral elements from the soil and air, convert them into organic form and after passing through the different trophic levels, are again returned to the soil and air.

Economic Importance of Grassland Ecosystem

Grasslands biomes are important to maintain the crop of many domesticated and wild herbivores such as horse, mule, ass, cow, pig, sheep, goat, buffalo, camel, deer, zebra etc. which provides food, milk, wool and transportation to man. Hence, we can say that the Grassland Ecosystem is a mixture of grass, clover and other leguminous species, dicotyledonous, herbs and shrubs which contribute to a high degree of the preservation.

B. Aquatic Ecosystem

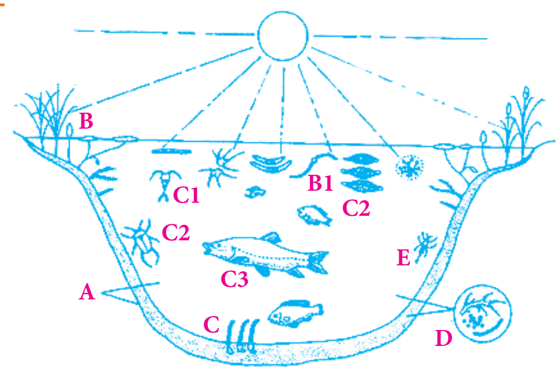
The aquatic ecosystems constitute the marine environments of the seas and the fresh water systems in lakes, rivers, ponds and wetlands. These ecosystems provide human beings with a wealth of natural resources. They provide goods that people collect for food such as fish and crustaceans. Natural aquatic systems such as rivers and seas break down chemical and organic wastes created by man. However, this function has limitations, as the aquatic ecosystem cannot handle great quantities of waste. Beyond a certain limit, pollution destroys this natural function. If aquatic ecosystems are misused or over utilized, their ability to provide resources suffers in the long term. Over-fishing leads to a fall in the fish catch. River courses that are changed by dams to provide electricity affect thousands of people who do not get a continuous supply of water downstream for their daily use. When wetlands are drained, their connected rivers tend to cause floods. These are all examples of unsustainable changes in the use of natural resources and nature's ecosystems that are dependent on hydrological regimes. Water is an important factor in all our ecosystems. Several ecosystems exist in freshwater and marine salt water. There is very little fresh water on earth, which is a key resource for people all over the world.

In aquatic ecosystems, plants and animals live in water. These species are adapted to live in different types of aquatic habitats. The special abiotic features are its physical aspects such as the quality of the water, which includes its clarity, salinity, oxygen content and rate of flow. The mud gravel or rocks that form the bed of the aquatic ecosystem alter its characteristics and influence its plant and animal species composition.

Examples of aquatic ecosystem include oceans, lakes and rivers. An aquatic ecosystem includes freshwater habitats like lakes, ponds, rivers, oceans and streams, wetlands, swamp, etc. and marine habitats include oceans, intertidal zone, reefs, seabed and so on.

Pond Ecosystem

The pond is the simplest aquatic ecosystem to observe. There are differences in a pond that is temporary and has water only in the monsoon, and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by terrestrial plants for the rest of the year. When a pond begins to fill during the rains, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they have remained dormant in the dry phase. Gradually more complex animals such as crabs, frogs and fish return to the pond. The vegetation in the water consists of floating weeds and rooted vegetation on the periphery which grow on the muddy floor under water and emerge out of the surface of the water. As the pond fills in the monsoon a large number of food chains are formed. Algae is eaten by microscopic animals, which are in turn eaten by small fish on which larger carnivorous fish depend. These are in turn eaten by birds such as kingfishers, herons and birds of prey. Aquatic insects, worms and snails feed on the waste material excreted by animals and the dead or decaying plant and animal matter. They act on the detritus, which is broken down into nutrients which aquatic plants can absorb, thus completing the nutrient cycle in the pond. The temporary ponds begin to dry after the rains and the surrounding grasses and terrestrial plants spread into the moist mud that is exposed. Animals such as frogs, snails and worms remain dormant in the mud, awaiting the next monsoon.



Pond Ecosystem

A- Abiotic component; B and B1 - Producers; C1- Primary consumers (herbivores); C2- Secondary consumer; C3- Teniary consumers; D- Decomposers- saprophytic bacteria and fungi.

Fig. 6.6

Ponds get their energy from the sun. As with other ecosystems, plants are the primary producers. The chlorophyll in aquatic plants captures energy from the sun to convert carbon dioxide and water to organic compounds and oxygen through the process of photosynthesis. Nitrogen and phosphorus are important nutrients for plants. The addition of these substances may increase primary productivity. However, too many nutrients can cause algal blooms, leading to eutrophication

a. Abiotic Factor

Abiotic environmental factors of a pond's ecosystem include **temperature**, flow, and salinity. The pollutants, nutrients, and pH of soil are also critical abiotic factors in a pond ecosystem. The percentage of dissolved oxygen levels in a water body determines what kind of organisms and fish grow there. A pond ecosystem consists of dissolved inorganic (CO_2, O_2, Ca,

Fig. 6.7

N, Phosphate) and organic substances (amino acids and humic acid) formed from the dead organic matter.

- **Environmental factors:** light, temperature, water
- **The edaphic factors:** Soil
- **Inorganic Components :** O_2, CO_2, N_2, nitrates, phosphates, carbonates etc.
- **Organic components :** carbohydrates, proteins, amino acids, fats, nucleic acids

b. Biotic Factor

Producers

The main producers in pond or lake ecosystem are algae and other aquatic plants, such as Azolla, Hydrilla, Potamogeton, Pistia, Wolffia, Lemna, Eichhornia, Nymphaea, Jussiaea, etc. These are either floating or suspended or rooted at the bottom. The green plants convert the radiant energy into chemical energy through photosynthesis. The chemical energy stored in the form of food is utilized by all the organisms. Oxygen evolved by producers in photosynthesis is utilized by all the living organisms in respiration.

Fig. 6.8

i. **Phytoplankton,** literally 'wandering plants,' are microscopic algae that float in the open water and give it a green appearance. They carry out photosynthesis using carbon dioxide that is dissolved in the water and release oxygen that is used by the bacteria and animals in the pond. Phytoplankton are not actually plants-they are protists.

ii. **Periphytic algae** are microscopic algae that attach themselves to substrates and give the rocks and sticks a greenish brown slimy appearance. They also carry out photosynthesis and produce oxygen, often near the bottom of the pond where it can be used by decomposers.

iii. **Submerged plants** grow completely under water

iv. **Floating plants** include plants that float on the surface and plants that are rooted on the bottom of the pond but have leaves and/or stems that float.

v. **Emergent plants** are rooted in shallow water but their stems and leaves are above water most of the time.

vi. **Shore plants** grow in wet soil at the edge of the pond.

Consumers

In a pond ecosystem, the primary consumers are tadpole larvae of frogs, fishes and other aquatic animals which consume green plants and algae as their food. These herbivorous aquatic animals are the food of secondary consumers. Frogs, big fishes, water snakes, crabs are secondary consumers. In the pond, besides the secondary consumers, there are consumers of highest order, such as water-birds, turtles, etc..

Fig. 6.9

i. **Zooplankton** are microscopic animals that eat phytoplankton or smaller zooplankton. Some are single-celled animals, tiny crustaceans, or tiny immature stages of larger animals. Zooplankton float about in the open water portions of the pond and are important food for some animals.

ii. **Invertebrates** include all animals without backbones. Macroinvertebrates are big enough to be seen with the naked eye. Some of them are only found in clean water.

iii. **Vertebrates** are animals with backbones. In a pond these might include fish, frogs, salamanders, and turtles.

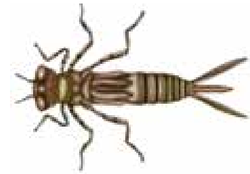


Fig. 6.10

Decomposers

Animal waste and dead and decaying plants and animals form **detritus** on the bottom of the pond. **Decomposers**, also known as **detritovores**, are bacteria and other organisms that break down detritus into material that can be used by primary producers, thus returning the detritus to the ecosystem. As this material decomposes it can serve as a food resource for microbes and invertebrates. During decay microbes living on detritus can pull nutrients from the overlying water thus acting to improve water quality. In the process of breaking down detritus, decomposers produce water and carbon dioxide.

Fig. 6.11

Activity 6.2

Observe the terrestrial and aquatic ecosystems around the school. Make a list of the biotic and abiotic factors that are there. Now explore their interrelationships and present them in the classroom.

Activity 6.3

Make a group of friends you like. The group sampled aquatic and terrestrial ecosystems and presented them in the classroom.

6.2 Food Chain

Plants and animals in the ecosystem depend on each other for their nutritional needs. In this system, when one organism eats another organism, the energy is transferred to the other organism. It forms the layer of a food chain. Such a layer is transferred from producer to consumer. In plants, solar energy is a constant force. Therefore, plants are the primary source for all kinds of animals, which is called the first trophic level. The **first**

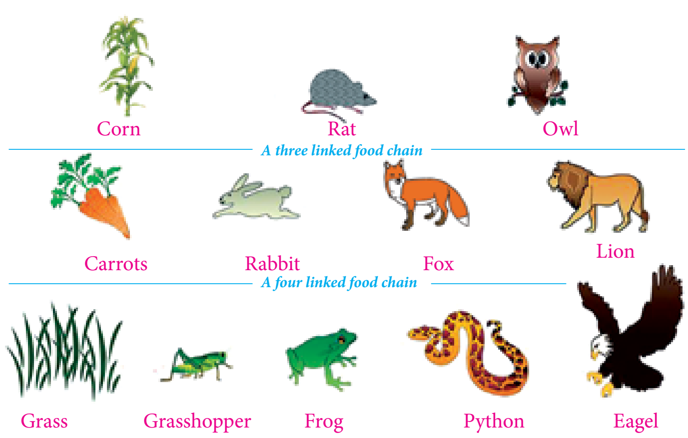


Fig. 6.12

trophic level is composed of algae and plants. Organisms on this level are called producers, as they make their own food by using photosynthesis to convert light energy into chemical energy. These organisms are known as autotrophs. Examples include seaweed, trees, and various plants. The **second trophic level** is composed of herbivores: animals that eat plants. They are considered primary consumers, since they are the first to eat the producers that make their own food. Examples of herbivores include cows, deer, sheep, and rabbits, all of which consume a variety of plant material. The **third trophic level** is composed of carnivores and omnivores. Carnivores are animals that eat other animals, while omnivores are animals that eat other animals *and* plants. This group is considered secondary consumers, since they eat the animals that eat the producers. Examples include snakes and bears.The **fourth tropic level** is also composed of carnivores and omnivores. Unlike the third level, however, these are animals that eat other carnivores. Therefore, they are known as tertiary consumers. Eagles are tertiary consumers.The **fifth trophic level** is composed of apex predators. These are animals that do not have natural predators and are thus at the top of the trophic pyramid. Lions and leopard are apex predators.When organisms die, other organisms called **decomposers** consume them and break them down so that the cycle of energy continues. Fungi and bacteria are examples of decomposers. Organisms called **detrivores** also contribute to this energy cycle. Detrivores are organisms that consume dead organic material. Examples of detrivores include vultures and worms.

The accompanying picture shows the relationship between third level, fourth level and fifth level producers and consumers in the land ecosystem, where maize, carrot and grass are producers. Producers are in the first level. Mouse, rabbit and grasshopper, which feed on the producers, are the first consumers and they form the second layer of nutrition. Owl, fox, frog, etc. eat producer and live. They make up the third layer of nutrition.

In the same way, the organism that feeds on the second consumer forms the third layer of nutrition. At the same time, the level of nutrition is increasing. Eventually, after the producer and consumer die, the disintegrator decomposes them and mixes them into the soil. Plants absorb from the soil and convert it into energy. The process of transferring energy in the same direction from producer to top consumer by eating others and being eaten by others is called **food chain.**

Fig. 6.13

Activity 6.4

Make a group of friends and visit nearby field. Prepare a short note based on observation and study of producer, primary consumer, secondary consumer and decomposer of that ecosystem.

6.2.1 Food Web

Food web is a network of food chains where all the chains are naturally interconnected. Each organism is generally eaten by two or more kinds or organisms which are again eaten by several other organisms and so instead of straight line food chain, the series of organisms dependent on one another food can be shown by branched lines which is called as a **food web**.

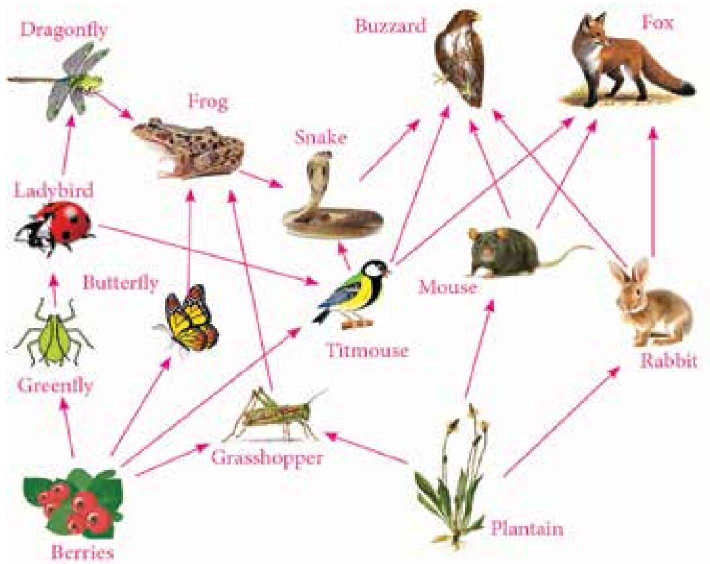


Fig. 6.14

Flow of energy in a food chain is unidirectional, once it reaches the next tropic level it does not come back again. For example- energy which passes to the herbivores does not come back again to autotrophs. The inter-connected food chains operating in an ecosystem which establish a network of relationship between various species, are a food web. In a food web, one organism may occupy a position in more than one food chain. An organism can obtain its food from different sources and in turn, may be eaten up by different types of organisms.

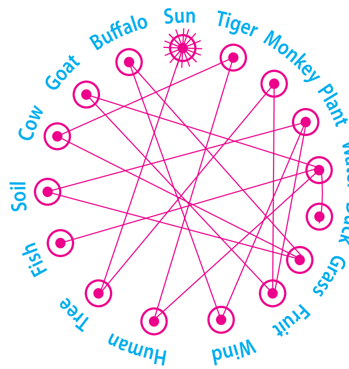
According to the picture, grass, birds and eagles are third level food chain, while grass, grasshopper, frog, snake and hawk are fifth level food chain. In this way, a large number of food chains come together to form a food web in which, insects survive by eating grass. They are eaten by birds. They are also eaten by frogs. In this way, many organisms in the same animal become increasingly dependent on food. And becomes a complex web. The process of transferring energy in a multi-directional way from the producer to the higher level consumers by eating others and being eaten by others in the ecosystem is called food web.

Food Chain and Food Web Difference Tabular form

Food chain	Food Web
A feeding hierarchy in which organisms in an ecosystem are grouped into trophic levels and are shown in a succession to represent a linear flow of food energy and the feeding relationships between them	A graphical model showing the interconnection food chains in an ecological community
A single unit	A collection of several interconnected food chains
May consist of 4-6 trophic levels	Consists of numerous trophic levels
A member of a higher trophic level can only feed upon a single type of organism in its lower trophic level	A member of a higher trophic level can feed upon several types of organisms in its lower trophic level
A disturbance on a single trophic level/organism disturbs the whole food	A disturbance on a sigle organism does not disturb the whole food web
Increases the instability of an ecosystem	Increases the stability of an ecosystem
Does not improve the adaptability and competitiveness of organisms	Improves the adaptability and competitiveness of organisms

Activity 6.5

Web of Life related games



Place : Ground of school

Materials : Threads, cards (of the sun, water, soil, wind, plants, animals), pins or clips

- All of the participants are seated in a circle.
- At a time a participants takes one card (sun, soil, water, wind, etc.).
- everyone will be able to see the picture of their card if they pin it.
- Being passing the sun's ball of thread to other using your fingure, wrap a twist of thread around it.
- Giving thread from the sun to a natural object (plant).
- Similarly, water from plants, fish from water, thus making a web when the threads from all sides are connected with each other.
- All participants raise their hands and stretch threads and show the shape of the web.
- All participants should keep their threads tight.

Discuss :

i. What is the interrelationship of different factors?

ii. What are the effects and benefits of stretching all the threads in the ecosystem formed by the interrelationship of these factors?

iii. What happens when the water is separated from the web and pressed as before?

iv. What happens when an object is deficient in an ecosystem?

6.3 Interaction Beetween Living Beings

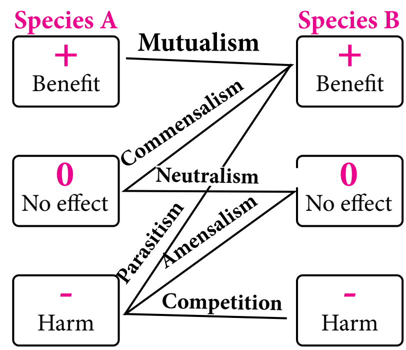


Fig. 6.15

Can you think of any natural habitat on earth that is inhabited just by a single species? There is no such habitat and such a situation is even inconceivable. For any species, the minimal requirement is one more species on which it can feed. Even a plant species, which makes its own food, cannot survive alone; it needs soil microbes to break down the organic matter in soil and return the inorganic nutrients for absorption. And then, how will the plant manage pollination without an animal agent? It is obvious that in nature, animals, plants and microbes do not and cannot live in isolation but interact in various ways to form a biological community. Even in minimal communities, many interactive linkages exist, although all may not be readily apparent. Interspecific interactions arise from the interaction of populations of two different species. They could be beneficial, detrimental or neutral (neither harm nor benefit) to one of the species or both. Assigning a '+' sign for beneficial interaction, '-' sign for detrimental and 0 for neutral interaction. Let us look at all the possible outcomes of interspecific interactions is detrimental to the other species (host and prey, respectively). The interaction where one species is benefitted and the other is neither benefitted nor harmed is called commensalism. In amensalism on the other hand one species is harmed whereas the other is unaffected. Predation, parasitism and commensalism share a common characteristic– the interacting species live closely together.

Let's look at some examples- birds sit on the body of the animal and eat the insects in the ears of their. Similarly, lichens in tree bark where algae find shelter from fungus. There the fungus gets food from the algae. In this way, there are various types of interrelationships and interactions between living things. Organisms interact in a variety of ways to conduct their life processes. There are various types of interactions. The main interactions are as follows:

a. Symbiosis/Mutualism
b. Commensalism
c. Parasitism
d. Competition
e. Predation

Activity 6.6

Fullfil the table:

S.N.	Name of animal/plants	Shelter	Nature	Interaction between living beings
1	Tick			
2	Hook worm			
3	Tapeworm			
4.	Bugs			
6.	Lichen found in tree bark			
7.	Mosquitoes			
8.	Clownfish			
9.	Head lice	Human hair	obligate outer parasites	they cannot survive without a human host.
10.	Barnacles			

a. Mutualism

Fig. 6.16

This interaction confers benefits on both the interacting species. Lichens represent an intimate mutualistic relationship between a fungus and photosynthesising algae or cyanobacteria. Similarly, the mycorrhizae are associations between fungi and the roots of higher plants. The fungi help the plant in the absorption of essential nutrients from the soil while the plant in turn provides the fungi with energy-yielding carbohydrates. The most spectacular and evolutionarily fascinating examples of mutualism are found in plant-animal relationships. Plants need the help of animals for pollinating their flowers and dispersing their seeds. Animals obviously have to be paid 'fees' for the services that plants expect from them. Plants offer rewards or fees in the form of pollen and nectar for pollinators and juicy and nutritious fruits for seed dispersers. But the mutually beneficial system should also be safeguarded against 'cheaters', for example, animals that try to steal nectar without aiding in pollination. Now you can see why plant-animal interactions often involve co-evolution of the mutualists, that is, the evolutions of the flower and its pollinator species are tightly linked with one another. In many species of fig trees, there is a tight one-to-one relationship with the pollinator species of wasp. It means that a given fig species can be pollinated only by its 'partner' wasp species and no other species. The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds within the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae. Orchids show a bewildering diversity of floral patterns many of which have evolved to attract the right pollinator insect (bees and bumblebees) and ensure guaranteed pollination by it. Not all orchids offer rewards. The Mediterranean orchid Ophrys employs 'sexual deceit' to get pollination done by a species of bee. One petal of its flower bears an uncanny resemblance to the female of the bee in size, colour and markings. The male bee is attracted to what it perceives as a female, 'pseudocopulates' with the flower, and during that process is dusted with pollen from the flower. When this same bee 'pseudocopulates' with another flower, it transfers pollen to it and thus, pollinates the flower. Here you can see how co-evolution operates. If the female bee's colour patterns change even slightly for any reason during evolution, pollination success will be reduced unless the orchid flower co-evolves to maintain the resemblance of its petal to the female bee.

b. Commensalism:

This is the interaction in which one species benefits and the other is neither harmed nor benefited. An orchid growing as an epiphyte on a mango branch, and barnacles growing on the back of a whale benefit while neither the mango tree nor the whale derives any apparent benefit. The cattle egret and grazing cattle in close association, a sight you are most likely to catch if you live in farmed rural areas, is a classic example of commensalism. The egrets always forage close to where the cattle are grazing because the cattle, as they move, stir up and flush out insects from the vegetation that otherwise might be difficult for the egrets to find and catch. Another example of commensalism is the interaction between **sea anemone** that has stinging **tentacles** and the clown fish that lives among them. The fish gets protection from predators which stay away from the stinging tentacles. The anemone does not appear to derive any benefit by hosting the clown fish.

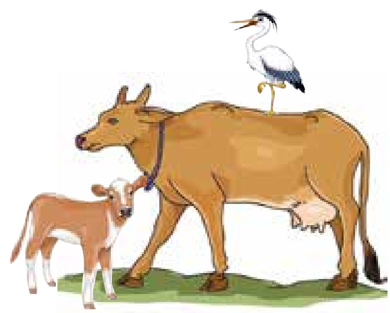


Fig. 6.17

c. Parasitism

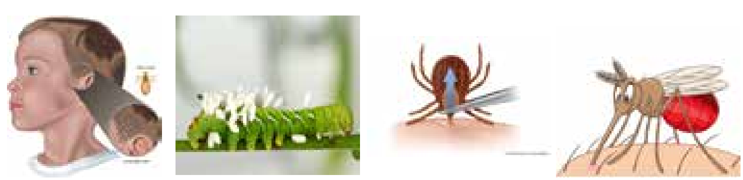


Fig. 6.18

Considering that the parasitic mode of life ensures free lodging and meals, it is not surprising that parasitism has evolved in so many taxonomic groups from plants to higher vertebrates. Many parasites have evolved to be host-specific (they can parasitise only a single species of host) in such a way that both host and the parasite tend to co-evolve; that is, if the host evolves special mechanisms for rejecting or resisting the parasite, the parasite has to evolve mechanisms to counteract and neutralise them, in order to be successful with the same host species. In accordance with their life styles, parasites evolved special adaptations such as the loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on to the host, loss of digestive system and high reproductive capacity. The life cycles of parasites are often complex, involving one or two intermediate hosts or vectors to facilitate parasitisation of its primary host. The human liver fluke (a trematode parasite) depends on two intermediate hosts (a snail and a fish) to complete its life cycle. The malarial parasite needs a vector (mosquito) to spread to other hosts. Majority of the parasites harm the host; they may reduce the survival, growth and reproduction of the host and reduce its population density. They might render the host more vulnerable to predation by making it physically weak. Do you believe that an ideal parasite should be able to thrive within the host without harming it? Then why didn't natural selection lead to the evolution of such totally harmless parasites? Parasites that feed on the external surface of the host organism are called ectoparasites. The most familiar examples of this group are the lice on humans and ticks on dogs. Many marine fish are infested with ectoparasitic copepods. Cuscuta, a parasitic plant that is commonly found growing on hedge plants, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant which it parasitises. The female mosquito is not considered a parasite, although it needs our blood for reproduction. Can you explain why? In contrast, endoparasites are those that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.). The life cycles of endoparasites are more complex because of their extreme specialisation. Their morphological and anatomical features are greatly simplified while emphasising their reproductive potential. Brood parasitism in birds is a fascinating example of parasitism in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them. During the course of evolution, the eggs of the parasitic bird have evolved to resemble the host's egg in size and colour to reduce the chances of the host bird detecting the foreign eggs and ejecting them from the nest. Try to follow the movements of the cuckoo (koel) and the crow in your neighborhood park during the breeding season (spring to summer) and watch brood parasitism in action.

d. Competition

When Darwin spoke of the struggle for existence and survival of the fittest in nature, he was convinced that interspecific competition is a potent force in organic evolution. It is generally believed that competition occurs when closely related species compete for the same resources that are limiting, but this is not entirely true. Firstly, totally unrelated species could also compete for the same resource. For instance, in some shallow South American lakes, visiting flamingoes and resident fishes compete for their common food, the zooplankton in the lake. Secondly, resources need not be limiting for competition to occur; in interference competition, the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant. Therefore, competition is best defined as a process in which the fitness of one species (measured in terms of its 'r' the intrinsic rate of increase) is significantly lower in

Fig. 6.19

the presence of another species. It is relatively easy to demonstrate in laboratory experiments, as Gause and other experimental ecologists did, when resources are limited the competitively superior species will eventually eliminate the other species, but evidence for such competitive exclusion occurring in nature is not always conclusive. Strong and persuasive circumstantial evidence does exist however in some cases. The Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats. Another evidence for the occurrence of competition in nature comes from what is called 'competitive release'. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range dramatically when the competing species is experimentally removed. Connell's elegant field experiments showed that on the rocky sea coasts of Scotland, the larger and competitively superior barnacle Balanus dominates the intertidal area, and excludes the smaller barnacle Chathamalus from that zone. In general, herbivores and plants appear to be more adversely affected by competition than carnivores. Gause's 'Competitive Exclusion Principle' states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise. More recent studies do not support such gross generalisations about competition. While they do not rule out the occurrence of interspecific competition in nature, they point out that species facing competition might evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is 'resource partitioning'. If two species compete for the same resource, they could avoid competition by choosing, for instance, different times for feeding or different foraging patterns. MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.

e. Predation

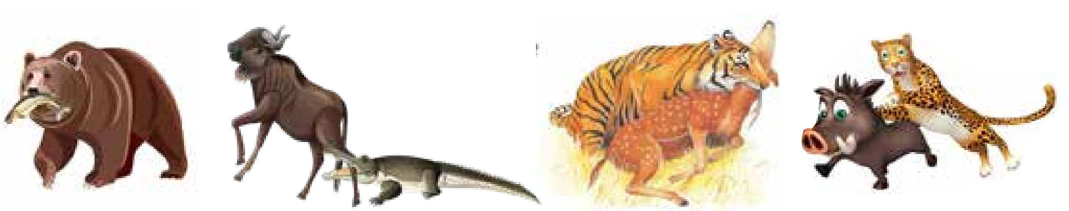


Fig. 6.20

What would happen to all the energy fixed by autotrophic organisms if the community has no animals to eat the plants? You can think of predation as nature's way of transferring to higher trophic levels the energy fixed by plants. When we think of predator and prey, most probably it is the tiger and the deer that readily come to our mind, but a sparrow eating any seed is no less a predator. Although animals eating plants are categorised separately as herbivores, they are, in a broad ecological context, not very different from predators. Besides acting as 'conduits' for energy transfer across trophic levels, predators play other important roles. They keep prey populations under control. But for predators, prey species could achieve very high population densities and cause ecosystem instability. When certain exotic species are introduced into a geographical area, they become invasive and start spreading fast because the invaded land does not have its natural predators. The prickly pear cactus introduced into Australia in the early 1920's caused havoc by spreading rapidly into millions of hectares of rangeland. Finally, the invasive cactus was brought under control only after a cactus-feeding predator (a moth) from its natural habitat was introduced into the country. Biological control methods adopted in agricultural pest control are based on the ability of the predator to regulate prey population. Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species. In the rocky intertidal communities of the American Pacific Coast the starfish Pisaster is an important predator. In a field experiment, when all the starfish were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, because of interspecific competition. If a predator is too efficient and overexploits its prey, then the prey might become extinct and following it, the predator will also become extinct for lack of food. This is the reason why predators in nature are 'prudent'. Prey species have evolved various defenses to lessen the impact of predation. Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator. Some are poisonous and therefore avoided by the predators. The Monarch butterfly is highly distasteful to its predator (bird) because of a special chemical present in its body. Interestingly, the butterfly acquires this chemical during its caterpillar stage by feeding on a poisonous weed. For plants, herbivores are the predators. Nearly 25 percent of all insects are known to be phytophagous (feeding on plant sap and other parts of plants). The problem is particularly severe for plants because, unlike animals, they cannot run away from their predators. Plants therefore have evolved an astonishing variety of morphological and chemical defences against herbivores. Thorns (Acacia, Cactus) are the most common morphological means of defence. Many plants produce and store chemicals that make the herbivore sick when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it. You must have seen the weed Calotropis growing in abandoned fields. The plant produces highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant. A wide variety of chemical substances that we extract from plants on a commercial scale (nicotine, caffeine, quinine, strychnine, opium, etc.,) are produced by them actually as defences against grazers and browsers.

Project Works

Build a food web

a. Choose a particular type of ecosystem (ex. freshwater, forest, prairie).
b. Research and create a list of the types of producers and consumers that live in the type of ecosystem you have chosen. (20 –25 organisms)
c. Do some further research to develop feeding relationship connections between the organisms you have listed?
d. Using a piece of plain white paper (min. size of 81/2 x 11) create a food web from the organisms you have listed
e. Examine your food web. Each individual food chain within your web should be complete and contain a producer, a top order consumer and all of the organisms in between. Your web should contain a minimum of 20 organisms. Be sure to include a decomposer or two.
f. Check your web one last time to be sure your arrows are pointing in the right direction and it is easy to follow. Add a title and few pictures or graphics for creativity.
g. Present your web in classroom.

Project Works

i. By observing a study of an ecosystem near your school and collecting a list of organic and inorganic components in the ecosystem. After this, you prepare a report on their interrelationships.
ii. By using various locally available materials and Prepare a model of the aquatic ecosystem and the terrestrial ecosystem.

Exercise

A. Choose the correct one and put the tick mark(√)

i. Which is NOT an example of an abiotic factor?
a. A hurricane
b. Cloud cover
c. Forest trees
d. Soil

ii. Which of these is an ecosystem?
a. A school of fish
b. A desert
c. Sunlight
d. A thunderstorm

iii. Abiotic factors _______.
a. are only important if they are large
b. come in a variety of sizes and types
c. are all living things in an ecosystem
d. cannot be studied

iv. In a food chain, man is
a. Primary and secondary consumer
b. Primary consumer
c. Secondary consumer
d. Producer

v. Which one of the following has the largest population in a food chain?
a. Producers
b. Primary consumers
c. Secondary consumers
d. Decomposers

vi. The second trophic level in a lake is
a. Phytoplankton
b. Zooplankton
c. Benthos
d. Fishes

vii. Secondary producers are
a. Herbivores
b. Producers
c. Carnivores
d. None of the above

viii. What is ecosystem?
a. A system consisting of biotic components that function together as a unit
b. A system consisting of abiotic components that function together as a unit
c. A system consisting of biotic and abiotic components that function together as a unit
d. None of the above

ix. Which of the following is producer in pond ecosystem?
a. Algae
b. Tadpole
c. Bacteria
d. Fish

x. **What is formed between the process of transfer of food between producer and consumer?**

a. Food web
b. Food chain
c. Society
d. All of above

B. Matching the following statements :

• Organism	A.	All of the individuals of one kind in a specified area at one time
• Community	B.	any living thing
• Individual	C.	Word for nonliving things in ecosystem
• Abiotic	D.	A system of interacting organisms and nonliving factors in a specified area
• Population	E.	Word for living things in an ecosystem
• Biotic	F.	One single organism
• Ecosystem	G.	All of the interacting populations in a specified area

C. Give reasons to these statements.

i. The number of producer is larger than consumer in nature.
ii. Bacteria are decomposers
iii. Algae are producers in pond ecosystem.
iv. Eagles are top consumers
v. All the factors have equal importance for a balanced ecosystem
vi. Ecosystem is beneficial for human beings.

D. Differentiate with examples

i. Biotic factors and abiotic factors
ii. Autotrophs and hetrotrophs
iii. Herbivores and carnivores
iv. Producers and consumers
v. Food chain and food web
vi. Producers and decomposers
vii. Grassland ecosystem and pond ecosystem
viii. Mutualism and Commensalism
ix. Parasitism and predation

E. Answer the following questions :

i. Give short description of ecosystem.
ii. Describe the factors of an ecosystem.
iii. What are abiotic factors of ecosystem? How do they affect ecosystem? Explain it.
iv. What is food chain? Describe about water and land ecosystem around your surrounding with figure.
v. Explain the relationship between plants and animals
vi. Describe briefly the role of decomposer in ecosystem with example.
vii. Differentiate between food chain and food web in two points.
viii. Draw a neat diagram of pond ecosystem and mention producer, primary consumer, secondary consumer and decomposer.

ix. There is balanced cycle between producer, consumer, decomposer and environment in an ecosystem. If imbalance occurs on any factor, ecosystem will also be damaged. Justify it with reason.
x. What will happen in ecosystem if all the snakes of land ecosystem are killed? Explain it.
xi. Mention the types of interactions. Describe each with an example.

F. What types of interactions are :

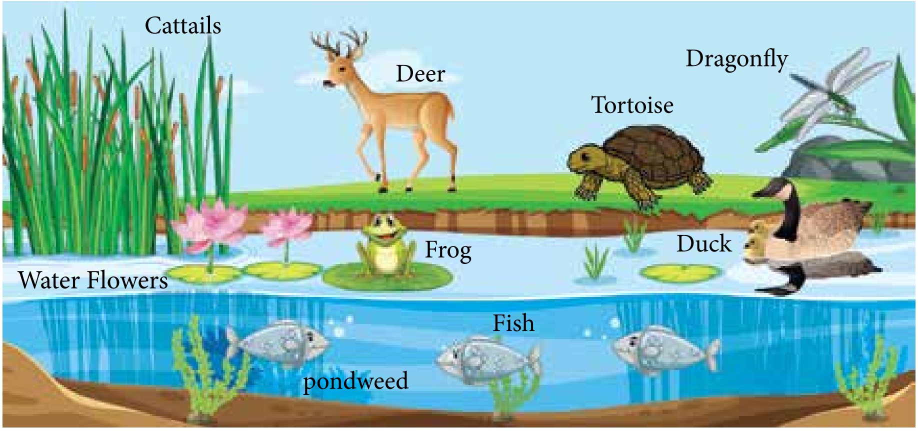
i. Two male deer may compete for the right to mate with all females in the herd.
ii. Organisms of one species feed on organisms of another species.
iii. A wolf consuming a hare.
iv. Plants can compete for soil nutrients, water and sunlight.
v. Animal can compete for food, water, shelter and mates.
vi. A lion catching a dear for dinner.
vii. Flowers depend on bees to pollinate is and the bees use the flower's nectar.
viii. Barnacles catch a 'ride' with whale for protection and food.
ix. Mosquitoes biting humans for their blood.
x. Tree frogs use plants as protection.
xi. Cattle egrets eat the insects stirred up by cattle when they are grazing

G. Critical Thinking Questions :

i. If all secondary consumers are killed off, what happens on primary consumers of an ecosystem. Explain.
ii. How do animals help plants in ecosystem?
iii. If the number of tertiary consumer is increased more than it is necessary and it causes the imbalance of ecosystem, how?

H. Diagrammatic Questions :

a. Studying this figure and answer the following questions.



i. Which type of ecosystem is shown?
ii. Write the name of a producer and a consumer?
iii. State the class of that consumer.
iv. In order to balance above ecosystem, which one should be highest number?
v. How do water lilies help animal?
vi. How do cattails help animals?

Unit 7

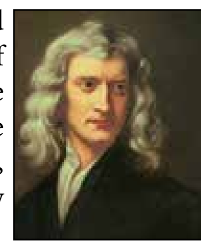
Force and Motion

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- define average speed , velocity and acceleration based on straight linear motion
- validate and use the equations of motion based on the definition of average speed and acceleration in straight linear motion.
- draw a graph of displacement-time and a graph of velocity-time
- distinguish uniform and non- uniform velocity / acceleration on the basis of inclination of related lines
- explain, demonstrate, and use Newton's three laws of motion
- introduce elasticity and plasticity based on the effect of consequential force on the shape and size of the object.

Isaac Newton, in full **Sir Isaac Newton**, (1643–1727), English physicist and mathematician, who was the culminating figure of the Scientific Revolution of the 17th century. In optics, his discovery of the composition of white light integrated the phenomena of colours into the science of light and laid the foundation for modern physical optics. In mechanics, his three laws of motion, the basic principles of modern physics, resulted in the formulation of the law of universal gravitation.



7.1 Introduction

If you observe a moving bus you will notice that the position of bus is changing with time. What does this mean? This means that the bus is in motion. Now suppose you are sitting in a bus moving parallel to another bus moving in the same direction with same speed. You will observe that the position of the other bus with respect to your bus is not changing with time. In this case the other bus seems to be at rest with respect to your bus. However, both the buses are moving with respect to surroundings. Thus, an object in motion can be at rest with respect to one observer whereas for another observer, the same object may be in motion. Thus we can say that the motion is relative. Let us understand the concept of relative motion. Suppose you are sitting in a vehicle waiting for traffic signal and the vehicle beside you just starts moving, you will feel that your vehicle is moving backward. Suppose Prashant (in a red t-shirt) and Sushant are going to the market. Sushant is running and Prashant is walking behind him. The distance between the two will

Prashant (Left) Sushant(Right)

Fig. 7.1

go on increasing, though both are moving in the same direction. To Sushant it will appear that Prashant is moving away from him. To Prashant also, it will appear that Sushant is moving ahead and away from him. This is also an example of relative motion.

Think and Do

One day, Nishant while standing on the bank of a river in the evening observed boats were approaching the bank, vehicles passing on the bridge, cattle going away from the bank of the river towards the village, moon rising in the sky, birds flying and going back to their nests, etc. Can you list some thoughts that could be emerging in the mind of the Nishant. What type of world Nishant has around him?

Motion is a continuous change in the position of the object with respect to the observer. Suppose you are moving towards your friend standing in a field. In what way are you in motion? Are you in motion if you are observing yourself? Is your friend in motion with respect to you Are you in motion with respect to your friend? Now you may have understood that observer with respect to itself can not be in motion. Thus, you are moving towards the object with respect to your friend and your friend is moving towards you with respect to you in opposite direction.

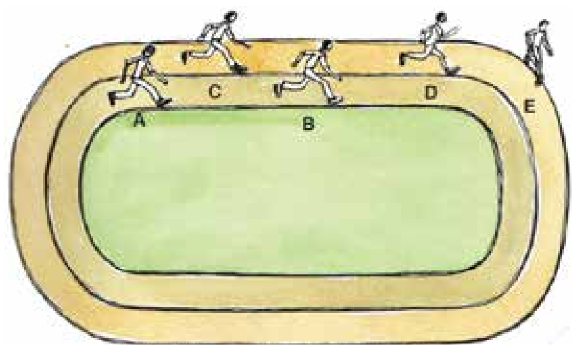


Fig. 7.2

Observer player	Player in motion	Player at rest	Remark
A B C D	B,C,D	E	E is in rest with respect to A because change in position of A and E in 1 second in zero while in other cases is not.

In other words the change in position of the object with respect to observer decides whether object is in motion. This change should also be continuous. Let us take an interesting example to understand the concept of motion. There are five players participating in 200 metre race event. They are running in their lanes as shown in the Fig. 7.2. The players A, B, C, D and E runs 2, 3, 4, 3, 2 metre respectively in one second. Can you help the player to understand that which player is in motion with respect to which player and which player is at rest with respect to which player? Fill your responses in the table given below.

Distance and displacement

In everyday language, the words distance and displacement are used in the same sense but in physics these two words have different meaning. Let us understand this difference by taking an example.

Suppose a man lives at place A (Figure 7.3 a) and he has to reach another place C, but first he has to meet his friend living at place B. Now, then man starts from point A and travels a distance of 5 km to reach B, and then travels another 3 km from B to reach C. Thus , the man goes along the path

ABC (shown by dotted lines). Length of the the path ABC gives us the actual distance travelled by the man. Thus, the distance travelled by a body is the actual length of path covered by a moving body irrespective of the direction in which the body travels. For example, in this case, the actual length of the path covered by man is 5km+3kn=8km, so the distance travelled by man is 8 km.

We will now discuss this problem in a different way. When the man has reached point C, we want to know how far he is now from the starting point A, that is, we want to know the shortest distance between point A and point C. Let us draw a straight line AC between A and C. The length of the straight line path AC (which is 4 km here) is the displacement of the man point A, that is on reaching C, the man is only 4 km away from the starting point A. This displacement is the East direction. Thus , when a body moves from one point to another, the distance travelled refers to the actual length of the indirect path whereas displacement refers to the straight line path between the initial and the final positions. So, whatever be the actual length of path followed by a moving body, displacement of the body is always represented by the shortest distance between the initial and final positions of the body. Thus, when a body moves from one position to another, shortest (straight line) distance between the initial position and final position of the body, alongwith direction , is known as its displacement.

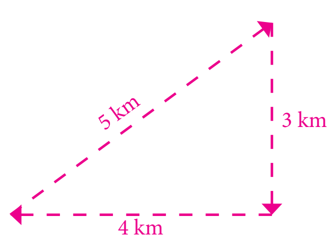
In the above example, the shortest distance between the initial position A and final position C of the man is 4 km, so the displacement of man is 4 km in the East direction. It is clear that the distance travelled has only magnitude whereas displacement has magnitude as well as direction.

Distance is a scalar quantity. It has magnitude only, it has no specified direction. Displacement is a vector quantity. It has magnitude as well as a direction.

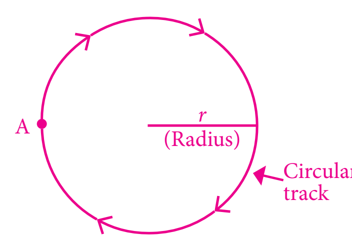
For example, if a car travels a distance of 45 km, then the expression '45 km' is the distance travelled, and if the car travelling in a straight line in the East direction (or any other direction), then the expression '45 km towards East' is the displacement of the car.

The distance travelled by a moving body cannot be zero but the final displacement of a moving body can be zero.

The displacement of a moving body will be zero if, after travelling a certain distance, the moving body finally comes back to its starting point (or starting position). This will become clear from the following examples. Suppose a man starts from place A and travels a distance of 5 km to reach place B [see Fig. 7.3a) From place B he travels another 3 km and reaches place C. And finally the man travels 4 km from place C to reach back to the starting point A. In this case, though the man has travelled a distance of 5 km + 3 km + 4 km = 12 km, but the final displacement of the man is zero.



a. Here: Distance travelled (from A to A) = 5 km + 3km + 4 km = 12 km. Displacement (from A to A) = 0



b. Here: Distance travelled (from A to A) = $2\pi r$ (where r is radius of the circular track). Displacement (from A to A) = 0

Fig. 7.3 a and b

This is because the man has reached back at the starting point A and the straight line distance between the initial position A and final position A is zero. Thus, if we take a round trip and reach back at the starting point then, though we have travelled some distance, our final displacement will be zero. This is because the straight line distance between the initial and final positions will be zero. For example, if we travel along a circular track of radius r and reach back at the starting point A [see figure 7.3(b)], then though we have travelled a distance $2\pi r$ (equal to circumference of track) but our final displacement will be zero. We will now solve a problem based on distance and displacement.

Sample Problem. A man travels a distance of 1.5 m towards East, then 2.0 m towards South and finally 43 m towards East.

i. What is the total distance travelled?
ii. What is his resultant displacement?

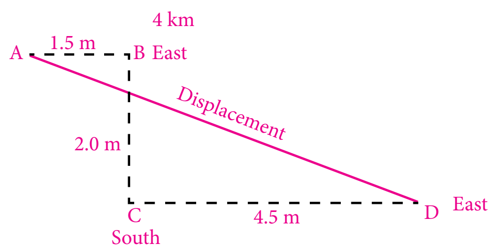


Diagram for sample problem
(Scale: 1 cm = 1 m)

Fig. 7.4

Solution:

i. Total distance travelled
   = 1.5 + 2.0 + 4.5 = 8.0 m

ii. To find the resultant displacement we should draw a map of the man's movements by choosing a convenient scale. Let 1 cm represent 1 m. Then 1.5 m can be represented by 1.5 cm long line, 2.0 m by 2.0 cm line and 4.5 m by a 4.5 cm long line.

   We draw a 1.5 cm long line AB from West to East to 1.5m East represent 1.5 m towards East (see Figure 7.4). Then, we draw a 2.0 cm long line BC towards South to represent 2.0 m towards South. And finally we draw a third line CD, 4.5 cm long, towards East to represent a distance of 4.5 m towards East.

   Now, the resultant displacement can be found by joining the starting point A with the finishing point D. Thus, the line AD represents the final displacement of the man. Let us measure the length of line AD. It is found to be 6.3 cm.

   Now, 1cm =1cm

   So, 6.3 cm = 6.3 m

   Thus, the final displacement as represented by AD is 6.3 metres.

   Please note that whenever a body travels along a zig-zag path, the final displacement is obtained by joining the starting point and the finishing point of the body by a straight line.

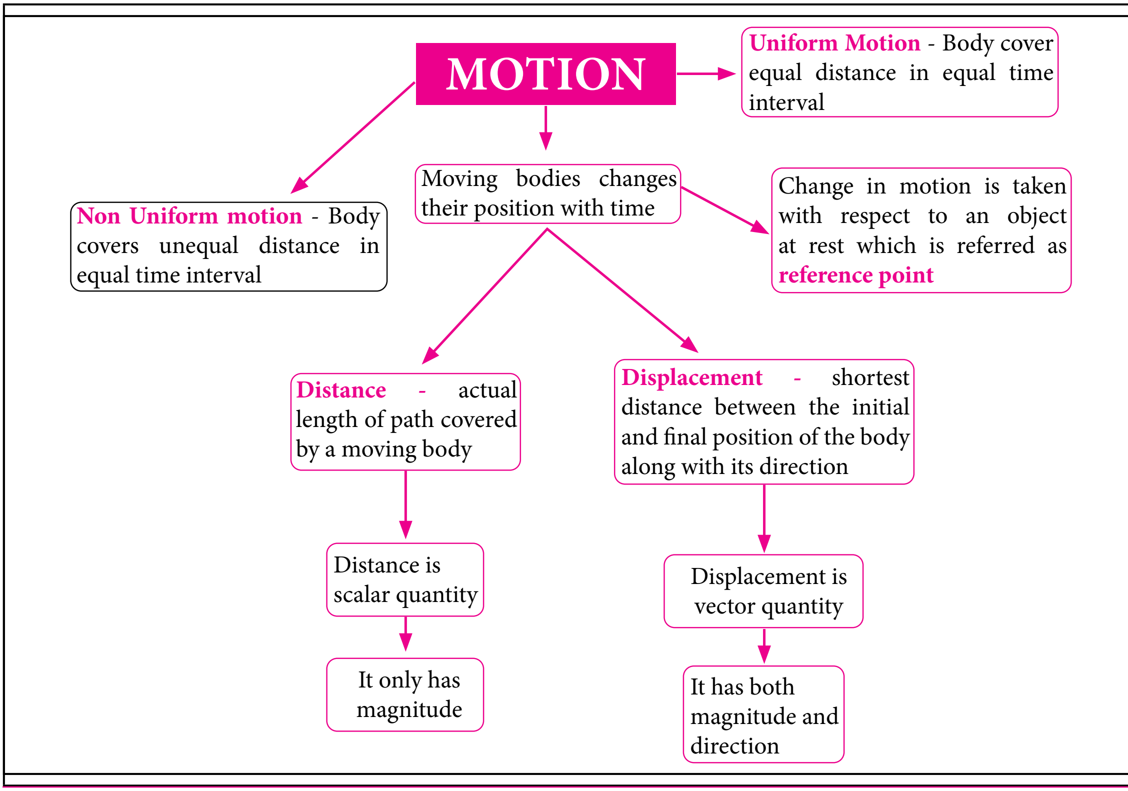

MOTION
Uniform Motion - Body cover equal distance in equal time interval
Moving bodies changes their position with time
Non Uniform motion - Body covers unequal distance in equal time interval
Change in motion is taken with respect to an object at rest which is referred as reference point
Distance - actual length of path covered by a moving body
Displacement - shortest distance between the initial and final position of the body along with its direction
Distance is scalar quantity
Displacement is vector quantity
It only has magnitude
It has both magnitude and direction

Fig. 7.5

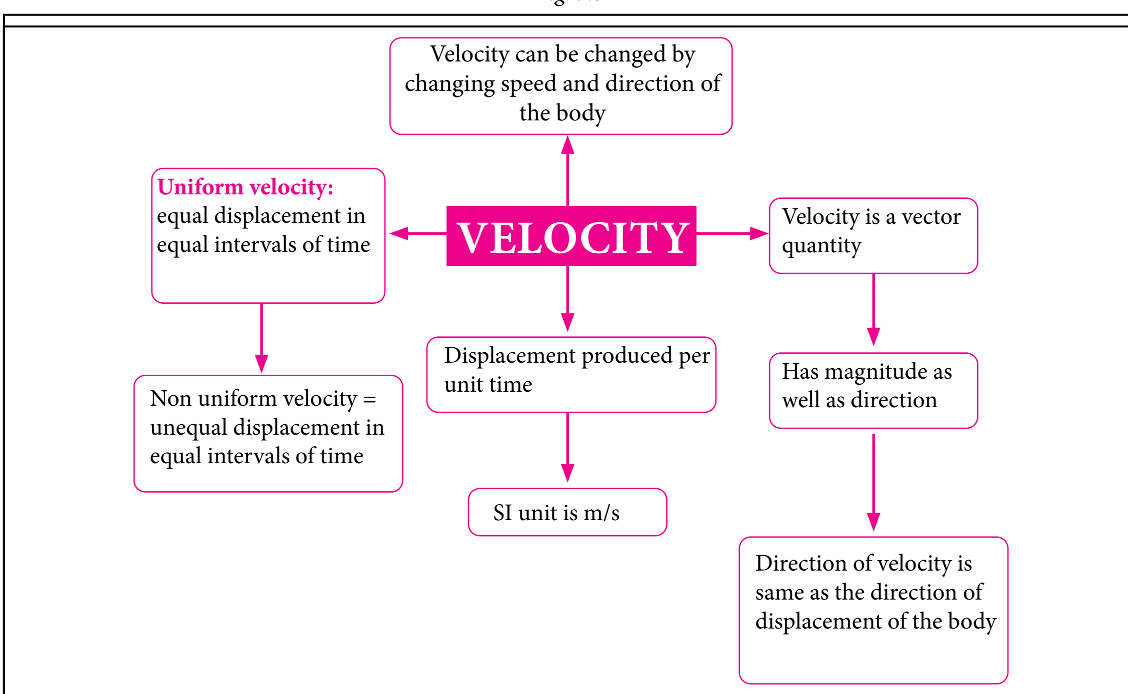

Velocity can be changed by changing speed and direction of the body
Uniform velocity: equal displacement in equal intervals of time
VELOCITY
Velocity is a vector quantity
Displacement produced per unit time
Has magnitude as well as direction
Non uniform velocity = unequal displacement in equal intervals of time
SI unit is m/s
Direction of velocity is same as the direction of displacement of the body

Fig. 7.8

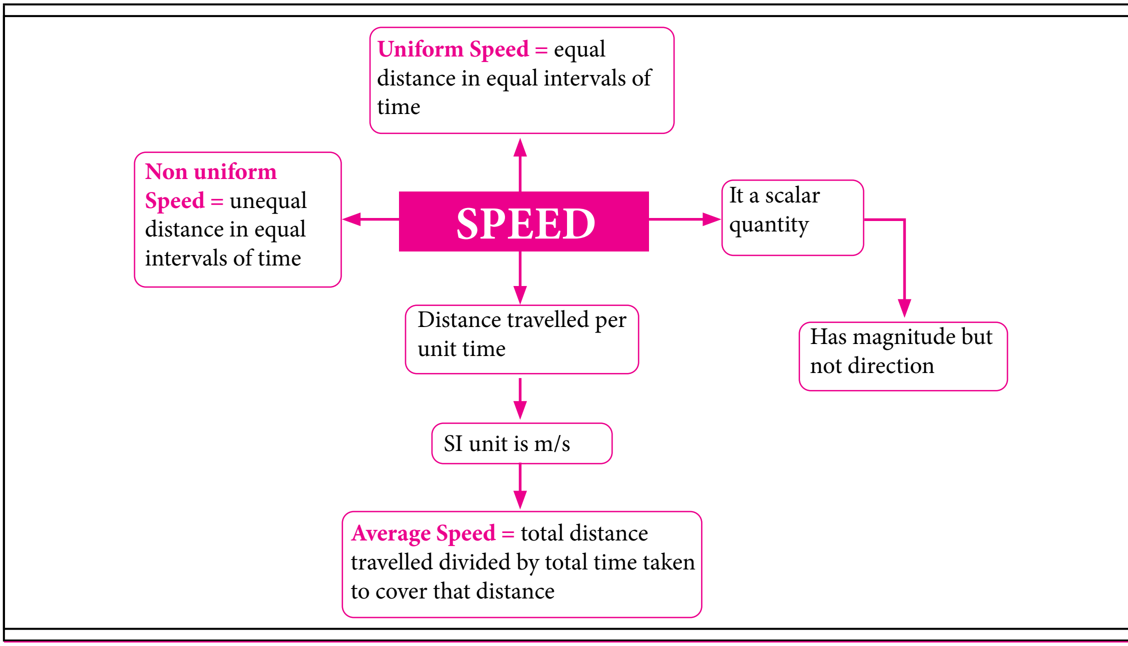


Fig. 7.9

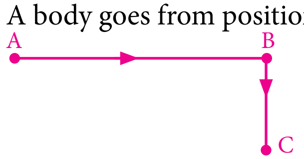
Activity 7.1

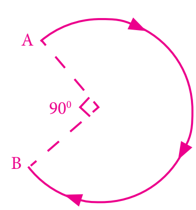
In the following cases measure the distance and displacement and write their values in the table given below:

a. A body moves from *A* to *B*

b. A body moves from *A* to *B* then comes to *C*

c. A body goes from position *A* **to** *B* and comes back to position *A*





d. A body goes from position *A* to *B* and then *C*

e. A body moves from position *A* to *B* along a circula arc

Case	Distance	Displacement
i.		
ii.		
iii.		
iv.		
v.		

Now you can conclude that:

a. Displacement is smaller or equal to the distance.
b. Displacement is equal to distance, if body moves along a straight line path and does not change its direction.
c. If a body does not move along a straight line path its displacement is less than the distance.
d. Displacement can be zero but distance can not be zero.
e. Magnitude of displacement is the minimum distance between final position and initial position.
f. Distance is the length of the path followed by the body.
g. Distance is path dependent while displacement is position dependent. Can you now, suggest a situation in which the distance is twice the displacement?

Speed and Velocity

SPEED

If a car is running slow, we say that its speed is low. And if a car is running fast, then we say that its speed is high. Thus, the speed of a body gives us an idea of how slow or fast that body is moving. We can now define the speed of a moving body as follows : Speed of a body is the distance travelled by it per unit time. The speed of a body can be calculated by dividing the 'Distance travelled' by the 'Time taken' to travel this distance. so, the formula for speed can be written as :

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

If a body travels a distance 's' in time 't', then its speed 'v' is given :

$$v = \frac{s}{t}$$

where v = speed
s = distance travelled
and t = timetaken (to travel that distance)

Suppose a car travels a distance 100 kilometres in 4 hours, then the speed of this car is given by :

$$\textbf{Speed} = \frac{\text{100 kilometers}}{\text{4 hours}}$$

or, speed of this car will be 25 kilometres per hour. This means that the car travels a distance of 25 kilometres 'every one hour'. The above given formula for calculating speed has three quantities in it : Speed, Distance travelled and Time taken. If we are given the values of any two quantities, then the value of third quantity can be calculated by using this formula.

The Sl unit of distance is metre (m) and that of time is second (s), therefore, the SI unit of speed is metres per second which is written as m/s or ms^{-1}. The small values of speed are expressed in the units of centimetres per second which is written as cm/s or cms^{-1}. To express high speed values, we use the unit of kilometres per hour, written as km.p.h. or km/h or km h^{-1}. Please note that if we have to compare the speeds of a number of bodies, then we must express the speeds of all of them in the same units. Speed has magnitude only, it has no specified direction, therefore, speed is a scalar quantity.

The speed of a running car at any instant of time is shown by an instrument called 'speedometer' which is fixed in the car. The speedometer gives the speed in kilometres per hour. The distance travelled by a car is measured by another instrument called 'odometer' which is also installed in the car. It records the distance in kilometres.

Average Speed

The average speed of a body is the total distance travelled divided by the total time taken to cover this distance. While travelling in a car (or a bus) we have noticed that it is very difficult to keep the speed of the car at a constant or uniform value because at many places the brakes are to be applied to slow down or stop the car due to various reasons. Thus, the speed of a body is usually not constant and the distance travelled divided by time gives us the average speed during that time. For example, for a car which travels a distance of 100 km in 4 hours, the average speed is 100/4 =25 km per hour. Although the average speed of this car is 25 km per hour, it does not mean that the car is moving at this speed all the time. When the road is straight, flat and free, the speed may be much more than 25 km per hour but on bends (curved road), hills or in a crowded area, the speed may fall well below the average value. We should remember that :

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

We will use this formula for solving numerical problems after a while.

The average speeds of some of the moving objects are given below.

	Moving object			Average speed
1.	Tortoise	0.06 m/s	or	0.216 km/h
2.	Human walking	2 m/s	or	7.2 km/h
3.	Human running (sprinter)	10 m/s	or	36 km/h
4.	Birds	5 to 15 m/s	or	18 to 54 km/h
5.	Cheetah	27 m/s	or	97.2 km/h
6.	Fast car	30 m/s	or	108 km/h
7.	Racing car	60 m/s	or	216 km/h
8.	Sound in air (at 20^0C)	344 m/s	or	1238.4 km/h
9.	Jet aeroplane	500 m/s	or	1800 km/h
10.	Light (in vacuum)	$3x10^8$ m/s	or	$1.08x10^9$ km/h

Table. 7.1

Uniform Speed (or Constant Speed)

A body has a uniform speed if it travels equal distances in equal intervals of time, no matter how small these time intervals may be. For example, a car is said to have uniform speed of say, 60 km per hour, if it travels 30 km every half hour, 15 km every quarter of an hour. 1 km every minute, and 1/60 km every second. In actual practice the speed of a body rarely remains uniform (or constant) for a long time. If, however, the speed of a body is known to be constant, we can find out exactly how much distance it will travel in a given time or if we know the distance travelled by the body, we can calculate the time taken to travel that distance. We will now solve some numerical problems based on speed.

Velocity

If you are asked to reach a destination and you are provided three, four paths of different lengths, which of the path would you prefer? Obviously, the path of shortest length but not always. This is also called displacement. When motion is along the shortest path, it is directed from the point of start to the point of finish. How fast this motion is determines the velocity. The velocity is the ratio of length of the shortest path i.e. displacement to the time taken.

$$\textbf{Velocity} = \frac{\text{Displacement}}{\text{Time taken}}$$

Velocity has same unit as the unit of speed i.e., ms^{-1} (S.I. unit) or kmh^{-1}. The shortest path or the displacement is directed from initial position of the object to the final position of the object. Hence, the velocity is also directed from initial position of the object to the final position of the object. Thus we can say that the velocity has direction. Speed does not have direction because it depends upon the total distance travelled by the object irrespective of the direction. The quantities which have direction are called vector and which do not have direction are called scalar quantity. Thus, velocity can also be expressed as-

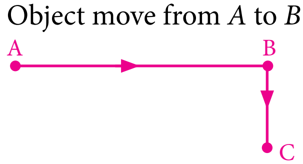
$$\textbf{Velocity} = \frac{\text{Change in position}}{\text{Time taken}}$$

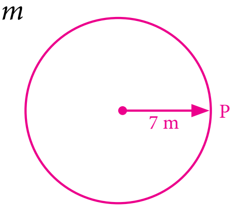
Activity 7.2

a. Observe the motion of an object in the following situations. Find speed and velocity in each situation and comment over the situation which you find different from other

Object moves from A to B in time 10 s on the scale 1 cm = 10 m

Object move from A to B than to C in 10 s on the scale 1 cm = 10 m

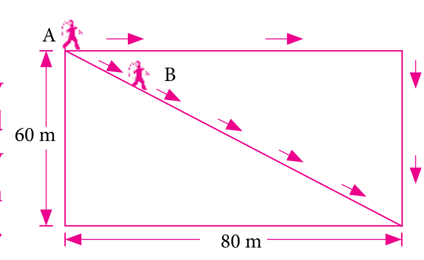




Object move from A to B than to C 20 s on the scale 1 cm =10 m

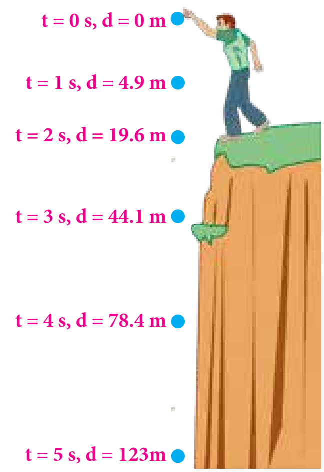
Object complete a round of radius 7 m in 10 s

b. In a rectangular field of sides 60 m and 80 m respectively two formers start moving from the same point and takes same time i.e. 30 minutes to reach diagonally opposite point along two different paths as shown in figure. Find the velocity and speed of both the formers.



Activity 7.3

Based on the data of free falling object given in the accompanying picture, what conclusions can be drawn from the following two calculations? Discuss with classmate and write down the conclusions.



(i) Average velocity ($\bar{v}$)

$$= \frac{\text{distance travelled in particular direction (s)}}{\text{time taken to travelled that distance (t)}}$$

$$= \frac{44.1}{3}$$

= 14.7m/s towards the center of the earth

(ii) Average velocity ($\bar{v}$)

$$= \frac{\text{initial velocity(u)+ final velocity (v)}}{2}$$

$$= \frac{0+2.9}{2}$$

= 14.7 m/s towards the center of the earth

Average Velocity

Average velocity is defined as the change in position or displacement (Δx) divided by the time intervals (Δt) in which the displacement occurs.The average velocity can be positive or negative depending upon the sign of the displacement. Average velocity is a vector quantity. The SI unit of average velocity is meters per second (m/s or ms^{-1}).

To calculate the average velocity (V_{av}) or $\bar{v}$, we need to divide the total displacement by the total time elapsed as follows:

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_o}{t_f - t_o}$$

Where ΔV is the average velocity, Δx is the displacement, Δt is the total time, x_f and x_0 are the initial and final positions, t_f and t_0 are the starting and ending times.

For object with the same accelation in linear motion :

Following formula can be used for objects with the same acceleration in linear motion

$$\text{Average velocity}(\bar{v}) = \frac{\text{initial velocity(u)+ final velocity}}{2}$$

Uniform Velocity

When an object undergoes equal displacement (in magnitude and direction) in equal interval of time, the object is said to be in uniform velocity. To be uniform velocity, the object should have same magnitude and direction. If the object moving in circular path covers equal distance in equal interval of time, even the object is not in uniform velocity. Because the object changes its direction each point of its path.

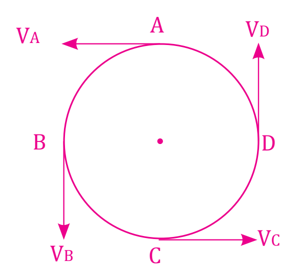


Fig. 7.8

When an object moves in circular path ABCD with uniform speed, the direction of motion at point A, B, C and D are not same.

How velocity of a body can be changed

The velocity of a body can be changed by the following ways.

i. Changing the speed of a body and keeping the direction same.
ii. Changing the direction of motion by keeping the speed constant.
iii. Changing both direction and speed of the body.

Non-Uniform Velocity

When an object undergoes unequal displacement (in magnitude or direction or both) in equal interval of time, the body is said to be in non-uniform motion. If the body covers equal distance in equal interval of time but in different direction, the velocity of the body is also said to be in non-uniform. In this condition speed of the object may be equal but direction is changing.

For example : Velocity of an object moving in circular path.

Acceleration

Consider the following situation. Starting from rest, you walk one step during the first second, two steps during the next second, three steps during the third second, and so on. So for each second the number of steps increases by one step. Two things are happening in this situation. First, the number of steps increases by one step per second every second (0, 1 step/second, 2 steps/second, 3 steps/second etc.). Second, let us also assume that each step equals 1 meter. Then you travel 1 meter in the first second, two meters in the next second, three meters in the third second, and so on.

The situation described above is what happens when an object is accelerating. Acceleration is defined as the rate of change of velocity or speed. So for an object to be accelerating, the object's speed has to change each second, and another consequence of acceleration is that the distance the object travels each second changes as well.

Any time your speed changes, you are accelerating. For instance, when you drive to work in the morning, you constantly have to stop and start when you hit traffic lights or stop signs. Every time you start the motercycle you accelerate, and every time you stop the motercycle for a light or a stop sign you accelerate (more commonly known as deceleration, although in physics accelerating just means that your speed changes, but does not necessarily mean that you're going faster). The main feature of accelerated motion is that the speed is different every second and the distance traveled every second changes as well. First table below illustrates motion that is NOT accelerated so you can compare it to the second table showing accelerated motion.

Time (in seconds)	Speed (in meters/second)	Distance (in meters)
1	2.0	2.0
2	2.0	4.0
3	2.0	6.0
4	2.0	8.0
5	2.0	10.0

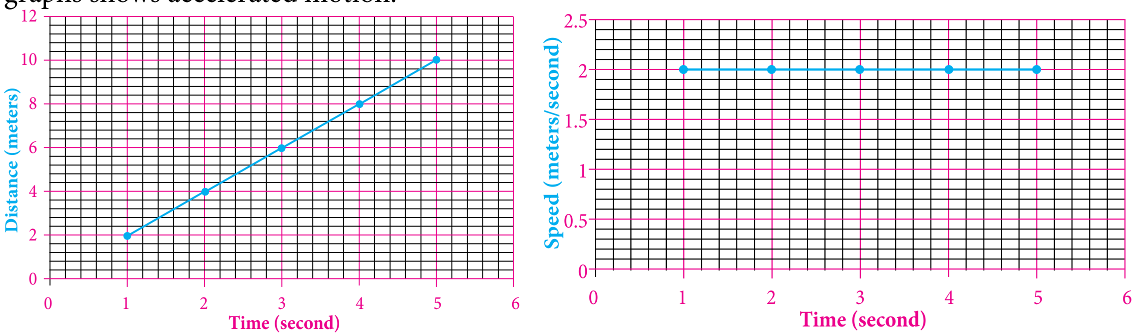
Table 7.2

Notice that the speed is the same every second and the distance traveled increases by the same amount each second; in this case, the distance increases by 2.0 meters every second. Contrast this table with the table below.

Time (in seconds)	Speed (in meters/second)	Distance (in meters)
1	1.0	0.5
2	2.0	2.0
3	3.0	4.5
4	4.0	8.0
5	5.0	12.5

Table 7.3

Notice that the speed increases by 1 meter per second every second and that the distance traveled increases from second to second. The second table is an example of accelerated motion. To further illustrate acceleration, two sets of graphs will be shown. The first set of graphs shows the speed versus time and the position versus time graphs of non-accelerated motion, and the second set of graphs shows accelerated motion.



Non-Accelerated Distance and Speed versus Time Graphs

Notice that the distance graph is a straight line while the speed graph is a horizontal line, indicating that there is no acceleration in this case.

Types of acceleration:

- Uniform acceleration: When an object is travelling in a straight line with an increase in velocity at equal intervals of time, then the object is said to be in uniform acceleration. Free falling of an object is an example of uniform acceleration.

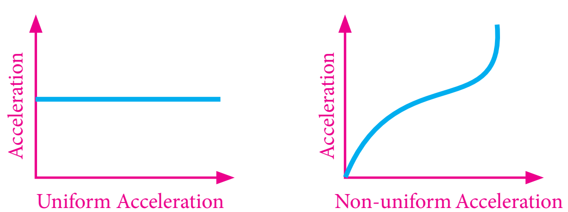


Fig. 7.9

- Non-uniform acceleration: When an object is travelling with an increase in velocity but not at the equal intervals of time is known as non-uniform acceleration. Bus moving or leaving from the bus stop is an example of non-uniform acceleration.
- Instantaneous acceleration: Acceleration of an object at any instant of time is known as instantaneous acceleration.

Acceleration Formula

Acceleration is the rate of change of velocity with time. It is a measure of the change in the velocity of an object per unit time and mathematically, acceleration formula is given as

$$Acceleration = \frac{Change\ in\ velocity}{time\ taken}$$

For describing average acceleration, we first consider the motion of an object along a straight line. Suppose at time t_1 object is at point P moving with velocity v_1 and at time t_2 it is at point Q and has velocity v_2. Now average acceleration of an object in moving from P to Q is

$$a = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

which is the change in velocity of the object with the passage of time.

If the velocity of an object changes from an initial value u to the final value v in time t, the acceleration a is given by,

$$a = \frac{v - u}{t}$$

and this kind of motion is called accelerated motion.

Important Points about Acceleration Formula

i. Since the velocity of a moving object has both magnitude and direction likewise acceleration depending on velocity has both magnitude and direction and hence acceleration is a vector quantity.
ii. SI unit of acceleration is ms^{-2}
iii. A body has uniform acceleration if it travels in a straight line and its velocity increases by an equal amount in equal intervals of time for example freely falling bodies, the motion of the ball rolling down the inclined plane etc.
iv. A body has non-uniform acceleration if its velocity increases or decreases by the unequal amount in equal intervals of time.
v. If acceleration is in the direction of the velocity then it is positive acceleration and if it is in the direction opposite to the direction of velocity then it is negative and the negative acceleration is termed retardation or deceleration.

Example

A motorbike moves in a straight road. The velocity at point A is 36 km/hr, It presses the accelerator paddle and reaches point B in 10 sec. The velocity at point B is 54Km/hr Find the average acceleration of the car from point A to point B?

Solution

Average acceleration is given by

$$Acceleration = \frac{Change\ in\ velocity}{time\ taken}$$

Initial velocity= 36 km/hr=10 m/s

Final Velocity = 54 km/hr=15 m/s

Average acceleration= (15-10)/10=.5 m/s^2

Retardation

Retardation means negative acceleration. The velocity of a body may increase or decrease. Acceleration takes place when the velocity of a body changes. So when the velocity of a body increase, the acceleration is said to be positive and when the velocity of a body decrease, the acceleration is said to be negative. Negative acceleration is called retardation or deceleration. A body is said to be retarded if its velocity is decreasing.

For example, a bus is said to be retarded when it slows down on reaching a bus-stop,i.e. the velocity decreases.Retardation is acceleration with negative sign or negative value of acceleration shows that the velocity of a body is decreasing. Similarly, when a stone is thrown upwards, it is under retardation.

Activity 7.4

Consider the following combination of signs for velocity and acceleration of an object with respect to a one dimensional motion along x-axis and give example from real life situation for each case:

Velocity	Acceleration	Example
a. Positive	Positive	Ball rolling down on a slope like slide or ramp
b. Positive	Negetive	
c. Positive	Zero	
d. Negative	Positive	
e. Negative	Negative	
f. Negative	Zero	
g. zero	Positive	
h. Zero	Negative	

Let's Know

Scalar vector	Vector
They are expressed only by their magnitudes	They are expressed by magnitude as well as direction.
They can be added, subtracted, multiplied or divided by simple arithmetic methods.	They can be added, subtracted or multiplied following a different algebra.
They are symbolically written by english letter.	They are symbolically written by their English letter with an arrow on top of the letter.
Example: mass, speed	Example: force, velocity

Distance	Displacement
It is a scalar quanity.	It is a vector quantity
The distance is the length of path travelled by the body.	The displacement is the shortest length in direction from initial to the final position.
It is always positive.	It can be positive or negative depending on the direction of the body.
Can be more than or equal to the magnitude of desplacement.	Can be less than or equal to the distance, but never greater than the distance.

Equations of linear motion

Consider an object moving with uniform acceleration, a. Let u be the initial velocity (at time t = 0), v, velocity after time t and S, displacement during this time interval. There are certain relationships between these quantities. Let us find out.

We know that $Acceleration = \dfrac{Change\ in\ velocity}{time\ taken}$

$$\therefore \quad a = \frac{v - u}{t}$$

$$or \quad v = u + at$$

This is called as the first equation of motion.

Question based on $v = u + at$

i. A cyclist speeds up at a constant rate from rest to 8 m/s in 6s. Find the acceleration of the cyclist.

Ans: u = 0 m/s [body starts from rest]

v = 8 m/s   t = 6 s

v = u + at

=> a = (v-u)/t = (8-0)/6 = 4/3 m/s^2 = 1.33 m/s^2

ii. An electron has a constant acceleration of 3.2 m/s^2. At a certain instant its velocity is 9.6 m/s. What is its velocity 2.5 seconds earlier?

Ans: a = 3.2 m/s^2

v = 9.6 m/s   u =?

t = 2.5 s   v = u + at

=> u = v - at = 9.6 -3.2 x 2.5 = 1.6 m/s

Also, we know that Displacement = (average velocity) × (time interval)

$$or, \left(\frac{v+u}{2}\right)t = \left(\frac{u+at+u}{2}\right) t \ (\because v = u+at)$$

$$or, \ s = ut + \frac{1}{2} at^2$$

This is called the second equation of motion. If object starts from rest, u = 0 and

$$s = 0\times t + \frac{1}{2} at^2$$

$$or, \quad s = \frac{1}{2} at^2$$

Thus, we see that the displacement of an object undergoing a constant acceleration is proportional to t^2, while the displacement of an object with constant velocity (zero acceleration) is proportional to t.

Question based on $s = ut + \frac{1}{2} at^2$

A racing car reaches a speed of 50 m/s. At this instant it begins a uniform negative acceleration using a parachute and a braking system and comes to rest 50 s later. How far does the car travel after acceleration starts.

Ans: u = 50 m/s

v = 0 m/s

t = 50 s

Here we have two unknowns 's' and 'a'. So first we will find 'a' using v = u + at.

0 = 50 + a x 5

=> 0 = 50 + 5a   => a = -50/5 = -10 m/s^2

Now, we find the distance travelled

$S = ut + \frac{1}{2} at^2$

= 50 x 5 + 1/2 x (-10) x 5^2)   = 250 -125 = 125 m

Now, if we take

$$or,\ a = \left(\frac{v+u}{t}\right) \text{ and } s = \left(\frac{v+u}{2}\right).t \text{ and multiply them, we find that}$$

$$a.s = a = \frac{(v+u)}{t} \left(\frac{v+u}{2}\right) t = \frac{(v^2+u^2)}{2t}$$

$$or,\ 2a.s = v^2 - u^2$$

$$or,\ v^2 = u^2 + 2as$$

This is called as third equation of motion. In case of motion under gravity 'a' can be replaced by 'g'.

Question based on $v^2 = u^2 + 2as$

A car brakes from a speed of 108 km/h to 72 km/h duing a displacement of 100m. What is its acceleration?

Ans: We write down the given data and make the units consistent. All the units should be in **SI**

u = 108 km/h = 108 × 1000/(60 × 60) = 108 × 5/18 = 30 m/s

[1 km = 1000 m and 1 h = 60 × 60 = 3600 s]

v = 72 km/h = 72 x 5/18 = 20 m/s

s = 100 m

$v^2 - u^2 = 2as$

=> a = $(v^2 - u^2)/(2 \times 100) = (400 - 900)/(2 \times 100) = -2.5$ m/s^2

Equation of Linear Motion

- $v = u + at$
- $s = \frac{1}{2}(u + v)\,t$
- $s = ut + \frac{1}{2}at^2$
- $v^2 = u^2 + 2as$

Shall I memorise these equations?

u = initial velocity
v = final velocity
a = acceleration
t = time
s = displacement

Graph of linear motion

A graph is a pictorial representation of the relation between two sets of data of which one set is of dependent variables and the other set is of independent variables. To describe the motion of an object, we can use line graphs. In this case, line graphs show dependence of one physical quantity, such as distance or velocity, on another quantity, such as time.

Distance–Time Graphs

The change in the position of an object with time can be represented on the distance-time graph. In this graph, time is taken along the x-axis and distance is taken along the y-axis. Distance time graphs of a moving body can be used to calculate the speed of the body as they specifically represent velocity.The distance time graph for a body moving at uniform speed is always a straight line as distance travelled by the body is directly proportional to time as shown below in the figure 1.

- The distance time graph for a body moving with non uniform speed is a curve and is shown below in the figure 2.

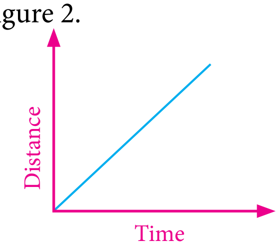


Figure 1 Distance time graph for uniform speed

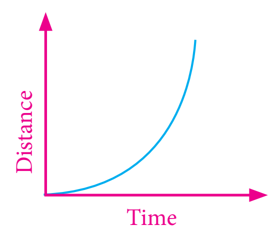


Figure 2 Distance time graph for non-uniform speed

Fig. 7.10

- The distance time graph is parallel to time axis when the object is at rest and is shown below in figure 3.

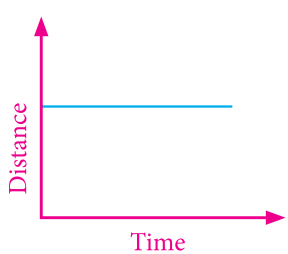


Figure 3 Distance time graph for objects at rest

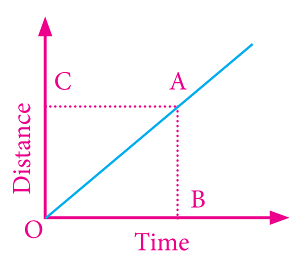


Figure 4 Calculation of speed from distance time

Fig. 7.11

- To calculate speed of the body from distance time graph say at point A, first draw a perpendicular AB on time axis and a perpendicular AC on distance axis so that AB represents the distance travelled by the body in time interval OB and since we know that.

$$speed = \frac{distance\ travelled}{time\ taken} = \frac{AB}{OB}$$

Displacement-time graph

Displacement-time graphs show how the displacement of a moving object changes with time. A horizontal line on a displacement-time graph shows that the object is stationary (not moving because the displacement does not change). A sloping line on a displacement-time graph shows that the object is moving. In a displacement-time graph, the slope or gradient of the line, is equal to the velocity of the object.

The steeper the line (and the greater the gradient) the faster the object is moving.

Example 1:

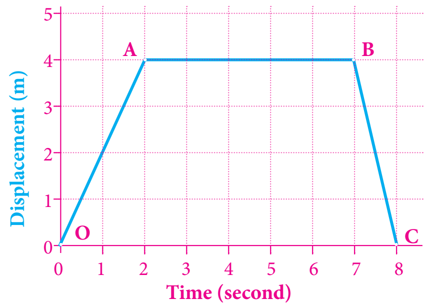


Fig. 7.12

Section of graph	What is represented
O – A	Positive constant velocity
	velocity = gradient of displacement-time graph = $\frac{displacement}{time}$
	displacement = 4 m – 0 m = 4 m
	time = 2 s – 0 s = 2 s
	velocity = $\frac{displacement}{time} = \frac{4m}{2s}$ = 2 m/s
A – B	Stopped
	displacement does not change: velocity = 0 m/s
B – C	Negative constant velocity
	the object is now travelling in the opposite direction
	velocity = gradient of displacement-time graph = $\frac{displacement}{time}$
	displacement = 0 m – 4 m = -4 m
	time = 8 s – 7 s = 1 s

Section of graph	What is represented
	velocity = $\dfrac{displacement}{time} = \dfrac{-4m}{1s}$ = -4 m/s
At C	the object has returned to its starting position
	the displacement is once again zero

Table 7.4

Example 2:

Any point on such a graph has coordinates (t,s), in which s is the displacement after a time t. Figure 1 shows the displacement-time graph for a tennis ball which is thrown vertically up in the air from a player's hand and then falls to the ground. The graph illustrates the motion of the ball. Taking the origin to be the starting point, the ball moves upwards (in the positive direction) to a maximum height of 2.5 m above the origin. It stops momentarily and then drops to the ground, which is 1.5 m below the initial release. Consequently, the velocity of the ball changes from positive (on the way up) to 0 at the top and then to negative (on the way down).

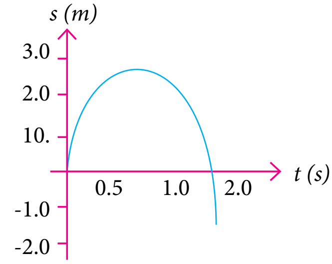
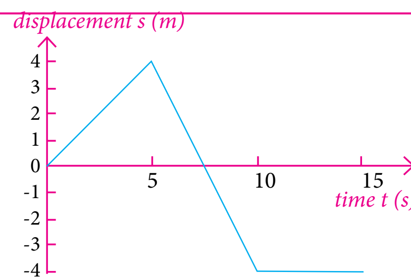


Fig. 7.13

The gradient of a displacement-time graph is velocity

Activity 7.5



i. A bus travels along a straight road for 600 m. It travels at a constant velocity for the whole journey, which takes 90 s. Sketch the displacement-time graph. What was the velocity of the bus?

ii. A snooker ball moves in a straight line with a constant speed of u m s^{-1}. It hits the cushion directly after a time t_1 and rebounds along the same path with a constant speed of (u – 0.2) m s^{-1}. Sketch the displacement-time graph. (Assume u > 0.2)

iii. Figure shows the displacement-time graph of a car during parking. Describe the motion of the car and find the velocity in each time interval

Velocity-time graph

Velocity-time plots represent variations in an object's velocity over the course of time. As such, the slope of such graphs provides a velocity change to time change ratio; this ratio represents the acceleration of the object. The slope is simply the change in the y–coordinates divided by the change in the x-coordinate.

Velocity-time plots can also be used to determine the distance traveled by an object and the displacement of an object. The area between a plotted line and the time axis (which could be a positive or a negative value) represents the displacement of the object. The area spoken of here is formed by the plotted line, the time axis and two imaginary vertical lines drawn at two specified points in time. The resulting area could be represented by either a rectangle, a triangle, a trapezoid or a collection of such shapes. The graphic below depicts a variety of resulting shapes and the appropriate formulas for calculating areas from each of them. Note that a complex shape (as shown in the rightmost graph) can be broken into a collection of smaller shapes.

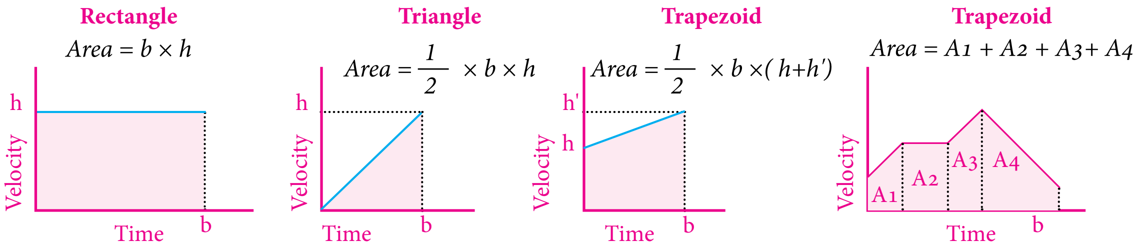


Fig. 7.14

Example :

Any point on such a graph will have coordinates (t,v), in which v is the velocity after a time t. Figure 2 shows the velocity-time graph for the motion of the tennis ball described in example-2 of displacement-time. It was thrown into the air with a velocity of 7 m s^{-1}.

It has zero velocity at 0.71 seconds and returns to the ground after 1.62 seconds with a velocity of -8.8 m s^{-1}.

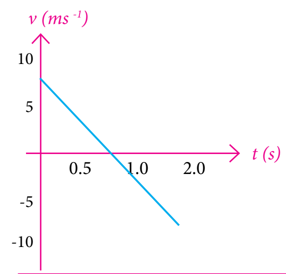


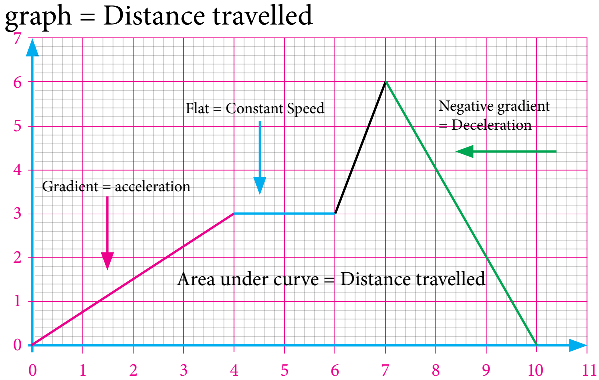
Fig. 7.14

The gradient of a velocity-time graph is acceleration

Velocity-Time Graphs – Key things to remember:

With speed on the yy-axis and time on the xx-axis, a speed-time graph tells us how someone/something's speed has changed over a period of time.

1. The gradient of the line = Acceleration
2. Negative gradient = Deceleration
3. Flat section means constant velocity (NOT STOPPED)
4. Area under the graph = Distance travelled



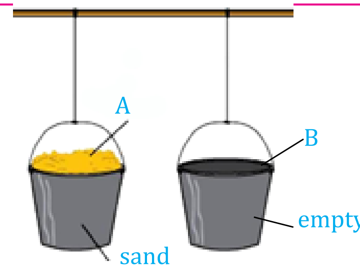
Inertia

An object at rest does not change its position by itself. Similarly, moving object in a particular direction does not stop and change its direction of motion by itself. The object at rest tries to remain at rest while the object moving in a particular direction also tries to remain in motion in that direction of motion. Here, only external force can change the state of rest and motion of the object. The property of an object due to which it remains or tends to remain in the state of rest or uniform motion in a straight line is called inertia.

Inertia of an object depends upon the mass of the object. The object having more mass has more inertia and vice versa.

Activity 7.6

Take two equal size empty cans 'A' and 'B'. using long threads. Fill the can 'A' with sand and keep empty 'B'. Hang them as shown, in figure. Push both cans to same distance. Which needs more force?



Release them to bring in motion. Then apply force to stop them. Which needs more force to bring at rest?

Again leave both of them to oscillate. Which one oscillate for longer time?

Here 'A' needs more force to hold and to stop than 'B'. 'A' oscillates more time than B. It is due to mass of 'A' is greater than mass of 'B'. So, it is concluded that greater mass has greater inertia and vice versa. It also shows that the mass of the body is the the measure of the inertia.

i. Inertia of rest

The inertia associated with the object at rest is called inertia of rest. Due to inertia of rest, the object at rest tries to remain at the state of rest.

Due to inertia of rest when mango tree is shaken, the mangoes fall. At first, the mango is at rest state along with branches of the tree. When we shake the branches of the tree it comes into motion. But due to inertia rest, mangoes continue to be at rest and that is separated from the branch and then falls.

When we beat a dusty carpet with stick, the dust particles separate from the carpet. It is also due to inertia of rest property of the dust particle.

Thus, inertia of rest is the property of an object by virtue of which it is unable to change its state of rest until external force is applied.

ii. Inertia of motion

The inertia associated with moving objects is called inertia of motion. Due to inertia of motion, moving object continues to be in state of uniform motion in a particular direction.

Blades of a running electric fan continue to spin for some time even after the electricity is switched off. Electric fan runs due to electric energy. After switch is off, the electric fan should come at rest state. But due to its inertia of motion. It does not come at rest state immediately when switch is off.

Due to inertia of motion, passenger of a bus jerks forwards, when a moving bus suddenly stops. When the bus is moving, both the bus and the passengers are in motion state. When the bus suddenly stops, the lower body parts of the passengers come into rest along with the bus. But upper parts of the body try to remain in motion due to inertia of motion.

iii. Inertia of direction

The property of a body by virtue of which it maintains or tries to maintain its direction of motion unless external forces act on it is called inertia of direction.

Example: When a car moves on a turning of roads, the person sitting inside it is thrown outwards in order to maintain his/her direction of motion due to inertia of direction.

The mud sticking to the wheel of vehicle flies off tangentially when the wheel rotates at a high speed. This is due to inertia of direction.

It is advised to tie our luggage kept on the roof of the vehicle with a strong rope because luggage can be thrown sideways due to inertia of direction.

Relationship between Mass and Inertia

We can push bicycle for some distance by applying force easily. But, we can't displace the truck by applying the same force. The inertia of rest of truck is greater than that of bicycle due to its greater mass. From this we can understand that greater mass has greater inertia and small mass has small inertia.

Newton's Laws of Motion

Sir Isaac Newton, the famous British Scientist, has given three laws to describe the motion of objects. These laws were published in 1687 AD. Here, we discuss his three laws of motion.

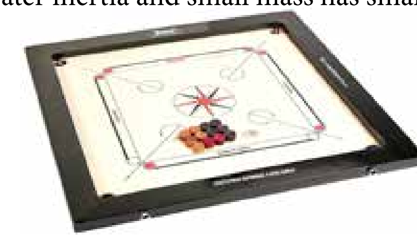


Fig. 7.15

Interpretation of the the Newton's first law of motion

According to Newton's first law of motion, everybody wants to continue its original state of rest or uniform motion unless it is acted upon by an external force. This law gives the concept of inertia and also defines force. Therefore, this law of motion is called the law of inertia.

To understand Newton's first law of motion, you do following activity by yourself.

Activity 7.7

Likewise in figure in a carrom board, put the carrom men one above another. Strike its bottom men with its striker and observe it. Discuss about it among your classmates.

At first the bottom man comes out from its pile and remaining men remain at same position as before. Here, at first the striker exerts force at bottom men. While striking, then it comes in motion but it does not exert force on remaining men. So, they remain at rest. According to this activity, we can define first law of motion:

Every body continues in its state of rest or uniform motion in a straight line unless it is acted upon some external forces.

This is called Newton's first law of motion. This law is completely about inertia. To transfer body at rest inertia into body at motion inertia and vice versa, force is needed. So, it is called law of inertia. This law also defines the force.

Examples of first law of motion

i. If we shake an orange tree, the oranges fall down.

It is because the shaking of orange tree brings the branches in motion however, the oranges tend to remain at rest due to inertia of rest. As a result, the oranges get detached and fall down.

ii. A person (passenger) while getting out of a moving bus falls in forward direction.

It is because when she/he steps down from a moving bus, his/her feet come at rest whereas the upper part of his/her body remains still in motion and she/he falls in forward direction. In order to avoid falling down, a passenger, getting out of a moving bus has to run forward in the same direction for some distance.

iii. When a bullet is fired from a gun on a window sheet, it makes a distinct hole on it without making cracks.

It is because the window sheet is in the state of rest and whole window sheet cannot share the motion of fired bullet, only bullet sized part shares the motion of bullet due to inertia rest. Therefore, a bullet makes a clear holes on the window sheet without any cracks.

iv. Before taking a long jump, athletes run for some distance.

It is because the running changes the state of athletes from rest to motion which helps them to cover a longer distance.

v. When we switch off the running fan, the blades of a fan continue to rotate for certain time.

It is due to the inertia of motion of the blades. However, after some time, fan stops due to frictional force.

Newton's Second Law of Motion

When a force is applied on a body, it produces an acceleration in the body. The acceleration produced depends upon the mass of the body and the force applied. If great force is applied, the body accelerates more. If the body is heavy, it accelerates less. In other word, the higher the force applied, the greater would be the acceleration produced. Also the higher the mass of the body the lower would be the acceleration produced.

Newton's second law of motion gives the relationship between (i) acceleration and force and (ii) acceleration and mass of a body concerned.

It states that the acceleration produced in a body is directly proportional to the force applied and inversely proportional to its mass.

That is,

acceleration $\propto$ force .... (1) [keeping mass (m) constant]

and

acceleration $\propto \frac{1}{mass}$ force [keeping force (F) constant]

This is called Newton's second law of motion.

Newton's second law of motion is called the real law of motion because the first and third law of motion can be derived from it.

Activity 7.8

Effect of Force on Acceleration

Strike the football on the ground by your foot. It produces acceleration on football. Again, strike the ball with great force than before. Now, the ball accelerates more than before.
It is clear that produced acceleration is directly proportional to the applied force by keeping its mass constant.

Where, $a \propto F$, [$\because$ mass (m) = constant]

F = applied force

a = acceleration produced in a body.

Effect of Mass on Acceleration

Take a spring balance and two bodies having different masses. Pull both bodies separately with equal force in the same direction by using the spring balance. What is the difference in the motion of the bodies? Why does it happen? Think about it. The body having less mass accelerates more and the body having greater mass accelerates less. Heavy body accelerates less and lighter body accelerates more.
From this we become clear that keeping force constant acceleration produced on a body is inversely proportional to its mass.

i.e. $a \propto \frac{1}{m}$ [$\because$ Force (F) = Constant]

Interpretation of Newton's Second Law of Motion

Let's consider that a body of mass (m) is accelerated with acceleration (a) by applying the force (F). Then from second law of motion:

$a \propto F$ .... (i) [$\because$ m = constant]

$a \propto \frac{1}{m}$ ....(ii) [$\because$ F = constant]

Combining eqn. (i) and (ii), we get

$a \propto \frac{F}{m}$

$\therefore$ $F \propto ma$

or, $F = k\,ma$ ....(iii)

where, k is the proportionality constant.

According to the definition of force, if unit of mass is accelerated by 1 m/s^2, 1 N force is required. If m = 1 kg and a = 1 m/s^2 then F = 1 N

Put F = 1 N in eqn. (iii), then k = 1

$\therefore$ F = ma -------------------------------- (iv)

This mathematical relation helps to find the quantity of force. Thus, Newton's second law measures the magnitude of force.

The amount of force that produces an accelerartion of $1 m/s^2$ when applied on object of mass 1 kg is called 1 N.

i. e. $1N = 1 \text{ kg} \times 1 \text{ m/s}^2$

Related Numerical Problems

1. A car having mass 1200 kg. is moving with velocity 50 m/s. By seeing a child on the way, the driver applies break. If the speed of car reduces to 20m/s in 20s. What is its retardation? How much force is applied on the car by driver?

Solution,

Here,

Initial velocity of car (u) = 50 m/s
Final velocity of the car (v) = 20 m/s
Time taken (t) = 20 s
Mass of car (m) = 1200 kg.
Acceleration produced on car (a) = ?
Force applied on car (F) = ?

We know that,

$$a = \frac{v - u}{t}$$

$$= \frac{20 - 50}{20} = \frac{-30}{20}$$

$$\therefore \quad a = -1.5 \text{ m/s}^2$$

$\therefore$ Negative sign indicates the retardation.

Again,

$$F = ma$$
$$= 1200 \times -1.5$$

$\therefore$ F = – 1800 N [Negative force indicates retarding force.]

$\therefore$ Retardation of car is 1.5 m/s^2 and applied retarding force on car is 1800 N.

2. A cricket ball having mass of 0.2kg. is moving with a velocity of 15 m/s is brought to rest by a player in 0.05s. Find the average force applied by the player.

Solution,

Here,

Mass (m) = 0.2kg
Initial velocity (u) = 15m/s
Final velocity (v) = 0 [ball is brought to rest]
time taken (t) = 0.05sec.
retardation (– a) =?
and force (F) =?

Since we have,

$$v = u + at$$

or, $0 = 15 + a \times 0.05$

or, $0 = 15 + 0.05a$

or, $-0.05a = 15$

or, $-a = \dfrac{15}{0.05}$

$\therefore$ $-a = 300 m/s^2$

Again, we have,

Force (F) $= ma$

or, F $= 0.2 \times (-300)$

$= -60N$

$\therefore$ Force (F) $= -60N$

Hence, the average force applied by a player to stop a moving ball is 60N.

Here, the negative sign indicates that the force is applied in the opposite direction to the motion of the ball.

Examples of Newton's Second Law of Motion

i. **A cricketer while catching a ball moves his hands backwards.** When batsman strikes a cricket ball, initially it is moving with a certain velocity (u). When player catches the balls, its final velocity (v) becomes zero if v = 0.

we have,

$$\text{Force (F)} = ma = m\left(\frac{v - u}{t}\right)$$

$$= \frac{mv - mu}{t}$$

Here, $mv - mu$ is constant,

Therefore,

$F \propto \dfrac{1}{t}$ i.e. force is inversely proportional to the time of impact (t).

By moving his hands backwards, player increases the time of impact and thereby decreasing force and hence can catch the ball safely and is saved from injury.

ii. **For a fast running bicycle, it is easier to stop by taking a long time rather than stopping it suddenly.** It is so because when the bicycle is stopped suddenly, the time period becomes less which increases retardation [$\therefore a = \dfrac{v - u}{t}$] and due to increased retardation, greater amount of effort is required [$\therefore F = ma$]. However, when the bicycle is stopped by taking a long time, the condition gets reversed thereby making it easier to stop a fast running bicycle.

iii. **It is easier to drag a large stone than to kick it.** It is so because dragging requires more time than kicking the stone. Since we have $a \propto \dfrac{1}{t}$.

Due to more time required for dragging a large piece of stone, there will be less acceleration produced which requires less effort to drag stone. However, in case of kicking, the condition gets reversed and we may get injured seriously.

iv. **It is easier to push an empty shopping cart than full one.** It is because the full shopping cart has more mass [F = ma and F $\propto$ m] than the empty one. Hence, more force is required to push the full shopping cart.

v. **If we kick a ball in space, it would keep on going (may be forever).** It is because there is no gravity, friction or air resistance going against it i.e. there is no any external agency (force) to oppose its state. It will only stop going in one direction if it hits something like a meteorite or reaches the field of another planet.

Newton's Third Law of Motion

When we are swimming we push the water backward with our hands and feet. As a result of this, we move forward. To move forward we need a force. This force is produced by pushing the water backward. We apply force in water backward so the water pushes our body forward. Similarly, when a rocket is launched, the fuel brunt rushes out with great force towards the ground and the rocket moves upward. Similarly, when a plastic ball is striked on the ground, it bounces back. From these activities involves a pair of forces. These forces are equal in magnitude but acts in opposite direction.

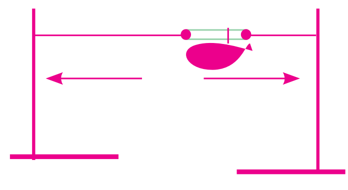


Fig. 7.16

According to Newton's Third Law of motion, "to every action, there is an equal and opposite reaction." This law explains nature of force. It makes us clear that force always exits in pair. The pair of the forces involved is called action and reaction.

Examples of Newton's Third Law of Motion

i. During launching of rocket the burnt gases comes out vertically downward with great force and rocket flies up.
ii. When a bullet is fired from the gun, bullet moves forward direction but gun moves backward.
iii. While rowing a boat, a person pushes water backward and the boat moves forward.
iv. It is difficult to walk on a slippery ground or sandy surface. It is so because we are unable to push the ground sufficiently hard. As a result, reaction is not sufficient enough to help us to walk.
v. During flying, birds push air with their wings (action). The air applies an equal and opposite force on the birds (reaction) and the force causes birds to fly in the sky.

Activity 7.9

Stretch a nylon rope across two poles or walls and tie two ends of the rope on opposite walls or the poles. Making slope slightly at one end to compensate the friction. Make a paper spool by rolling a piece of paper. Push the spool on the higher level of the rope.

Inflate a balloon and fix the balloon in the spool with the help of piece of tape making its face towards the higher level of the rope. Then release the air from the balloon by opening its mouth. What happens? Observe it. Observe the direction of motion of balloon when air comes out of the open mouth of the balloon.

When air comes out of the open mouth of the balloon, the air coming out from it pushes in opposite direction. Air coming out of the balloon is action and motion of balloon in opposite direction is reaction. From this we can explain Newton's third law of motion.

Activity 7.10

- Request two children to stand on two separate carts as shown in below.
- Give them a bag full of sand or some other heavy object. Ask them to play a game of catch with the bag.
- Does each of them receive an instantaneous reaction as a result of throwing the sand bag (action)?
- You can paint a white line on cartwheels to observe the motion of the two carts when the children throw the bag towards each other.

Elasticity and Plasticity

By now, you probably know about the concept of elasticity. In layman terms, it means that some substances get back to their original shape after being stretched. You have played with a slingshot. Haven't you? That is an elastic material.

Fig. 7.17

A rigid body generally means a hard solid object having a definite shape and size. But in reality, bodies can be stretched, compressed and bent. Even the appreciably rigid steel bar can be deformed when a sufficiently large external force is applied on it. This means that solid bodies are not perfectly rigid. A solid has definite shape and size. In order to change (or deform) the shape or size of a body, a force is required. If you stretch a helical spring by gently pulling its ends, the length of the spring increases slightly. When you leave the ends of the spring, it regains its original size and shape. The property of a body, by virtue of which it tends to regain its original size and shape when the applied force is removed, is known as elasticity and the deformation caused is known as elastic deformation. However, if you apply force to a lump of putty or mud, they have no gross tendency to regain their previous shape, and they get permanently deformed. Such substances are called plastic and this property is called plasticity. Putty and mud are close to ideal plastics. The elastic behaviour of materials plays an important role in engineering design. For example, while designing a building, knowledge of elastic properties of materials like steel, concrete etc. is essential. The same is true in the design of bridges, automobiles, ropeways etc. One could also ask — Can we design an aeroplane which is very light but sufficiently strong? Can we design an artificial limb which is lighter but stronger? Why is glass brittle while brass is not?

We also know that in a solid, each atom or molecule is surrounded by neighbouring atoms or molecules. These are bonded together by interatomic or intermolecular forces and stay in a stable equilibrium position. When a solid is deformed, the atoms or molecules are displaced from their equilibrium positions causing a change in the interatomic (or intermolecular) distances.

When the deforming force (a force which produce a change in configuration (size or shape) of the object on applying it) is removed, the interatomic forces tend to drive them back to their original positions. Thus, the body regains its original shape and size.

Elasticity	Plasticity
Elasticity is the ability of an object or meterial to resume its normal shape after being stretched or compressed.	Plasticity is the quality of being easily shaped or moulded.
Deformation is reversible	Deformation is irreversible.
Materials showing elasticity hav elastic properties.	Materials showing elasticity do not have elastic properties.
Materials showing elasticity do not break quickly apart when stretched.	Materials showing plasticity breaks apart quickly when stretched.
Materials that can reversibly deform to a high extent show elasticity.	Materials that are either ductile or brittle when comparatively a small stress is applied show plasticity.

Table 7.5

Project Works

i. Build a balloon-powered toy car using the materials available around you.

ii. Make a list of examples that prove Newton's first, second, and third laws of motion and discuss them in the classroom.

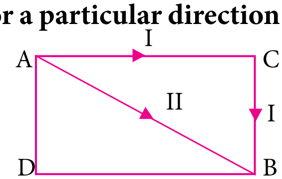
Exercise

A. Choose the correct one and put the tick mark(√)

i. The rate of change of distance per unit time in a straight line or a particular direction is called

a. Speed b. Velocity

c. Displacement d. Acceleration



ii. Two persons start from position A and reach to position B by two different paths ACB and AB respectively as shown in Figure.

a. Their distances travelled are same

b. Their displacement are same

c. The displacement of I > the displacement of II

d. The distance travelled by I < distance travelled by II

iii. An object initially at rest moves for t seconds with a constant acceleration a. The average speed of the object during this time interval is

a. $\frac{at}{2}$ b. 2at

c. $\frac{at^2}{2}$ d. $\frac{a^2t}{2}$

iv. A car starts from rest with a uniform acceleration of 4 ms^{-2}. The distance travelled in metres at the ends of 1s, 2s, 3s and 4s are respectively,

a. 4, 8, 16, 32 b. 2, 8, 18, 32
c. 2, 6, 10, 14 d. 4, 16, 32, 64

v. Total distance divided by total time is

a. average speed b. constant speed
c. instantaneous speed d. acceleration

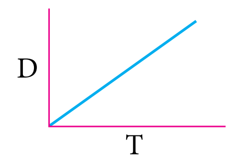
vi. What is velocity?

a. the quickness of an object b. the location of an object
c. acceleration d. speed in a specific direction

vii. The correct equation to calculate speed is

a. distance/time b. time/distance
c. distance × time d. distance/time^2

viii. The graph represents



a. Acceleration b. No motion
c. Deceleration d. Constant Velocity

ix. There are two statements
Statement A Newton's first law is valid from the pilot in an aircraft which is taking off Statement B, Newton's first law is valid from the observer in a train moving with constant velocity which of the following is correct?

a. A only b. B only
c. Both A and B are correct d. Both A and B are wrong

x. Dust can be removed out a blanket using :

a. Law of inertia
b. Newton's second law of motion
c. Newton's third law of motion
d. Newton's second law of gravitation

xi. According to the third law of motion, action and reaction

a. always act on the same body
b. always act on different bodies in opposite directions
c. have same magnitude and directions
d. act on either body at normal to each other

xii. When a car at high speed makes a sharp turn, the driver in a car tends to get thrown to the side opposite to the turn. This is due to the

a. inertia of motion b. inertia of time
c. inertia of rest d. inertia of direction

xiii. Which of the following is an incorrect statement?

a. Mass is measure of inertia of a body.
b. Newton's first law of motion is the law of inertia.
c. Unbalanced force produces constant velocity.
d. Newton's third law talks about the direction of the force.

B. Fill in the following blanks with suitable words :

i. Displacement is a……………… quantity whereas distance is a……………

ii. The physical quantity which gives both, the speed and direction of motion of a body is called its……………………….

iii. A motorcycle has a steady……………. of 3 m/s^2. This means that every………………. its…………….. increases by…………

iv. Velocity is the rate of change of……………………… It is measured in.

v. According to second law of motion "the rate of change of momentum is directly proportional to ……………… applied".

vi. According to third law of motion "to every action there is an equal and ……………… reaction and they act on two different bodies".

C. Differentiate with examples

i. displacement and distance

ii. Displacement-time graph and velocity-time graph

iii. Inertia of rest and inertia of motion

iv. Elasticity and Plasticity

D. Give reasons to these statements.

i. When an object falls freely to the ground, its acceleration is uniform.

ii. Even though the magnitudes of action force and reaction force are equal and their directions are opposite, their effects do not get cancelled.

iii. It is easier to stop a tennis ball as compared to a cricket ball, when both are travelling with the same velocity.

iv. When a motorcar makes a sharp turn at a high speed, we tend to get thrown to one side.

v. It is dangerous to jump out of a moving bus.

vi. Passengers are jerked backward if the bus starts to move suddenly.

vii. Dust particles falls down if the carpet is bitten with stick.

viii. A long jumper runs some distance before jumping.

ix. A boat comes back when jump out of it.

E. Answer the following questions :

i. Define the term displacement.

ii. Define average speed.

iii. What is inertia?

iv. State Newton's first law of motion.

v. State Newton's second law of motion.

vi. State Newton's III law of motion.

vii. Which will have more inertia a body of mass 10 kg or a body of mass 20 kg?

viii. Why are roads on mountains inclined inwards at turns?

ix. Why do you think it is necessary to fasten your seat belts while travelling in your vehicle?

x. When you kick a football it flies away but when you kick a stone you get huh why?

xi. If a person jumps from a height on a concrete surface he gets hurt. Explain.

xii. What is the relation between Newton's three laws of motion?

xiii. Give any three examples in daily life which are based on Newton's third law of motion.

xiv. Explain different types of inertia. Give 3 examples in daily life which shows inertia.

xv. What is elasticty. How is plasticity related to elasticity?

F. Derive the formula (where the symbols have usual meanings) ::

i. $v = u + at$.
ii. $v^2 = u^2 + 2as$.
iii. $s = ut + \frac{1}{2}at^2$
iv. $F=m.a$

G. Critical Thinking Questions :

i. What is the difference between 'distance travelled' by a body and its 'displacement'? Explain with the help of a diagram.
ii. Place a water-filled tumbler on a tray. Hold the tray and turn around as fast as you can. We observe that the water spills. Why?
iii. Class IX students were playing cricket with the cork hall in the school campus. Monika a senior student told them about the accidents that can occur due to cork ball in the campus and also advised them to bring soft cosco ball to play the game.
   (a) Why it was safe to play with soft ball and not with hard cork ball?
   (b) A player pulls his hands backwards after holding the ball shot at high speed. Why?
   (c) What value of Monika is seen in this act?

H. Numerical problems

i. A motorcyclist drives from place A to B with a uniform speed of 30 km h^{-1} and returns from place B to A with a uniform speed of 20 km h^{-1}. Find his average speed.
ii. A cyclist starts from rest and reaches a speed of 6 m/s after travelling with uniform acceleration for 3 s. What is his acceleration?
iii. An aircraft travelling at 600 km/h accelerates steadily at 10 km/h per second. Taking the speed of sound as 1100 km/h at the aircraft's altitude, how long will it take to reach the 'sound barrier'?
iv. If a bus travelling at 20 m/s is subjected to a steady deceleration of 5 m/s^2, how long will it take to come to rest?
v. The distance between Kathmandu and Rajbiraj is 300 km. A bus travels the first 100 km at a speed of 50 km/h. How fast must the bus travel the next 100 km, so as to average 70 km/h for the whole journey?
vi. A car is moving along a straight road at a steady speed. It travels 150 m in 5 seconds :
   (a) What is its average speed?
   (b) How far does it travel in 1 second?
   (c) How far does it travel in 6 seconds?
   (d) How long does it take to travel 240 m?
vii. Find the initial velocity of a car which is stopped in 10 seconds by applying brakes. The retardation due to brakes is 2.5 m/s^2
viii. Describe the motion of a body which is accelerating at a constant rate of 10 m s^{-2}. If the body starts from rest, how much distance will it cover in 2 s?
ix. A motorcycle moving with a speed of 5 m/s is subjected to an acceleration of 0.2 m/s^2. Calculate the speed of the motorcycle after 10 seconds, and the distance travelled in this time.
x. A bus running at a speed of 18 km/h is stopped in 2.5 seconds by applying brakes. Calculate the retardation produced.
xi. A train starting from rest moves with a uniform acceleration of 0.2 m/s^2 for 5 minutes. Calculate the speed acquired and the distance travelled in this time.
xii. A cyclist is travelling at 15 m s^{-1}. She applies brakes so that she does not collide with a wall 18 m away. What deceleration must she have?

xiii. Boy runs for 20 min. at a uniform speed of 18km/h. At what speed should he run for the next 40 min. so that the average speed becomes 24km/hr.

xiv. A train accelerated from 10km/hr to 40km/hr in 2 minutes. How much distance does it cover in this period? Assume that the tracks are straight?

xv. A train starts from rest and accelerate uniformly at the rate of 5 m/s^2 for 5 sec. Calculate the velocity of train in 5 sec.

xvi. A bullet leaves a rifle with a muzzle velocity of 1042 m/s. While accelerating through the barrel of the rifle, the bullet moves a distance of 1.680 m. Determine the acceleration of the bullet (assume a uniform acceleration)

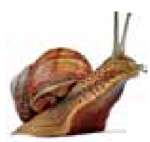
xvii. A bike riding at 22.4 m/s skids to come to a halt in 2.55 s. Conclude the skidding distance of the bike.

xviii. A race scooter is seen accelerating uniformly from 18.5 m/s to 46.1 m/s in 2.47 seconds. Determine the acceleration of the scooter and the distance travelled.

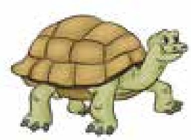
xix. A car is travelling with a speed of 36 km/h. The driver applied the brakes and retards the car uniformly. The car is stopped in 5 sec. Find i. The acceleration of car and ii. Distance before it stops after Applying breaks?

I. Diagrammatic Questions

a. Calculate the average speed of snail, tortoise and sprinter (in red vest):



The snail covers a distance of 100 meters in 50 hours



The tortoise cover the same distance of 100 metres in 15 minutes.

And this sprinter (in red vest cover a distance of 100 metres in just 9.83 second.

i. The snail covers a distance of 100 metres in 50 hours. Calculate the average speed of snail in km/h.

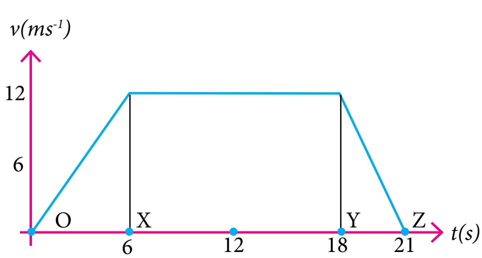
ii. The tortoise covers a distance of 100 metres in 15 minutes. Calculate the average speed of tortoise in km/h.

iii. A sprinter (in red vest) covers a distance of 100 metres in 9.83 seconds. Calculate the average speed of snail in km/h.

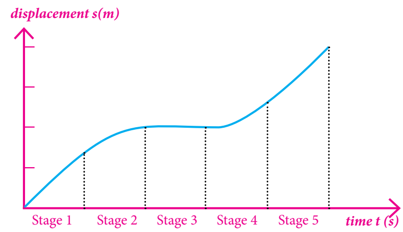
b. Figure shows the velocity-time graph for a moped, which travelled between two sets of traffic lights on a straight road.

i. What is the moped's acceleration in each of the time intervals OX, XY and YZ?

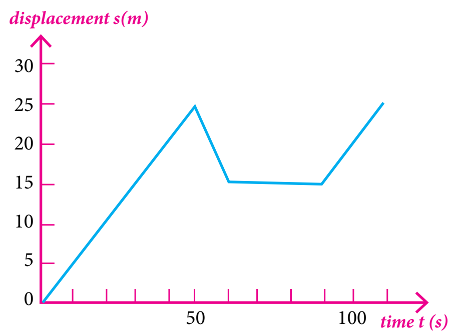
ii. What was the total distance between the two sets of traffic lights?



c. **Given figure is the displacement-time graph for a car encountering a traffic light. Describe the motion of the car at each stage qualitatively.**

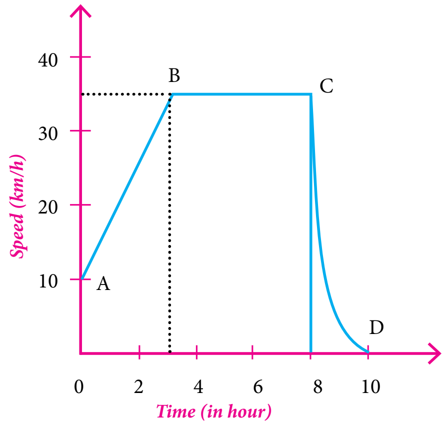


d. **A boy walks at a velocity of 0.5 m s^{-1} along a street for 50 s, suddenly he remembers that he has to buy something in a shop that he has passed by, so he turns around and walks at a velocity of -1m s^{-1} for 10 s. He then stops for 30 s at the shop, and finally walks forward again at 0.5 m s^{-1} for another 20 s. Plot a displacement-time graph for the motion of the boy.**



e. **The graph given alongside shows how the speed of a car changes with time.**

i. What is the initial speed of the car?
ii. What is the maximum speed attained by the car?
iii. Which part of the graph shows zero acceleration?
iv. Which part of the graph shows varying retardation?
v. Find the distance travelled in first 8 hours.



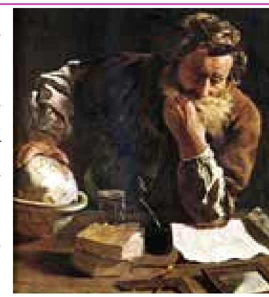
Unit 8

Machine

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- define inclined plane, pulleys and wheels and axle as simple machines
- solve mathematical problems related to mechanical advantage and velocity ratio
- explain the working principle of a simple machine
- introduce efficiency of a simple machine
- describe a complex machine as a combination of simple machines



In ancient Greece a scientist, mathematician and inventor named **Archimedes** (c.287-212 BC) came up with the idea that there are simple machines which can be used to make work easier.These machines could change the direction of movement and could lessen the amount of work needed for moving things. Later, scientists and artists like **Galileo** and **Da Vinci** advanced this idea and came up with the six simple machines we have today: pulley, screw,wheel and axle,wedge, lever and inclined plane.

Archimedes designed all sorts of pumps and the Archimedean water screw is still in use in some parts of the world. The story of Archimedes jumping from the bath naked is usually linked with his discovery of the principle of hydrostatics. Archimedes discovered the laws of levers and used pulleys. After the discovery of the laws of the levers, he boasted ***'Give me a place to stand and rest my lever on, and I can move the Earth'.***

8.1 Introduction

We can use a machine to transform energy, transfer energy, multiply speed, multiply force, or change the direction of a force so we can accomplish work more quickly, easily, or both.A simple machine is a device that does work with only one moment.

We use a number of devices in our daily life. These devices are useful to us in many ways. We use a pulley to draw water from well. If the tyre of a car or bus is to be replaced, the screw jack is used to lift the car or bus. Loading of truck is done with the help of an inclined plane. Similarly, in our daily life we use scissors, forceps, knives, punching machine, bicycle, fire tongue, etc. All these devices are simple in structure and they make our works easier, faster and more convenient due to their simple structure. They are called simple machines.

The tools or instruments which are used in our daily life to make our work more easier, faster and comfortable by reducing both time and labour are called simple machines. Knife, scissors, wheel and axle, pulley etc. are some examples of them.

Nail cutter, broom, scissors, fire tongue, beam balance, crowbar, wheel and axle, inclined plane, screw, pulley, sewing machine, screw jack, ladder, etc. are some other examples of simple machine. These devices do not need other energy sources like diesel, petrol, electricity, etc. They run only by human effort (force).

When a force is applied on them:

i. they make work easier,
ii. they change direction of force,
iii. they enhance the speed of work,
iv. they transfer force from one point to another point.

Simple machines are devices that can be used to multiply or augment a force that we apply – often at the expense of a distance through which we apply the force. The word for 'machine' comes from the Greek word meaning 'to help make things easier'.

Mechanical Advantage (MA)

Force is required to do work by simple machine. The resistive force which has to be overcome in a simple machine is called load (L) and the force applied in order to overcome the load is called effort (E).

The ratio of the load to the effort applied in a simple machine is called mechanical advantage (MA) of that machine.

Mathematically,

$$\text{Mechanical Advantage (MA)} = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

i.e. $\therefore \text{MA} = \frac{L}{E}$ Where, L = Load E = Effort

By using simple machine we can lift a heavy load by applying less effort. Machine makes our work easier. In mathematical definition this is called mechanical advantage. It can be defined as the ratio of load overcome by machine to the effort applied.

It has no unit because it is the ratio of two similar physical quantities (i.e. two forces). It is the measure of number of times by which a simple machine multiplies the applied force. For example:

When a man applied 100 N force to lift the heavy load of 500 N by using simple machine, the MA of this machine is :

$$\text{MA} = \frac{L}{E} = \frac{500}{100} = 5$$

It means that a man can lift a load five times heavier than the effort applied by using that simple machine. If the mechanical advantage of a machine is 1, it means that the machine can not multiply the applied effort. Such machine makes our work easier by changing the direction of force. The machine whose mechanical advantage is more than 1 increases the rate of doing work.

Velocity ratio (VR)

The ratio of velocity of effort to velocity of load is called velocity ratio (VR).
i.e.

$$\text{Verocity (VR)} = \frac{\text{Velocity of effort}}{\text{Velocity of load}}$$

$$\text{or,} \quad VR = \frac{\dfrac{\text{Distance travelled by effort}}{\text{time interval}}}{\dfrac{\text{Distance travelled by load}}{\text{time interval}}}$$

As load and effort travel particular distance in the same interval of time.

$$VR = \frac{\text{Distance travelled by effort}}{\text{Distance travelled by load}}$$

$$\therefore VR = \frac{\text{Effort distance (Ed)}}{\text{Load distance (Ld)}}$$

Thus, velocity ratio is the ratio of distance travelled by effort to distance travelled by load. It does not have unit because it is the ratio of two distances.

By using any simple machine if load covers 25m distance when effort travels 50m, then velocity ratio of that machine is:

$$VR = \frac{\text{Distance travelled by effort}}{\text{Distance travelled by load}}$$

$$\text{or,} \quad VR = \frac{50}{25} = 2 \qquad \therefore \qquad VR = 2$$

It means effort has to move twice the load distance to lift a load up to a particular height. The velocity ratio of any simple machine is greater than mechanical advantage because frictional force does not affect the velocity ratio but it affects the mechanical advantage.

Input work

The work done by effort on a machine is called Input work.

Mathematically,

i.e. Input work = work done by effort

= effort $\times$ effort distance = $E \times Ed$

Output work

The work done by load on a machine is called output work. Mathematically,

i.e. Output work = work done by load

= load $\times$ load distance = $L \times Ld$

Efficiency (η)

The efficiency of a simple machine can be defined as the ratio of useful work done by the machine (output work) to the total work put into the machine (input work).

Mathematically,

$$\text{Efficiency } (\eta) = \frac{\text{Output Work } (L \times Ld)}{\text{Input Work } (E \times Ed)} \times 100\%$$

Efficiency is the ratio of two works and it is expressed in percentage.

Relation between MA, VR and (η)

Since we know that,

Efficiency $(\eta) = \dfrac{\text{Output Work}}{\text{Input Work}}$ $\eta = \dfrac{\text{Work done by load}}{\text{Work done by effort}} \times 100\%$

or, $\eta = \dfrac{L \times Ld}{E \times Ed} \times 100\%$ or $\eta = \dfrac{L}{E} \times \dfrac{Ld}{Ed} \times 100\%$

or, $\eta = \dfrac{L}{E} \times \dfrac{1}{\dfrac{Ed}{Ld}} \times 100\%$ or, $\eta = \dfrac{MA}{VR} \times 100\%$

$$[\, MA = \frac{L}{E} \text{ and } VR = \frac{Ed}{Ld} \,] \therefore \eta = \frac{MA}{VR} \times 100\%$$

Hence, Efficiency is the ratio of mechanical advantage to the velocity ratio expressed in percentage.

In a simple machine, some amount of input work is always wasted in the form of heat due to friction. Hence, the value of output work is always less than the input work because no machine can be made frictionless. Due to this reason, a simple machine can not have 100% efficiency. If in any machine input work is equal to output work, then such machine is called an ideal machine or perfect machine. Such type of machine has no frictional force and has 100% efficiency.

However, in practice there is no machine without friction. The friction in the moving parts of a machine can be decreased by applying grease or lubricating oil. This increases the efficiency of the machine.

The efficiency of a simple machine is 80%, what do you mean by it ?

80% efficiency of a machine indicates that 80% of the input work is converted into useful work and remaining 20% of energy is converted into heat energy while overcoming the friction.

Effect of Friction on MA, VR and η

The force that opposes the motion of one body when it slides over that surface of another body in contact is called friction or frictional force. The frictional force depends on the nature of surface (rough or smooth), nature of material, and nature of motion (sliding or rolling), etc. Friction causes wastes of kinetic energy in the form of heat energy.

Since the velocity ratio (VR) is the ratio of effort distance (Ed) to load distance (Ld), it is not affected by friction. Therefore, the value of MA is always found lesser than that of VR. In order to increase the value of MA and efficiency (η) of a simple machine, it is necessary to reduce frictional force.

The frictional force in a simple machine can be reduced by:

a. using lubricating oil like grease,
b. using ball bearings, wheels and rollers,
c. making the sliding surface smooth,
d. rolling instead of sliding.

Principle of Simple Machine

A simple machine does not perform work by itself. Hence, we have to apply force on the machine to do a particular work.

All machines work on a basic principle which can be stated as follows.

In a balanced condition, the work done on a machine (input work) is equal to the work done by the machine (output works).

i.e Input work = Output work

or, Effort (E) × Effort distance (Ed) = Load (L) x Effort distance (Ld)

Types of Simple Machine

On basis of structure and function, simple machines are divided into six types.

i. Lever	ii. Pulley	iii. Wheel and axle
iv. Inclined plane	v. Screw	vi. Wedge

Solved Numerical problem

i. Calculate the efficiency of the lever from the data given in figure.

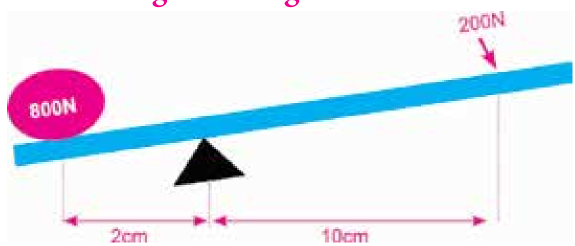


Fig. 8.1

Here,

Load (L) = 800N

Effort (E) = 200N

Load distance (L.d) = 2cm

Effort distance (E.d) = 10 cm

We have,

$$\text{Mechanical advantage (MA)} = \frac{L}{E} = \frac{800}{200} = 4$$

$$\text{Velocity ratio (VR)} = \frac{ED}{LD} = \frac{10}{2} = 5$$

$$\therefore \quad \text{Efficiency } (\eta) = \frac{MA}{VR} \times 100\%$$

$$= \frac{4}{5} \times 100\%$$

$$= 80\%$$

∴ Hence efficiency of the given lever is 80%

ii. If a crowbar is used to lift a load of 300N by applying an effort of 80N. If the load is lifted up to 0.05m and the applied force covers a distance of 0.25m.

Calculate MA, VR and η of a machine (crowbar) from given data (given Ed = 0.75m)

Solution,

Given,

Load (L) = 300N

Effort (E) = 800N

Load distance (Ld) = 0.15m

Effort distance (Ed) = 0.75m

Distance covered by load = 0.05m

Distance covered by effort = 0.25m

Mechanical advantage (MA) =?

and efficiency (η) =?

We have

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}} = \frac{300}{80} = \frac{30}{8} = 3.75$$

and

$$VR = \frac{\text{Effort distance}}{\text{Load distance}} = \frac{0.25}{0.05} = 5$$

Again,

We have

$$\text{efficiency } (\eta) = \frac{MA}{VR} \times 100\%$$

$$= \frac{3.75}{5} \times 100$$

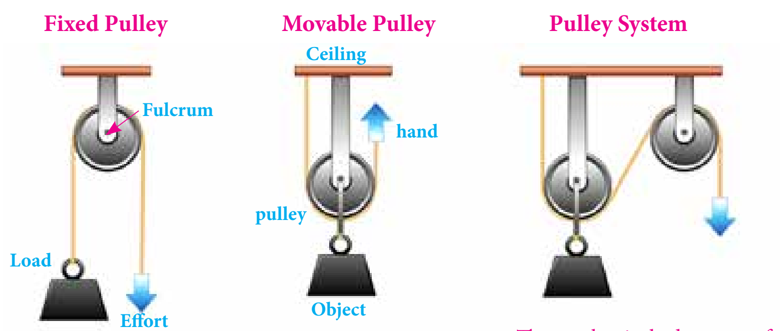
$$= 75\%$$

$\therefore$ MA, VR and η of crowbar are 3.75, 5 and 75% respectively.

Pulley

A pulley is hard metallic or wooden disc with a groove rim. A rope moves around the groove of the disc. The load is tied to one end of the rope and it is pulled from another end of the rope by applying effort.

Types of pulleys



The Mechanical advantage of a fixed pully is 1

The mechanical advantage of a movable pulley is 2

The machanical advantage of a pulley system is equal to the number of sections of rope pulling up on the object

Fig. 8.2

Pulleys are used to draw water from well, to lift heavy load in cranes and in elevators.

There are two types of pulley system : movable and fixed.

Velocity ratio of single fixed pulley is 1. The mechanical advantage of this type of pulley has 1 or less then 1. But we use this pulley to change the direction of applied force.

As increase in the number of pulleys in pulley system, velocity ratio, and mechanical advantage also increase. The velocity ratio (VR) and mechanical advantage (MA) of pulley system is:

Velocity ratio (VR) = The number of rope segments to support the load

= Number of pulley system

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

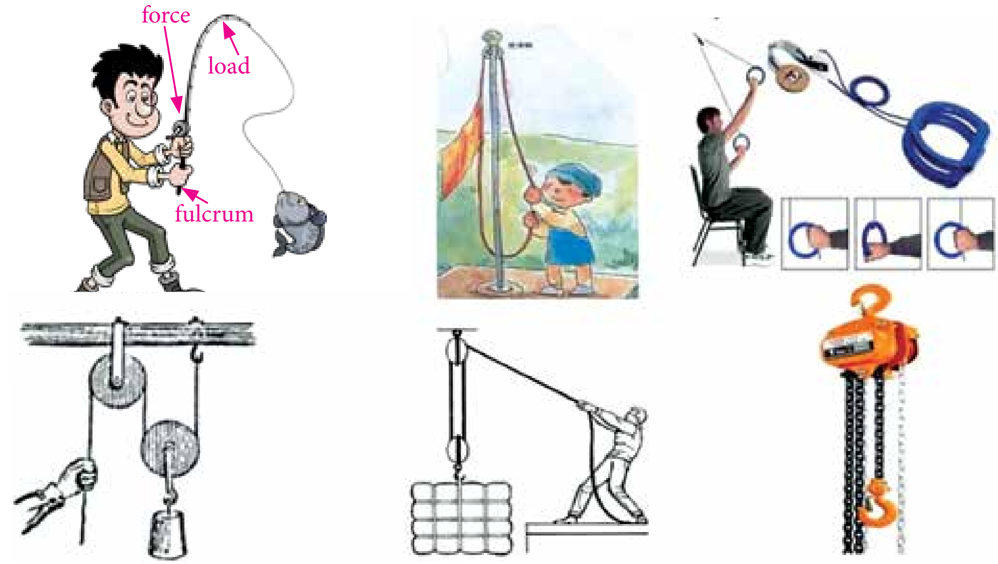
But velocity ratio of single movable pulley is 2.

Quick Question

i. What is pulley ? A pulley system has a velocity ratio 3 and an efficiency of 80%. Draw a labelled diagram of this pulley system. Calculate :
   a. the mechanical advantage of the system, and
   b. the effort required to raise a load of 300 N.

ii. A block and tackle system has 5 pulleys. If an effort of 1000 N is needed in the downward direction to raise a load of 4500 N, calculate :
   a. the mechanical advantage ,
   b. the velocity ratio, and
   c. the efficiency of the system.

These are some other examples of pulley machine



Solved Numerical Problem

The efficiency and mechanical advantage of pulley are 80% and 4 respectively. What is the number of pulley used?

What effort will be needed to lift a load of 1000 N in such pulley system?

Here,

Efficiency (η) = 80% Mechanical Advantage (MA) = 4

Number of pulley (N) = VR = ? Effort (E) =?

Load (L) = 1000 N

We have,

$$(\eta) = \frac{M.A}{V.R} \times 100$$

$$\text{or,} \quad 80 = \frac{4}{V.R} \times 100$$

$$\text{or,} \quad V.R = \frac{4 \text{ x } 100}{80} = 5$$

$\therefore$ N = V.R = 5

Again,
We know,

$$M.A = \frac{L}{E}$$

$$\text{or,} \quad 4 = \frac{1000}{E}$$

$$\text{or,} \quad E = \frac{1000}{4} = 250N$$

Therefore, required number of pulleys and effort in the pulley system are 5 and 250 N respectively.

Activity 8.1

Fix different types of pulley system. Find the efforts to lift 0.4 N load by using that pulley separately.
Similarly, how much effort should be applied to lift 0.6 N and 0.8 N loads?
How long distance should effort travel to lift the load by 30 cm. distance using each pulleys system? Measure it by using scale. Make the table for the measurement and fill it and find their velocity ratio, mechanical advantage and efficiency.

Pulley System	Load Distance	Effort Distance	Velocity Ratio	Load	Effort	MA	Efficiency
1. Fixed	30cm			0.4N 0.6N 0.8N			
2. Movable	30cm						
3. Combined	30cm						

Perfect Machine

The term perfect machine refers to a hypothetical mechanical system in which energy and power are not lost or dissipated through friction, deformation, wear, or other inefficiencies. It is also called ideal machines. Ideal machines have the theoretical maximum performance, and therefore are used as a baseline for evaluating the performance of real machine systems. A simple machine, such as a lever, pulley, or gear train, is 'ideal' if the power input is equal to the power output of the device, which means there are no losses. In this case, the mechanical efficiency is 100%. Mechanical efficiency is the performance of the machine compared to its theoretical maximum as performed by an ideal machine. The mechanical efficiency of a simple machine is calculated by dividing the actual power output by the ideal power output. It means output work and input work are equal; also mechanical advantage (MA) and velocity ratio (VR) are equal. Practically, it is not possible, no any machines are perfect. Its power is usually expressed as a percentage. Power loss in a real system can occur in many ways, such as through friction, deformation, wear, heat losses, incomplete chemical conversion, magnetic and electrical losses.

Inclined plane

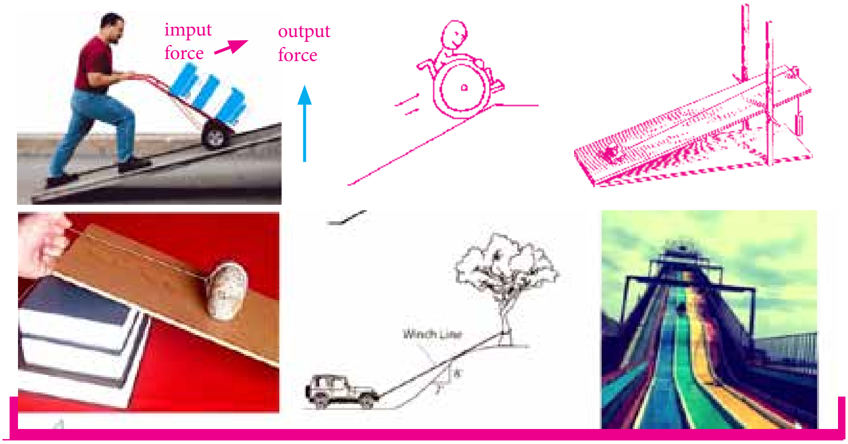


Fig. 8.3

Winding road on hills, spiral stair-case, wooden plank used for loading goods in a truck are examples of inclined plane. Inclined plane is used for lifting the heavy load applying less effort. The inclined plane is defined as:

A slanted surface over which a load can be pulled or pushed is called inclined plane.

Mechanical advantage (MA) and velocity ratio (VR) of inclined plane are:

$$VR = \frac{\text{Length of inclined plane (L)}}{\text{Height of inclined plane (H)}}$$

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

$$\text{efficiency} = \frac{\text{output work}}{\text{input work}} \times 100\%$$

or, $$\text{efficiency} = \frac{\text{length of inclined plane} \times \text{effort}}{\text{height of inclined plane} \times \text{load}} \times 100\%$$

As increasing length of inclined plane by keeping its height remains constant, mechanical advantage and velocity ratio increases. When length of inclined plane increases by keeping its height constant, the angle between inclined plane and the ground surface decreases. In above figure AB is height and BC is length of inclined plane. Keeping the same height and taking length BD instead of BC, the length of inclined plane increases than before. Because of this, velocity ratio of inclined plane increases. From this we conclude that when length of inclined plane increases, its velocity ratio also increases and vice versa.

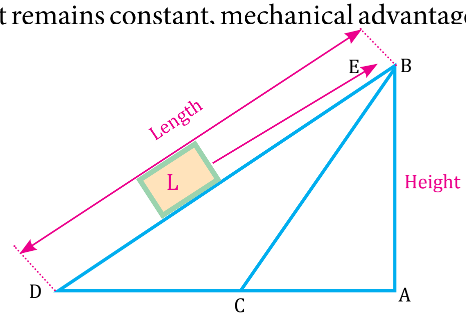


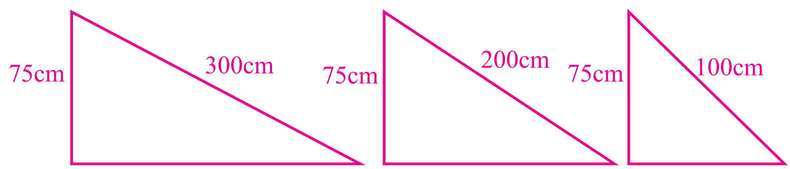
Fig. 8.4

Activity 8.2

Take three wooden plank having length 100 cm, 200 cm and 300 cm. Put them on benches of 75cm height.

As shown in figure, measure the weight of body by using spring balance. The body is pulled up on these inclined planes separately and measure how much effort is applied. Make the table for observed values as below:

S.N.	Inclined Plane						
	Length (d)	Height (h)	VR	Load	Effort	MA	E
1	100 cm	75cm					
2	200cm	75cm					
3	300 cm	75cm					



Answer the following questions.

1. Is mechanical advantage increasing as increasing length of inclined plane?
2. What happens to the efficiency of inclined plane when length of inclined plane increases? Explain with reason. We can find efficiency of inclined plane by another method.

Quick Question

- Define inclined plane.
- How is velocity ratio of inclined plane calculated?

Wheel and axle

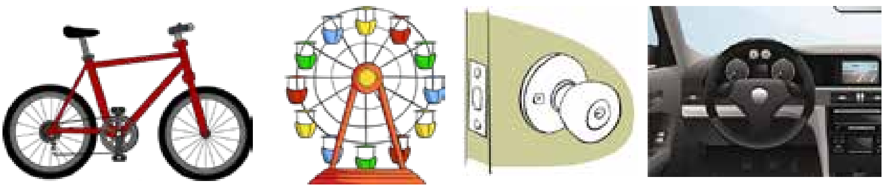


Fig. 8.5

Wheel and axle is a very useful simple machine. Screw driver, door knob, wheel of a vehicle, spanner, handle and paddle of cycle, etc. are some examples of wheel and axle we use in our daily life. The wheel and axle consists of two co-axial cylinders of which, the larger cylinder is wheel and smaller cylinder is axle. Ropes are coiled round both the wheel and axle in opposite directions as shown in figure. When effort is applied on the wheel, it magnifies the effort so that axle can lift the load.

In a wheel and axle, the circumference of larger cylinder (wheel) is considered as effort distance and that of smaller cylinder (axle) is considered as load distance. The MA and VR of wheel and axle can be calculated as:

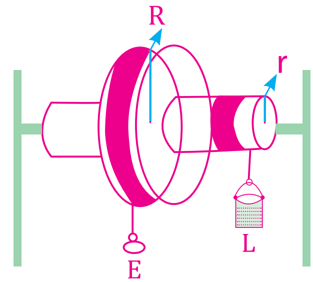


Fig. 8.6

Mechanical advantage (MA) $= \dfrac{Load\ (L)}{Effort\ (E)}$

$\therefore \quad MA = \dfrac{L}{E}$

Similarly,

Velocity Ratio (VR) $= \dfrac{Effort\ distance}{Load\ distance}$

$= \dfrac{2\pi R}{2\pi r}$ *R = radius of wheel*, *r = radius of axle*

$\therefore \quad VR = \dfrac{R}{r}$

Thus, velocity ratio of a wheel and axle is always greater than 1 because the radius of large cylinder (wheel) is always greater than that of smaller cylinder(axle).

Wheel and axle is regarded as a continuous lever because the effort distance and load distance changes continuously while using wheel and axle. The axis of wheel and axle is considered as the fulcrum and it can rotate about 360 degrees. So wheel and axle can be used continuously as a lever while working.

Activity 8.3

Take a wheel and axle, and coil the rope around the axle. A load is connected at another end of the rope. Again, another rope is coiled around wheel and spring balance is connected at its another end. Then measure how much load is required to hold the load. Take different load and repeat the above process. Find radius of wheel and axle.

Answer the following questions.

i. What is the distance travelled by effort and load when a wheel moves one complete revolution?
ii. Find input work and output work.
iii. What is the efficiency of the machine?
iv. What are the factors that affect the efficiency of simple machine?

Solved Numerical Problem

A wheel of diameter 50 cm is connected with an axle of diameter 10 cm if a weight of 1000 N is lifted by applying 250 N force. Calculated MA, VR and efficiency of the machine.

Here,

Load (L) = 1000 N

Effort (E) = 250N

$$\text{Radius of wheel} = \frac{\textit{Diameter of wheel}}{2} = \frac{50}{2}$$

$$\text{Radius of axle (r)} = \frac{\textit{Diameter of axle}}{2} = \frac{10}{2} = 5 \text{ cm.}$$

MA = ? VR = ? Efficiency (η) = ?

We have,

$$MA = \frac{L}{E} = \frac{1000}{250} = 4$$

$$VR = \frac{R}{r} = \frac{25}{5} = 5$$

Again,

$$\eta = \frac{MA}{VR} \times 100\% = \frac{5}{4} \times 100\% = 80\%$$

Thus, MA ,VR and efficiency of the given machine are 4, 5 and 80% respectively.

Screw

Screw is a simple machine which seems to have an inclined plane wrapped around a cylindrical surface. A screw has spiral edges. The distance between the adjacent threads of screw is called pitch. In other word, the distance moved by screw in one complete rotation on being driven into the wood is called pitch.

The VR and MA of screw is given as:

$$MA = \frac{\textit{Load (L)}}{\textit{Effort (E)}} \qquad VR = \frac{\textit{Distance travelled by effort}}{\textit{Distance travelled by load}}$$

$$= \frac{\textit{circumference of circle made by arm of screw driver}}{\textit{Pitch of the screw (P)}}$$

$$\therefore \quad VR = \frac{2\pi R}{P}$$

Jack screw and nail driller are examples of screw.

Examples of screws include:

- wood screws
- the screw in a car jack
- the screw on the lid of a jar
- the blades of a fan
- the blades of an aeroplane propeller.

Fig. 8.7

Wedge

A wedge is a simple machine which has a sharp part at one end and flat part at the another end. The effort is generally applied upon the flat part and the sharper part performs the work. A wedge is used to split the wooden logs. Axle, knife, khukuri, nail, chisel, needle, etc. are the examples of wedge. VR and MA of wedge is given as,

$$VR = \frac{\textit{Distance travelled by effort}}{\textit{Distance travelled by load}}$$

$$= \frac{\textit{Length of wedge (L)}}{\textit{Thickness of wedge (t)}}$$

$$VR = \frac{L}{t}$$

$$MA = \frac{\textit{Load (L)}}{\textit{Effort (E)}}$$

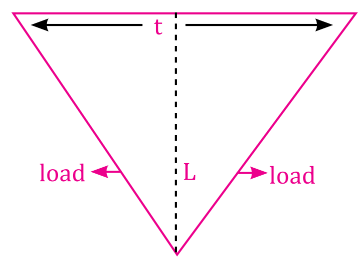


Fig. 8.8

Other examples of wedges include:

- a knife blade
- the point at the end of a nail
- a doorstop that is wedged under a door to prevent it from moving.

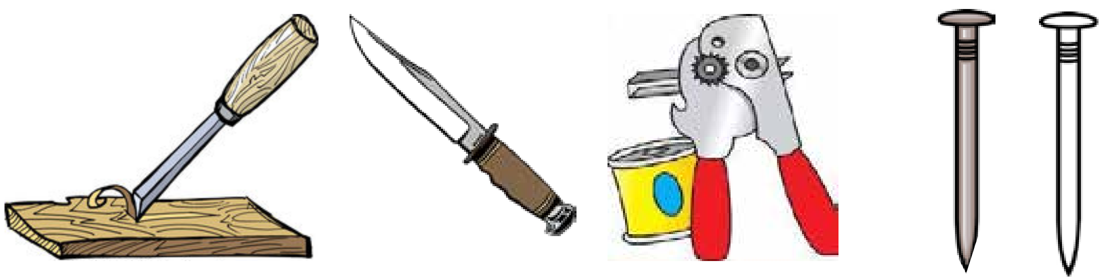


Fig. 8.9

Moment of Force

When an external force is applied on a body it moves either in straight line or in circular path. When we open or close the door. We apply force on it.

The force applied on it makes the door move to the particular axis. This turning effect of force is called moment of force. When we open the nut, we apply force on spinner and that force help to turn. Here, the turning effect of force on nut is called moment. So, it can be defined as.

The turing effect of force acting upon a body about its axis is called moment of force or moment.

Mathematically,

Moment = force $\times$ perpendicular distance from axis of rotation to point of applied force

The factors that affects the moment of force are :

1. The magnitude of applied force (F) and
2. The perpendicular distance line or the line of action made by the force and axis of rotation.

The SI unit of moment of force is newton meter (Nm).

Law of moment

When a body is in equilibrium state, the sum of clockwise moments about any point is equal to the sum of anticlockwise moments about the same point. This is called law of moment.

Activity 8.4

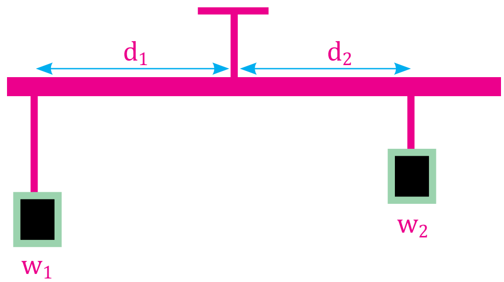
Take a wrench. Fix it on nut. Apply the force on its another end of the wrench. Change the point of action of force between the length of the wrench. Between these two points we feel easy when force is applied at end point.

Obviously we feel easy when force is applied at the end of the wrench. This means the perpendicular distance between axis of rotation and line of action of force increases which increases moment of force. Moment is equal to the product of force and perpendicular distance from axis of rotation.

Activity 8.5

Verification of the law of moment

Make a hole at the middle of the meter scale and pivot it on stand as shown in figure. Now hang different load at the end of the scale. When the load on right side of scale is greater than left. It rotates toward left side (antilock wise direction). But balance the scale by keeping load equal on both side of it.



Now find effort, effort distance, load and load distance. Find load x load distance and effort x effort distance. At balanced condition, they are found equal.

In this way, $load \times load\ distance = effort \times effort\ distance$

or, $w_1 \times d_1 = w_2 \times d_2$

Thus, law of moment is verified.

A complex machine as a combination of simple machines

Complex machines can be created by combining simple machines. They can be as small as a mechanical watch or as large as a construction crane. Complex machines are also called compound machines. Two or more simple machines work together to form a complex machine. Compound machines can do more difficult jobs than simple machines alone. Examples of complex machines are bicycle, wheel barrow, crane, car jack, lawn mover, etc.

Compound Machines

Quick Question

i. How are simple machines and complex machines related?
ii. Is scissors a simple or complex machine?
iii. What are 10 complex machines?
iv. Is a wheelbarrow a complex machine?

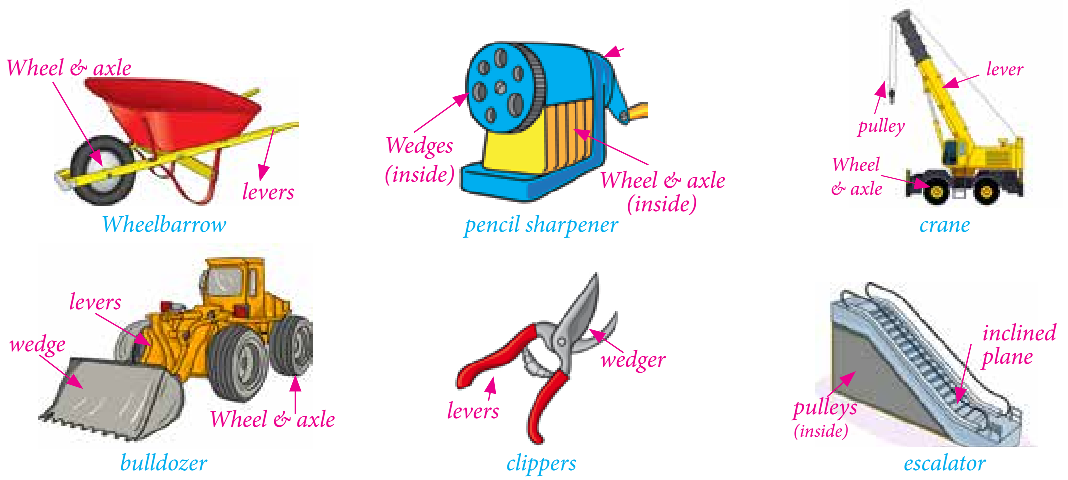


Fig. 8.10

Some Examples of compound machines used in Everyday Life

Scissors

A pair of scissors is a prominent example of complex machines. It is made up of two simple machines, namely a wedge and a lever. The blades of the scissors are wedge-shaped, whereas the handles of the scissors act as the first-class lever.

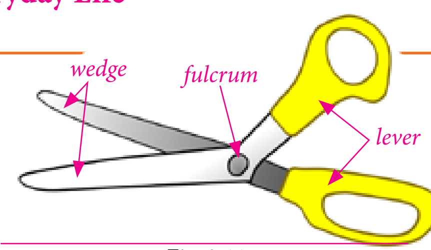


Fig. 8.11

Wheelbarrow

A wheelbarrow is a combination of three simple machines, namely, an inclined plane, a wheel and axle combination, and a lever. The container of the wheelbarrow is an inclined plane that helps to store the load easily. The handles of the wheelbarrow act as levers, allowing the user to lift the load easily. The wheel attached to the base of the wheelbarrow is the wheel and axle arrangement that helps the machine move from one place to another with ease.

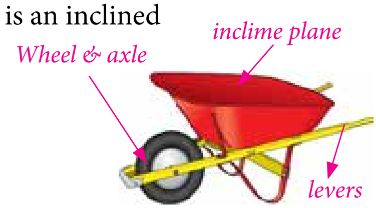


Fig. 8.12

Fishing Rod

The stick of the fishing rod is an example of a first-class lever simple machine where the load is attached at one end, the force or the effort is applied from the opposite end, and the fulcrum is present in the middle. The winding and unwinding of the reel are done with the help of a pulley. The hook attached at one end of the reel is a wedge. Hence, a fishing rod is a compound machine that is formed by merging three simple machines together, namely a lever, a wedge, and a pulley.

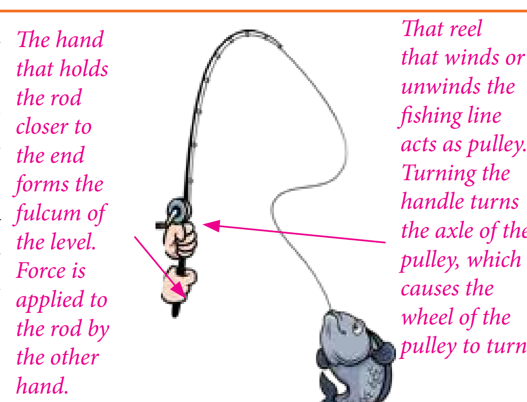


Fig. 8.13

Can Opener

A can opener comprises four simple machines, namely, lever, gear, wheel and axle, and wedge. The arms of the can opener act as two levers that help to grip and open the can. The cutter attached to the mouth of the opener is a wedge that helps the machine pierce right through the metallic body of the can. The round part attached to the opener is the gear that rotates and helps the user hold the can still. The rotating handle is the wheel and axle simple machine that supplies energy to the gear and the wedge.

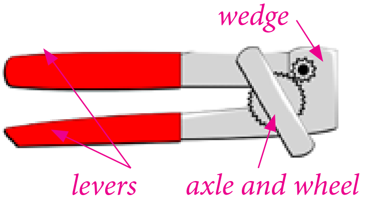


Fig. 8.14

Stapler

A stapler is a complex machine that is made up of two simple machines, namely, a lever and a wedge. The punching mechanism of the stapler acts as the second-class lever, whereas the stapler pins act as the wedges. When the user applies push force to the lever of the stapler, the wedge-shaped stapler pin pierces through the papers, thereby simplifying the task of attaching two papers together.

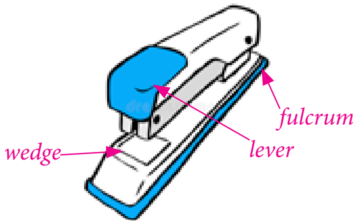


Fig. 8.15

Escalator

Escalators are yet another example of a compound machine. An escalator is made up of two simple machines, namely, a pulley and an inclined plane. The mechanism that helps the escalator belt move comprises a pulley simple machine, while the steps of the escalator are a modified version of inclined planes.

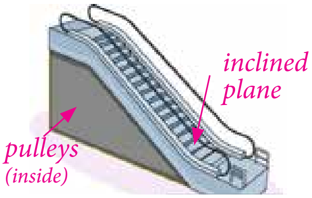


Fig. 8.16

Shovel

A shovel is a compound machine that is a combination of a wedge and a lever simple machine. The arm of the shovel acts as a third-class lever, while the tip of the shovel is a wedge. The lever helps the user move the shovel, and the wedge helps it penetrate the heap of soil or the ground with ease.

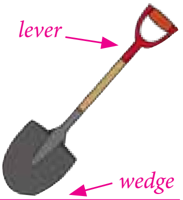


Fig. 8.17

Crane

A crane consists of multiple simple machines, for example, a lever, a pulley, a combination of wheel and axle, etc. The pulley system helps the user pick or lift heavy loads with ease. The frame of the crane to which the pulley is attached is the lever simple machine. The tyres of the crane act as a wheel and axle combination that helps the machine move from one place to another.

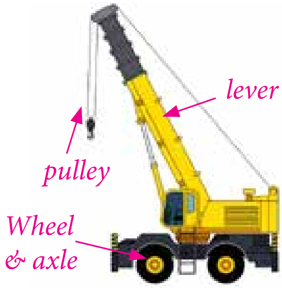


Fig. 8.18

Activity 8.6

Make a list of the complex machines used around us. What are the simple machines that make up these complex devices ? Make a table like given below :

S.N.	Complex machines	Simple machines
1.	Clipper	Wedge and lever
2.	Electric fan	
3.		
4.		
5.		
6.		

Efficiency and Mechanical Advantage of Compound Machines

Because compound machines have more moving parts than simple machines, they generally have more friction to overcome. As a result, compound machines tend to have lower efficiency than simple machines. When a compound machine consists of a large number of simple machines, friction may become a serious problem, and it may produce a lot of heat. Lubricants such as oil or grease may be used to coat the moving parts so they slide over each other more easily. This is how a car's friction is reduced. Compound machines have a greater mechanical advantage than simple machines. That's because the mechanical advantage of a compound machine equals the product of the mechanical advantages of all its component simple machines. The greater the number of simple machines it contains, the greater is its mechanical advantage.

Activity 8.7

Write down what type of simple machine is used in each of the objects.

Object	Simple machine
Flag pole	Clipper
Broom	Electric fan
Car's Windshield	
Saw	
Clock	
Pin	
Light Switch	
Jar Lid	
Staircase	
Sketes	
Bathtub	
Scissors	
Garage Gate	
Crane	

Exercise

A. Tick the correct answer.

i. What is the efficiency of perfect machine?
   a. 100% b. 90% c. 80% d. 50%

ii. Which work is done by effort?
   a. Input work b. Output work c. Both d. None of above.

iii. Which one is not affected by friction?
   a. Mechanical Advantage b. Velocity ratio
   c. Efficiency d. None of above

iv. What is the velocity ratio of single movable pulley?
   a. One b. Two c. Three d. Four

v. 6 m long wooden plank is used to lift a load up on the truck, of 2 m. height as a inclined plane. What is the velocity ratio of that inclined plane?
   a. One b. Two c. Three d. Four

vi. What is the SI unit of moment of force?
   a. Nkg b. N/m^2 c. N/m d. Nm

vii. The velocity ratio of a wheel and axle is given by.................. .
   a. r/R b. L/E c. R/r d. L/H

viii. The velocity ratio of inclined plane is given by.................. .
   a. R/r b. R/r c. L/E d. L/h

B. Answer these questions in very short.

i. What is a mechanical advantage? Write its unit also.

ii. What is a perfect machine? Why is it not possible in our daily life?

iii. What is moment of force? Write law of moment. A long spanner is used to open tight nut, why?

iv. A machine has mechanical advantage,what does it mean?

v. A simple machine has 90% efficiency what does it mean? The efficiency of a simple machine can never be 100 % Why?

vi. On what factors does moment of force depend?

vii. How can you find the velocity ratio of a wheel and axle? It kept it in 'Give reasons' section.

viii. Why is mechanical advantage always less than that of velocity ratio?

ix. Oil is frequently used in sewing machine why?

x. There is a rusted nut. We have two spanner one is 15 cm. and another is 20 cm long. Which spanner is used to open the nut easily and why?

xi. The probability of breaking a tall tree is more than a short -one during storms, why?

xii. Differentiate between the following pairs.
   a. Pulley and wheel and axle
   b. Practical machine and perfect machine
   c. Screw driver and jack screw

xiii. Derive the relationship between MA ,VR and efficiency (η) of a machine.

xiv. Solve the following numerical problems.

a. A lever is used to lift a load of 500 N by applying 200 N effort. Its load distance and effort distance are 20 cm and 60 cm respectively. Find its MA, VR and efficiency (η)

[Ans. M.A = 2.5 , V.R = 3, η= 83.33%]

b. A lever has an efficiency of 60%. Its mechanical advantage is 4.

i. Find the effort to lift a load of 1000 N *[Ans. E = 250 N]*

ii. Find the V.R of the lever *[Ans. V.R = 6.60]*

iii. When load travels 20 m distance, find output work. *[Ans. 20,000 J]*

xv. In a wheel and axle, the diameter of the wheel is 60cm and radius of the axle is 0.1m. If its MA is 2, find the effort required to lift the load of 1600N up to the height of 6 meters. Also calculate VR, η, output work and input work

[Ans. E=800N, VR = 3η = 66.677, output work = 9600J, Input work = 14400]

xvi. A meter scale has been suspended horizontally in its middle. A load of 500N is placed at 5cm at one end of it. At what distance should 80 N effort to be applied in order to balance it?

[Ans. 0.3125m]

xvii. The efficiency of a lever is 60%. If MA is 3, calculate:

a. Effort required to lift a load of 1200N by using the lever.

b. Velocity ratio of the lever.

c. Output work when load is turned 10cm high

d. Input work *[Ans. a. 400N, b. 5, c. 120J, d. 200J]*

xviii. If a load of 650N is lifted by using five pulley system up to 4 meters by applying an effort of 300N. Find,

a. MA b. VR c. Output d. Input work e. Efficiency (η)

[Ans. a. $\frac{13}{0}$ b. VR = 5 c. 2600J d. 6000J e. η = 43.33%]

C. Give reasons to the following statements.

i. A machine is never 100% efficient.

ii. The probability of breaking a tall tree is more than a short one during storm.

iii. The value of VR is always greater than MA.

iv. The work output of a simple machine is always less than work input.

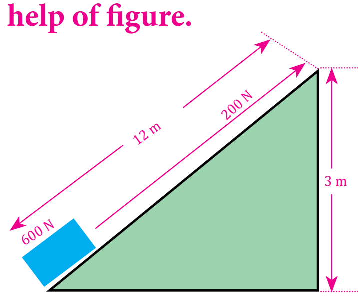
v. Grease and oil are used in machines.

vi. Winding roads are made on hills.

vii. Long spanners are used to open a rusted nut.

viii. Wheel and axle is regarded as continuous lever.

D. In adjoining figure a load is about to lift by using inclined plane. Answer the following questions with help of figure.



i. Find M.A and VR of the simple machine.

[Ans. MA = 3, VR = 4]

ii. Find efficiency of the machine.

[Ans. η=75%]

iii. When the load is completely lifted up what are the input and output work?

[Ans. Input = 2400 J, output = 1800J]

iv. What should be the length of the inclined plane to lift the same load with the effort of 150 N by keeping efficiency of machine the same? *[Ans. l = 16 cm]*

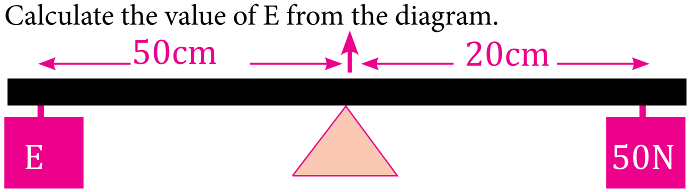
v. 20 cm long spanner is used to open the nut by applying effort of 20 N. Find the moment of force produces. *[4 Nm]*

vi. A block and tackle consists of 6 pulleys is used to lift a load of 300N and effort of 75 N. Calculate MA , VR and η of the machine?
[Ans. MA = 4, VR = 6, η = 66.67%]

vii. A wheel and axle arrangement having the wheel of radius 20 cm and the axle with radius 10 cm can lift the load of 150 N with an effort of 90 N. Calculate MA, VR and (η)
[Ans. MA = 1.67 ,VR = 2 ,η = 83.51%]

viii. If a lever lift a load four times the effort applied and the effort distance is 5 times the load distance. Calculate its efficiency. [80%]

ix. Calculate the value of E from the diagram.



[Ans. 20 N]

E. Differentiate with examples

i. Pulley and wheel and axle
ii. Wedge and Screw
iii. Mechanical advantage and Velocity ratio
iv. Inclined plane and wedge
v. Output work and input work
vi. Jack Screw and axe
vii. Simple machine and compound machine

F. The following complex machines are made of which simple machine –

i. Bicycle
ii. Hand drill
iii. Stapler
iv. Can opener
v. Watch
vi. Sewing machine

Unit 9 Energy

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- describe the process by which energy is generated in the sun.
- introduce solar energy technology and build equipment based on it.
- describe the various types of biofuels and their applications.
- explain and use the technology of making briquettes and biogas
- investigate alternative energy sources and development opportunities in Nepal.

James Prescott Joule (1818 – 1889) was an English physicist, mathematician and brewer, born in Salford, Lancashire. Joule studied the nature of heat, and discovered its relationship to mechanical work . This led to the law of conservation of energy, which in turn led to the development of the first law of thermodynamics. The SI derived unit of energy, the Joule, is named after him. He worked with Lord Kelvin to develop an absolute thermodynamic temperature scale, which came to be called the Kelvin scale. Joule also made observations of magnetostriction, and he found the relationship between the current through a resistor and the heat dissipated, which is also called Joule's first law. His experiments about energy transformations were first published in 1843.

9. The Concept of Energy

Energy is the capacity to do work. We use energy to perform various activities. It is measured in Joule (J). It is found in different forms like heat energy, light energy, sound energy, chemical energy, nuclear energy, potential energy, electrical energy, kinetic energy etc. Excessive use or over exploitation of energy by growing population causes the energy crisis. We should use energy and its sources wisely, economically and scientifically so that we can avoid energy crisis.

Sources of energy

Coal, petroleum products, wood, dung, biogas etc. are the sources of energy. These are also called fuel. Fuels burn in air and produce heat. Sources of energy are classified as primary and secondary on the basis of the form they are used.

On the basis of the form there are two types of sources of energy.

Sources of energy on the basis of form

- **Primary sources of energy**
- **Secondary sources of energy**

i. **Primary sources of energy**

Those sources of energy which can be used in the same form in which they occurs in nature are called primary source of energy. Wood, coal, crude oil, natural gas, dung, solar energy etc. are the primary sources of energy.

ii. **Secondary sources of energy**

Those sources energy which are derived from primary sources of energy are called secondary sources of energy. Coal gas, bio gas, kerosene, petrol, diesel, char coal, etc. are the example of secondary sources of energy.

On the basis of replacing period, there are two types of sources of energy. They are:

i. **Non- renewable sources of energy**

Those sources of energy which have limited stock in the nature, which get depleted and can not be used again and again are called non - renewable sources of energy. Coal, petroleum, natural gases are non- renewable sources of energy. These sources of energy are formed in nature but take millions of years to be formed. They are also called fossil fuels.

ii. **Renewable sources of energy**

Those sources of energy which never exhaust from nature and can be obtained continuously are called renewable sources of energy. They are formed in a short period of time. Wood, biogas, geothermal energy, solar energy, wind energy, hydroelectricity etc. are some of the examples of renewable sources of energy. They can be stored.

9.1 Introduction to Solar Energy

Solar energy is the energy obtained by capturing heat and light from the Sun. Energy from the Sun is referred to as solar energy. Technology has provided a number of ways to utilize this abundant resource. It is considered a green technology because it does not emit greenhouse gases. Solar energy is abundantly available and has been utilized since long both as electricity and as a source of heat.

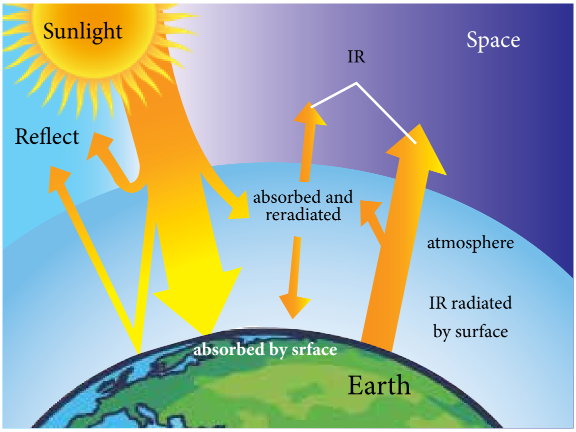


Fig. 9.1

Solar energy, radiation from the Sun capable of producing heat, causing chemical reactions, or generating electricity. The total amount of solar energy incident on Earth is vastly in excess of the world's current and anticipated energy requirements. If suitably harnessed, this highly diffused source has the potential to satisfy all future energy needs. In the 21st century solar energy is expected to become increasingly attractive as a renewable energy source because of its inexhaustible supply and its nonpolluting character, in stark contrast to the finite fossil fuels coal, petroleum, and natural gas.

The potential for solar energy is enormous, since about 200,000 times the world's total daily electric-generating capacity is received by Earth every day in the form of solar energy. Unfortunately, though solar energy itself is free, the high cost of its collection, conversion, and storage still limits its exploitation in many places. Solar radiation can be converted either into thermal energy (heat) or into electrical energy, though the former is easier to accomplish.

The Sun is an extremely powerful energy source, and sunlight is by far the largest source of energy received by Earth, but its intensity at Earth's surface is actually quite low. This is essentially because of the enormous radial spreading of radiation from the distant Sun. A relatively minor additional loss is due to Earth's atmosphere and clouds, which absorb or scatter as much as 54 percent of the incoming sunlight. The sunlight that reaches the ground consists of nearly 50 percent visible light, 45 percent infrared radiation, and smaller amounts of ultraviolet and other forms of electromagnetic radiation.

Nuclear reactions in the sun

Solar energy is produced due to thermonuclear fusion reaction. The sun is rich in hydrogen gas. It has about 74% hydrogen gas. In thermonuclear fusion reaction, lighter hydrogen nucleus combine to form a single heavy nucleus of helium. So, vast amount of energy is released during this reaction. Due to high temperature of the sun, hydrogen splits up into proton and electron.

In the 1st step, two protons ($_1H^1$) combine to form a deuteron and a positron ($_1e^0$). Then the deuteron thus formed combine with one more proton ($_1H^1$) and produce light helium ($_2He^3$). Finally, two light helium combine to form a stable helium ($_2He^4$) along with two protons and energy. In this process a huge amount of energy is produced in the sun.

$$_1H^1 + {}_1H^1 \longrightarrow {}_1H^2 + {}_1e^0 + \text{energy}$$

$$_1H^2 + {}_1H^1 \longrightarrow {}_2He^3 + \text{energy}$$

$$_2He^3 + {}_2He^3 \longrightarrow {}_2He^4 + {}_1H^1 + {}_1H^1 + \text{energy}$$

In short, $2\,{}_1H^1 + 2\,{}_1H^1 \longrightarrow 2He^4 + 2\,{}_1e^0 + \text{energy}$

Conditions Required for Nuclear Fusion in the Sun

- Abundance of hydrogen gas in the sun.
- Extremely high temperature and pressure of the sun.

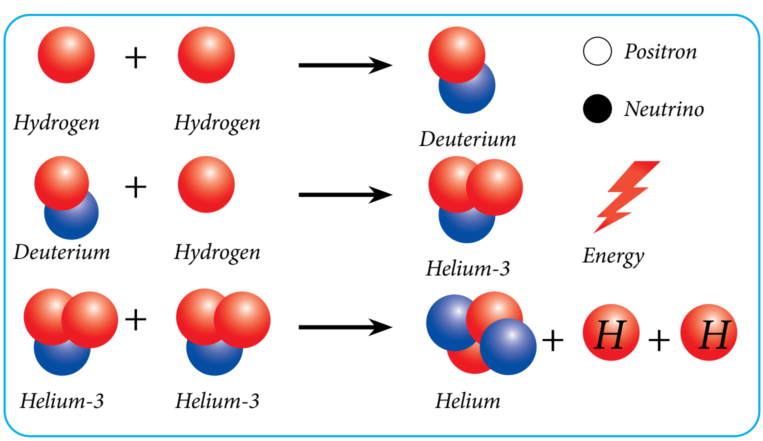


Fig. 9.2

9.2 An Introduction to Solar Energy Technology

Solar energy technologies harness the energy of solar irradiance to produce electricity.There are three primary technologies by which solar energy is commonly harnessed: photovoltaics (PV), which directly convert light to electricity; concentrating solar power (CSP), which uses heat from the sun (thermal energy) to drive utility-scale, electric turbines; and heating and cooling systems, which collect thermal energy to provide hot water and air conditioning.

Solar technology can be broadly classified as –

- **Active Solar** – Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Active solar is directly consumed in activities such as drying clothes and warming of air.
- **Passive Solar** – Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

Conversion of Solar Energy

The solar energy is the energy obtained by capturing heat and light from the Sun. The method of obtaining electricity from sunlight is referred to as the Photovoltaic method. This is achieved using a semiconductor material.

The other form of obtaining solar energy is through thermal technologies, which give two forms of energy tapping methods.

- The first is solar concentration, which focuses solar energy to drive thermal turbines.
- The second method is heating and cooling systems used in solar water heating and air conditioning respectively.

The process of converting solar energy into electricity so as to utilize its energy in day-to-day activities is given below –

- Absorption of energy carrying particles in Sun's rays called photons.
- Photovoltaic conversion, inside the solar cells.
- Combination of current from several cells. This step is necessary since a single cell has a voltage of less than 0.5 V.
- Conversion of the resultant DC to AC.

A 'Solar Lamp' is a lighting device consisting of a PV module, battery, lamp, and electronics. Battery, lamp, and electronics are placed in a suitable housing. A solar lamp also named as a **solar light** or a **solar lantern** is an illumination device consisting of an LED lamp, a solar panel, battery, a charge controller .

Fig. 9.3

The solar lamp is especially suitable for study purposes.

PV module converts sun light into electricity, charges the battery which powers the luminaire. Luminaire consists of White Light Emitting Diode (W-LED), a solid state device which emits light when an electric current passes through it.

In developing countries the solar lamp is a cheap alternative to a Solar Home System (SHS) providing 4-5 hours of high quality lighting service or 15 hours of listening to the radio. It provides higher quality light than the use of candles or kerosene lamps. They are also used to provide street lighting in rural areas. In this case Light Emitting Diode (LED) solar lanterns are usually used. There are some more models of the solar lamp with additional provision for mobile phone charging in an emergency.

Solar lights work on the principle of photovoltaic effect. Solar panels absorb sunlight with the help of solar cells and convert this solar energy into direct electrical current which is stored into solar batteries via a charge controller for later use. A single solar cell is capable of producing a maximum of 0.45 volts and the current generated depends on the size of the cell and the amount of sunlight striking the solar panel.

Solar Street lights are being widely used to light up street, lawns, parks, etc. These solar street lights consume no power from the grid and work solely on the solar power. They also eliminate the need for underground cabling and multiple switching points.

The solar energy is absorbed in the daytime and is stored in the battery to power the light in the night. The light is set to be switched on once the input voltage from the solar energy falls below a threshold limit. The light is set to be switched off automatically, once the input voltage from the solar energy raises above a threshold limit. This makes the light to glow once it becomes dark and light to switch off in the dawn.

Solar Street Lights are of two types.

i. **Traditional Solar Street Lights :** The components of the solar street light are distinct and are placed at different positions.

ii. **All in One Solar Street Lights :** In all in one solar street lights, all the components of the solar street light is inbuilt in a single body.

Fig. 9.4

Components of a Solar Street Light

Solar Panel : Solar panel is the source of power for the solar street light. It collects the solar energy from the sun and converts it into DC power. The power of the solar panel depends on the luminary capacity and the required autonomy days.

Luminary: The luminary is the light that provides the requisite lighting. Earlier, CFL luminaries were quite prevalent. However, for the past 8 years, LED luminaries have become more prevalent. Based on the lighting requirements, the size of the luminary has to be chosen.

Charge Controller: Charge Controllers regulate the charging and discharging of the battery They regulate the incoming voltage to charge the battery and prevents the deep discharge of the battery. In a solar street light, the circuit to switch on and off the luminary is enclosed along with the charge controller. The charge control is either provided as a separate device or enclosed inside the luminary.

Battery: Battery stores the power generated by the solar panel. The type of battery used is C 10 Tubular battery. In some cases SMF batteries are also used as they are maintenance free and economical. The all in one street lights use Lithium Ion batteries. In terms of longer life, C 10 rated tubular batteries are the best.

Pole: The all in one street light can be fitted either on a pole or on a wall. In the traditional solar street, the luminary alone can be fitted either in a pole or a wall. The pole is either MS or GI and is anti corrosive. The pole has provisions to mount the solar panels and the battery. The pole has a luminary mounting arm and solar panel mounting arm.

Battery Box : The battery box is either a MS box or UV protected polymer box.

Installation

All in Solar Street Lights are ready to fix. Traditional street lights has to be assembled at the site location.

Step by Step installation Procedure for Traditional solar street lights

i. The Solar Panel mounting structure has to be mounted on the pole.
ii. The Light arm to fix the luminary has to be fixed along with the pole.
iii. The Solar panel has to be mounted on the solar panel mounting structure.
iv. The LED luminary has to be fixed on the luminary.
v. The wiring from the solar panel to the LED luminary with inbuilt charge controller has to be done. The wiring has to be concealed inside the pole. In case of an external charge controller, the wiring has to be done from the solar panel and the luminary to the charge controller. In either case, the wiring from the luminary to battery has to made. However the battery has to be fixed only after the erection.
vi. The pole is erected on the ground pit. The pit has to be covered with concrete mix.
vii. After the pole can stand on its own, the battery can be kept inside the battery box and the connections can be completed by connecting the wire from the luminary / charge controller with the battery.

Solar heater, the use of sunlight to heat water or air in buildings. There are two types of solar heater, passive and active.

Passive heater relies on architectural design to heat buildings. The building's site, structure, and materials can all be utilized to maximize the heating (and lighting) effect of the sunlight falling on it, thereby lowering or even eliminating its fuel requirement. A well-insulated building with a large glass window facing south, for instance, can effectively trap heat on sunny days and reduce reliance on gas or oil (for heating) or electricity (for lighting). Entering sunlight warms the air and the solid surfaces in those rooms exposed to it, and this warmth is carried to other rooms in the building by natural convection. Interior finishes such as brick or tile are often incorporated into buildings to absorb the sunlight and reradiate the heat at night.

Fig. 9.5

In active heater, mechanical means are used to store, collect, and distribute solar energy in buildings in order to provide hot water or space heating. The sunlight falling on a building's collector array is converted to heat, which is transferred to a carrier fluid (usually a liquid, less commonly air) that is then pumped to a conversion, storage, and distribution system. In liquid-based systems, water (or less commonly glycol) is pumped through tubes that are in contact with a flat-plate collector. The latter is a blackened metal plate that absorbs sunlight and is insulated on the front with layers of glass and air; the glass allows visible light to fall on the plate but traps the resulting heat, which is then transferred to the carrier fluid. Alternatively, the fluid may be pumped through an evacuated glass tube or a volume of space onto which a large volume of sunlight has been focused (and hence concentrated) by reflecting mirrors.

After picking up heat from the collector, the carrier fluid is pumped down to an insulated storage tank, where it can be used immediately or stored for later use. The system can supply a home with hot water drawn from the storage tank, or, with the warmed water flowing through tubes in floors and ceilings, it can provide space heating. The storage tank allows water heated during sunny periods to be used at night or during cloudy days. If the carrier fluid contains antifreeze to keep it from freezing during cold weather, a heat exchanger is used to transfer the carrier fluid's heat to water that can be used for domestic purposes. Residential heating systems using flat-plate collectors typically heat carrier fluids to temperatures between 66° and 93° C (150° and 200° F).

We use a solar cooker for cooking the food by using the energy radiated by the Sun. Solar cooker works on the principle that sunlight warms the pot, which is used for cooking the food.

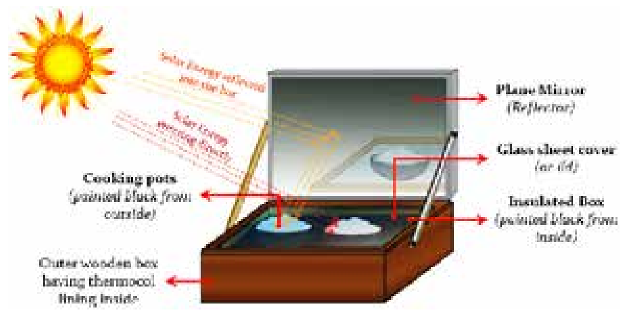


Fig. 9.6

Now, this warming of the pot occurs by converting light energy to heat energy.

Concave mirrors are used in these types of cookers because these mirrors reflect sunlight into a single focal point. Here, the mirror focuses sun rays onto a receiver such as a cooking pan.

A solar cooker lets the UV light rays in and then transforms them into longer infrared light rays that cannot escape.

Infrared radiations have the energy to make the water, fat, and protein molecules in food vibrate energetically and heat up. The process by which the interaction between the light energy and the receiver material turns light to heat is called conduction.

We can maximize this transformation by using materials that can conduct and retain the heat.

Types of Solar Cooker

There are two types of solar cookers, that is:

1. **Type 1 - Box Type - Heat Up**
   In this type of cooker, heat gets reflected by a reflector into a box, and then the heat gets trapped by the top glass like a greenhouse effect and heats the cooking utensils.
2. **Parabolic Type - Converge Heat to a Single Point**
   In this type, the heat converges to a point where the cooking utensils are kept; it gets heated up and cooks the food.
   ther categories are:
   i. Box cookers (often called box ovens) ii. Parabolic cookers iii. Tube cookers

Box Type Solar Cooker

The main components of box-type solar cookers are:

i. An insulating metal box painted black from the inside,
ii. A glass sheet, and
iii. A reflector such as a plane mirror.

Let's understand the working of the box-type cooker:

The box is covered by a transparent glass sheet which allows the infrared rays coming from the sun to enter the box.

The metallic box is painted from inside and acts as a black body as we know that the black body absorbs the lights of all wavelengths.

Similarly, this box absorbs these infrared rays and heats up.

We also know that the black body in heating up radiates all the lights of varying wavelengths absorbed by it. This box also starts emitting the infrared rays absorbed by it.

However, the glass sheet surrounding the box doesn't allow the heat to go out.

In this way, a glass sheet enables the cooker to entrap heat inside the box.

Making of Solar Cooker

Let us make a box-type solar cooker for household use.

Materials Required:

i. A wooden box having a styrofoam lining inside,
ii. Aluminum sheet,
iii. Black paint,
iv. Mirror,
v. Glass sheet,
vi. Hinges,
vii. Wooden lid for the box, and
viii. Containers to cook food

Construction:

Step 1 : Take a wooden box and make a box out of the aluminum sheet.
Step 2 : Paint the inner side of the aluminum box with black paint.
Step 3 : Place this box inside the wooden box
Step 4 : Now, fix the mirror to the lid, and with the help of the hinges, fix the lid to the wooden box.
Step 5 : Now, cover the box with a glass sheet.
Step 6 : Now, to cook the food, paint the containers in which we wish to cook, and paint these utensils with black color from outside.
Step 7 : Place these containers filled with food items inside the box.

Result:

The glass sheet helps in entrapping the heat inside the box and the mirror converges the light onto the box, heats it and the solar cooker is ready to cook the food.

Advantages and Disadvantages of Solar Cooker

Advantages:

Pollution-free.
They don't use fuel.
Solar energy is freely available.
Very low management cost.

Disadvantages:

We can use solar energy at a certain time during the day.
We cannot use it at night, during the rainy season, or during foggy winters.
It is time-consuming as compared to the normal cookers.

Solar Pressure Cooker

Let us make a parabolic solar cooker to understand how solar pressure works.

Materials Required:

Take a parabolic dish from the old TataSky receiver.

Solar reflective film and cut it into small pieces of equal sizes.

Construction:

Now, clean the surface of this dish rec.
Paste the reflective films on the entire surface of the receiver as you can see below:
Make sure no bubbles are trapped inside the films.
Now, connect the reflector on the stand.
Fix a holder in the front of this surface, and place the cooker on this holder.
This is how we can cook the food in the pressure cooker using the parabolic solar cooker.

Result: Parabolic solar cookers converge sunlight to a single point.

When this point is focused on the bottom of a pressure cooker, it can heat it quickly to very high temperatures.

Solar Cookers and their Significance

Solar cookers are one of the simplest utensils used to cook food. It's safe as well since it does not use fire and is environment-friendly as it does not consume any fuel. It harnesses the power of the sun to cook food. It is usually designed in the form of a simple box in which you place your food. The box is lined with some kind of reflective metal and covered with glass. It then uses the energy of the sun to cook your food as per the temperature that you want your food to be cooked in. The food gets completely cooked. Solar cookers are thus inexpensive, eco-friendly, and easily used.

Making of a simple solar heater

Solar energy – the experiment on the efficiency of the solar heating working model is one of the easiest science experiment that you can prepare in your school fair science project. This working model is quick, simple and very informative.

The result may vary if the project is performed outdoor due to the wind and weather condition, so it is recommended to conduct the experiment indoors.

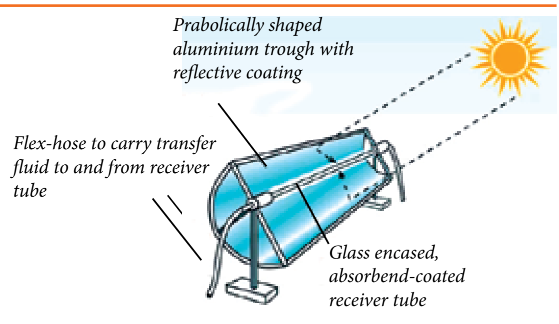


Fig. 9.7

In this solar heater project, use reflectors to concentrat the solar energy in one small place to collect and store heat energy. In this experiment, you will see the efficiency of solar energy

Materials Required

i. A wooden stand
ii. Thermometer
iii. A concave or converging mirror
iv. Tube to flow liquid.
v. Black paper

Procedure

i. Mount the wooden stand.
ii. Roll pieces of black paper around the tube.
iii. Attach the tube in the concave mirror in a way where the sunlight concentrate in one direction.

iv. Fill the tube with tap water
v. After 30 minutes record the temperature of the tube.

Observations

To calculate the efficiency of the concave mirror solar heater, you can divide the temperature increase by the direct sunlight. Eventually, the temperature of the water increase after 30 minutes as the heat is transferred through the concave mirror and concentrated on the tube.

Uses Of Solar energy

Water heating: Solar energy is used to replace electric heaters and gas as efficiency is more with 15-30%.

Heating of swimming pools: Solar blankets are used to keep the pool warm. The other way is by using a solar water heater to keep the water warm.

Cooking purposes: Solar cookers are used for cooking food. Solar energy is used to heat, cook and pasteurize the food. A solar cooker consists of an elevated heat sink such that when food is placed in it, it gets cooked well.

9.3 The Concept of Bioenergy

Bioenergy is one of many diverse resources available to help meet our demand for energy. Bioenergy is defined as renewable energy produced from natural sources and is capable of replacing fossil energy. It can offer renewable, low-carbon energy systems, sequestering atmospheric carbon as well as offer numerous environmental and socioeconomic benefits and therefore supporting global climate change targets and wider environmental, social, economic, and sustainable targets.

There is scientific evidence of the benefits of bioenergy, but results are often subject to variation and uncertainty. Additionally, it is important to consider various sustainable aspects of bioenergy systems beyond carbon. Treating bioenergy only as part of the energy sector will fail to ensure: sustainable biomass production and sourcing, clean applications with low health impacts, and fair and affordable energy vectors. Ensuring that bioenergy offers the required holistic emission reduction, context, specific and long-term approaches are necessary to understand synergies and tradeoff of the bioenergy and related agricultural and forestry systems. Assessing the environmental and wider sustainable impacts of bioenergy, full supply chains as well as direct and indirect stakeholders, their drivers, benefits and challenges needs to be considered. With these, we have to assess and evaluate bioenergy and its impacts in the context of the specific system it is part off and its direct and wider impacts on environment, economy, and society.

Energy resources will play an important role in the world's future. Rural bioenergy is still the predominant form of energy used by people in the less developed countries, and bioenergy from biomass accounts for about 15% of the world's primary energy consumption and about 38% of the primary energy consumption in developing countries. Furthermore, bioenergy often accounts for more than 90% of the total rural energy supplies in some developing countries.

Bioenergy is a form of renewable energy that is derived from recently living organic materials known as biomass, which can be used to produce transportation fuels, heat, electricity, and products.

Few types of fuels used to generate biomass are –

a. Scrap Lumber
b. Woody construction and Forest debris (Wood waste, sawmill waste, green waste from landfills and other vegetative)
c. Certain agricultural crops and wastes
d. Manure
e. Animal waste
f. Ethanol waste
g. Municipal solid waste (sewage sludge or other landfill organics)
h. Landfill gas
i. Other industrial waste (i.e. paper sludge from paper recycling processes)

For generating biomass, often the energy sources are thought to be limited to plant wastes but that's not the case. Even animal-derived materials are used for biomass generation. Biomass is the prime building block of biofuels, highly used for electricity production to produce heat in the context of energy, as an alternative to fossil fuels.

The chemical composition of Biomass – Carbon, Hydrogen, and Oxygen along with nitrogen and alkali atoms, heavy metals and alkaline earth.

9.3.1 The Importance of Bioenergy

i. The carbon dioxide (CO2) released from biomass during production of bioenergy is from carbon that circulates the atmosphere in a loop through the process of photosynthesis and decomposition. Therefore, production of bioenergy does not contribute extra CO2 to the atmosphere like fossil fuels. Bioenergy is carbon neutral
ii. Generally, Greenhouse Gas (GHG) emissions reduction from bioenergy systems is greatest where waste biomass is converted to heat or combined heat and power in modern plants located near to where the waste is generated. Bioenergy's GHG reduction benefits are potentially greater than those of other renewables. For example, stubble that is destined to be burnt in the field, can be harvested and combusted in an emissions controlled bioenergy plant.
iii. Bioenergy is a renewable energy that can generate many additional benefits, the extent of which depends on a combination of factors including the types of feedstocks used, how they are produced and transported and the efficiency of the technologies deployed to convert them to bioenergy.
iv. Unlike most other renewable energy sources, biomass can generate both heat and electricity in a combined heat power (CHP) plant. This can then be used for a range of heating and cooling applications in industry or for small communities.
v. The organic materials used to produce bioenergy is infinite, since our society consistently produces waste such as garbage, wood and manure.
vi. It reduces the overreliance of fossil fuels. Not only there is a limited supply of fossil fuels, but fossil fuels come with environmental baggage, including the release of large amounts of carbon dioxide into the atmosphere and the pollutants that result from removal, transportation and production.
vii. While fossil fuel production requires a heavy outlay of capital, such as oil drills, gas pipelines and fuel collection, bioenergy technology is much cheaper. Manufacturers and producers are able to generate higher profits from a lower output.

viii. Bioenergy production adds a revenue source for manufacturers. Producers of waste can add value by channeling their garbage to create a more profitable use in the form bioenergy.
ix. By burning solid waste, the amount of garbage dumped in landfills is reduced by 60 to 90 percent, and reduces the cost of landfill disposal and amount of land required for landfill.

9.4 Briquette

A briquette is a compressed block of coal dust or other biomass material such as charcoal, sawdust, or paper used for fuel and to begin a fire. The term derives from the French word briquette meaning brick.

Briquetting is the procedure of creating briquettes. A briquette is mainly a block of compressed biomass waste get from natural materials like agricultural waste, forestry waste, coal pieces, etc. These briquettes perform as the best substitute for nonrenewable fuel that is nature-friendly. This briquette poses no harmful effect on the environment and is atmosphere friendly. The major use of these briquettes is as a substitute to fuel, coal, cooking and even in boilers.

Briquettes can be produced with a density of 1.2 g/cm^3 from loose biomass Briquettes of bulk density 0.1 to 0.2 g/cm^3 These can be burnt clean and therefore are eco-friendly air those advantages that are associated with the use of biomass are present in the briquettes.

9.4.1 The Process of Making Briquettes

Briquettes are small, compact blocks of organic waste you can use for burning in the stove or fire. While some briquettes require expensive machinery to make, anyone can easily make their own with simple waste materials. To make briquettes on your own, use simple materials like sawdust and paper. While the process takes a great deal of effort, many find it's worth it to reuse waste. If you're interested in reducing your carbon footprint, making briquettes can be a rewarding experience.

Materials for making briquettes

i. Scrap paper
ii. Bucket
iii. Organic material (i.e., sawdust, pine needles, rice husks, grass/leaves)
iv. 2-liter soda bottle
v. Plastic bag
vi. Can of food (i.e., can of beans)

Fig. 9.8

Working Your Waste into a Paste

i. Put on old clothes and wear gloves. Making briquettes is an incredibly messy process. Before you begin, you should wear gloves to protect your hands and also put on old clothing.
ii. Shred scrap papers into small pieces. Find scrap paper around your home. Old mail, flyers, and work papers work well. Shred them into tiny pieces.
iii. Soak your paper for a few days. Place the papers in a bowl or bucket and cover them with water. Let the papers soak for two days. This allows the papers to soften and also releases fibers from the papers, which act as a binding agent for your briquettes.

Reuse old scrap paper, such as mail, to make briquettes. This way, you're reusing old waste during the process.

iv. Work the paper into a porridge-like paste. After two days have passed, use your hands to knead and squeeze the paper. Keep going until you have a porridge-like mixture. The precise amount of time this will take depends on how much paper you're using.

v. Add in your organic material. Organic material must be mixed into the paper to make briquettes. You can use saw dust, pine needles, rice husks, or chopped leaves and grass. Mix one part soaked paper with three parts of your organic material.
Most organic material will already be fine enough that it should not require shredding. If you're using larger leaves, however, it can't hurt to break them up a bit.

vi. Add water. Start with a small amount of water and mix it into the paper mixture using your hands. Keep adding water until the paper mixture becomes easily moldable. When squeezed, your mixture should hold together easily.

Molding Your Briquettes

vii. Cut off the upper quarter of a soda bottle. Use a 2-liter soda bottle to make your briquette mold. Use an x-acto knife, or any sharp knife from your kitchen, to cut off the upper quarter of the bottle.

viii. Make drainage holes in the bottom. Turn the bottle over so the bottom is facing upward. Use a sharp knife to cut a dozen small holes circling the bottom of the bottle. These are drainage holes, where the water will leak out as your briquettes set.

ix. Punch holes in a small plastic bag to create a liner. Take any small plastic bag you have on hand, such as a bag from the grocery store. Use a twig or something similar to punch a dozen holes in the bottom of the bag. These are also drainage holes.

x. Add your briquettes to the mold. Take a handful of your briquette mixture and place it in the plastic bag. Then, place the bag in the soda bottle. If necessary, add more briquette mixture to fill the soda bottle to the brim.

xi. Squeeze out excess water with a can. Place a can of some kind of food, like beans, over the briquette mixture inside of the mold. Place the mold on the ground and put your foot over the can and press down with your foot. Keep pressing the can until you can't move the mixture down any further.
Water will seep out during this part of the process, so you should press the mixture outside.

Drying the Briquettes

xii. Remove your briquette from the mold. Take hold of the sides of the plastic bag. Slowly pull the bag upward, removing the briquette from the mold. Then, remove the briquette from the plastic. Your briquette should now be in the form a small, cylinder shape.

xiii. Set your briquettes in a dry place. Briquettes need time to dry before you can use them. Find a dry place, either in your home or outdoors, where the briquettes will not be disturbed.
For example, store the briquettes in a closet in your living room. Avoid humid areas of the home, like the bathroom or kitchen.

If you store the briquettes outside, do not leave them in the open air in case it rains. Instead, you could store them in a shed.

xiv. Let the briquettes dry for three to seven days. Once the briquettes are stored safely, simply let them sit for three to seven days. When done, briquettes should be completely dry to the touch and compact. After they're finished drying, you can burn your briquettes.

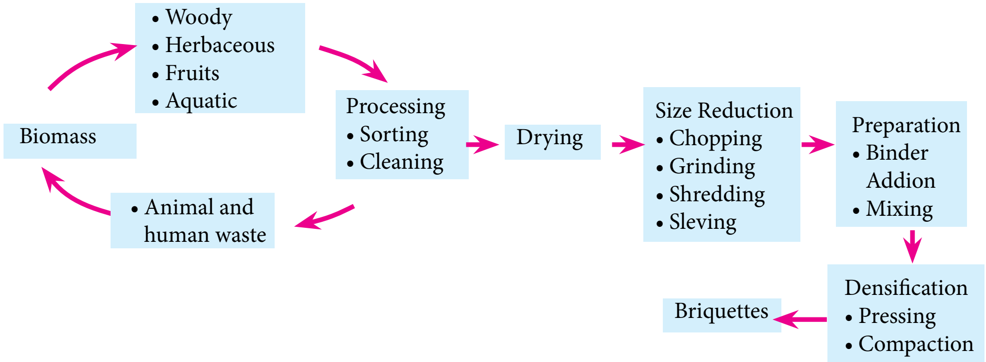


Fig. 9.9

9.4.2 Briquettes' Application

Domestic use: Many households generally use briquettes for cooking, space, and water heating purposes.

Hospitality: Hospitals used Briquettes for space and water heating, and cooking applications.

Ceramic production: Many ceramic industries use Briquettes for tile creation, brick kilns, and pot firing.

Textiles: Textile industries use high-quality Briquettes for bleaching and drying functions

Commercial and institutional catering: Commercial firms use these Briquettes for grilling, cooking, and water heating.

Food Processing Industries: Food processing industries use Briquettes in the drying, bakeries, distilleries, canteens, and restaurants.

Industrial Boilers: Industrial boilers use high-density Briquettes for the steam generation and heat generation

Poultry: Briquettes generated out of Briquette Machines are used by the poultry for the heating of chicks and incubation purposes.

Agriculture-based Industries: Agro-based industries use Briquettes for tea drying, tobacco curing, and oil milling, etc.

Gasification: Many industries use Briquettes as the fuel for the gasifiers to produce electricity.

9.4.3 Biogas

Biogas is a renewable, as well as a clean, source of energy. Gas generated through biodigestion is non-polluting; it actually reduces greenhouse emissions (i.e. reduces the greenhouse effect). No combustion takes place in the process, meaning there is zero emission of greenhouse gasses into the atmosphere; therefore, using gas from waste as a form of energy is a great way to combat global warming.

Unsurprisingly, concern for the environment is a major reason why the use of biogas has become more widespread. Biogas plants significantly curb the greenhouse effect: the plants lower methane emissions by capturing this harmful gas and using it as fuel. Biogas generation helps cut reliance on the use of fossil fuels, such as oil and coal.

Another biogas advantage is that unlike other types of renewable energies, the process to create the gas is natural, not requiring energy for the generation process. In addition, the raw materials used in the production of biogas are renewable, as trees and crops will continue to grow. Manure, food scraps, and crop residue are raw materials that will always be available, which makes it a highly sustainable option.

Overflowing landfills don't only spread foul smells- they also allow toxic liquids to drain into underground water sources.

Subsequently, another advantage of biogas is that biogas generation may improve water quality. Moreover, anaerobic digestion deactivates pathogens and parasites; thus, it's also quite effective in reducing the incidence of waterborne diseases. Similarly, waste collection and management significantly improve in areas with biogas plants. This in turn, leads to improvements in the environment, sanitation, and hygiene.

The by-product of the biogas generation process is enriched organic digestate, which is a perfect supplement to, or substitute for, chemical fertilizers. The fertilizer discharge from the digester can accelerate plant growth and resilience to diseases, whereas commercial fertilizers contain chemicals that have toxic effects and can cause food poisoning, among other things.

The technology used to produce biogas is quite cheap. It is easy to set up and needs little investment when used on a small scale. Small biodigesters can be used right at home, utilizing kitchen waste and animal manure. A household system pays for itself after a while and the materials used for generation are absolutely free. The gas produced can be used directly for cooking and generation of electricity. This is what allows the cost of biogas production to be relatively low.

Farms can make use of biogas plants and waste products produced by their livestock every day. The waste products of one cow can provide enough energy to power a lightbulb for an entire day.

In large plants, biogas can also be compressed to achieve the quality of natural gas and utilized to power automobiles. Building such plants requires relatively low capital investment and creates green jobs.

Biogas generators save people from the daunting task of firewood collection. As a result, more time is left for cooking and cleaning. More importantly, cooking on a gas stove, instead of over an open fire, prevents the family from being exposed to smoke in the kitchen. This helps prevent deadly respiratory diseases.

9.4.4 The Process of Making Biogas

Biogas is produced from organic waste (carbon) which biodegrades by means of bacteria in an anaerobic environment. This process is expedited at a process temperature of 38°C/100°F (mesophilic) or 52°C/125.6°F (thermophilic) in the plant's digester.

The biogas plant receives all kinds of organic waste - typically livestock manure and organic industrial waste. The dry solid in livestock manure contains carbon, among other things, and in the process this carbon is transformed into biogas, a compound of methane (CH_4) and carbon dioxide (CO_2).

The manure and waste are mixed in the plant's receiving tank before being heated to 38-52°C/100-125.6°F and pumped into the digester in which the biogas is produced. The biomass stays in the digester for 2-3 weeks and the fermented slurry can subsequently be used as crop fertilizer. This fertilizer has improved qualities such as less odour inconveniences when spreading the slurry and significant reduction of green house gasses.

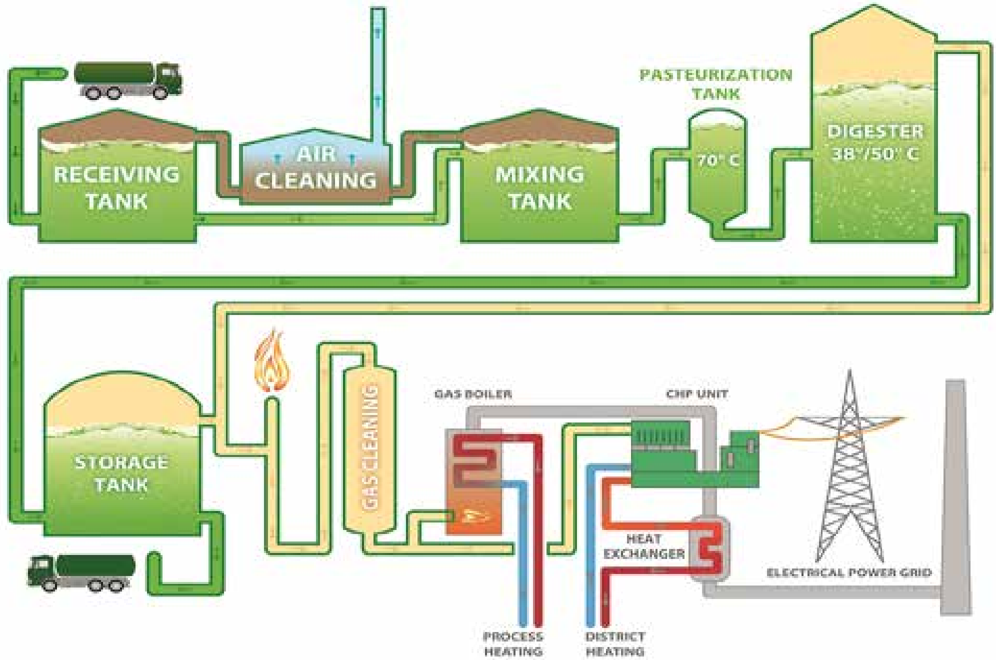


Fig. 9.10

9.4.5 Applications of Biogas

Biomass is a versatile energy source. Organic matter that is used as a source of biomass energy includes trees, timber waste, wood chips, corn, rice hulls, peanut shells, sugar cane, grass cuttings, leaves, manure, sewage, and municipal solid waste.

Biomass systems range from small stoves used in homes for heating or cooking to large power plants used by centralized utilities to produce electricity.

In residential applications, biomass can be used for space heating or for cooking. Wood is the most common source of fuel, although many different materials are used. New designs for woodstoves can improve the efficiency of the cooking or heating system, reducing the amount of fuel that is needed.

Industry and businesses use biomass for several purposes, including space heating, hot water heating, and electricity generation. Many industrial facilities, such as lumber mills, naturally produce organic waste.

i. Biogas as a Cooking Fuel.
ii. Use of Biogas as a Lighting Fuel
iii. Utilisation of Biogas for Pumping Water and Miscellaneous other Applications
iv. Biogas as a Fuel for Running IC Engines
v. Biogas as a Vehicle Fuel
vi. Applications of Biogas for Power Generation

9.5 Alternative sources of energy and their development Possibilities in Nepal

The renewable sources of energy that can be used instead of non-renewable sources of energy are called alternative sources of energy . Alternative sources of energy help to preserve the non-renewable sources of energy for future use. Due to lack of fossil fuels in Nepal, it is important to use alternative sources of energy. The following are the alternative sources of energy used in Nepal.

i. Hydropower, ii. Solar energy, iii. Biomass,

iv. Biogas v. Wind energy.

Nepal is a country endowed with high potential for renewable energy resources like hydro, solar, wind, biomass etc. The country has abundant hydroelectric potential. The theoretical hydroelectric potential has been estimated to be as high as 83,000 MW of which 42,000 MW are considered to be technically and economically feasible. Similarly, Nepal also has huge potential for solar energy. The country is located at favorable latitude that receives ample amounts of solar radiation. From solar energy alone, around 2,920 GWh of energy per year can be harnessed with utilization of just 0.01% of the total land area of Nepal. Other renewable energy sources abundantly available in the country are biomass and wind. The sustainable supply of fuel wood from reachable area of all land resources is around 12 million tons. Likewise total production of animal dung is about 15 million tons. Utilization of 10% of the total area of Nepal could commercially generate more than 3,000 MW of electricity with consideration of the installed capacity of 5MW per km^2.

However, we are not able to fully convert it into useful energy. Presently, around 12 % of population is electrified by alternative energy sources like micro hydro plant and solar home system. Around 900 thousand households are using clean energy solutions like improved cook stoves, biogas etc. for cooking. Although, the share of alternative energy sources is still small, it has increased by more than 50% since 2005.

Alternative energy or renewable energy is only one viable mean in Nepal to increase access of energy to its population. The high potentiality of the renewable energy resources available in the country is the most appropriate option for Nepal. It also helps to reduce the dependency on the traditional biomass energy resources and fossil fuels and to manage the energy crisis of the nation. This ultimately helps to minimize the degradation of the environment.

Initial investment cost of alternative energy technologies are expensive compared to the other traditional sources of energy. But, in the long-run alternative energy is mostly cheaper than the traditional sources because alternative source is almost free . Hence, if the financial mechanism can be developed in such a way that users can pay in installment basis like house, vehicle mortgage than users will not feel initial financial burden.

There is no doubt regarding the fact that Solar energy based technologies such as Solar Photovoltaic or Solar Thermal systems are the best substitutes. Right now, in the urban sector, we can see individual households opting for small scale Solar PV solutions for home-use. Even the institutions like banks, corporate offices, hospitals have adopted larger size system to meet their immediate energy needs. Besides Solar PV which generates direct electricity; Solar Thermal systems also play a crucial role in minimizing use of electricity from national grid as well as reduce dependency on imported petroleum products.

The demand for energy is increasing rapidly every year in every country, including Nepal.In order to meet the growing demand for energy, different kinds of alternative energy sources can be used, of which biogas is worth mentioning.

Biogas, which is considered an ideal energy converter, burns much more efficiently, and the residue, sludge, is a better fertiliser than the raw dung, providing the output over twice as much heat and nearly three times as much useful fertiliser as would have been obtained from the original dung.

The manure produced from biogas plants can be used as a better organic fertiliser by 20 to 30 percent than other compost fertilisers. In addition, the residue, sludge, produced from these plants kills the weeds and helps every crop thrive luxuriantly.

Human waste and some vegetation waste can also be used in biogas plants. Since proper treatment eliminates some pest disease carrying organisms, it improves the sanitation of a country.

The use of biogas not only reduces cooking time but also saves the consumption of kerosene, which has to be imported from other countries using scarce foreign exchange. To operate pumps and other machines, the clean smokeless gas emitted from biogas plants can be used.

Apart from reducing deforestation, the use of biogas helps maintain an ecological balance indirectly and stimulates the stable feeding of livestock.

Nepal has enormous and low-cost solar energy resources. The solar potential in Nepal is 50,000 terawatt-hours per year, which is 100 times larger than Nepal's hydro resource and 7,000 times larger than Nepal's current electricity consumption. Solar can easily meet all future energy needs in Nepal.

By 2030 Nepal aims to reduce dependence on traditional and imported energy by increasing access to renewable energy. The use of solar energy is more reliable than traditional electricity in Nepal. Solar panels are installed privately more frequent in urban areas and used as a backup during the power outages.

Project Works

1. Take a tour of the briquette and biogas production sites with the help of your teacher or parent. Prepare a report on the briquette and biogas production after the on-site visit and submit it to the science teacher.
2. What do you use energy to do based on your one-day activities? Make a list and present it in the classroom..

Exercise

A. Choose the correct one and put the tick mark(√).

i. What are the main source of energy ?

a. Electricity b. Sun
c. Biofuels d. Biomass

ii. Solar energy is the energy obtained

a. by capturing heat and light from the biofuel
b. by capturing heat and light from the heater
c. by capturing heat and light from the hydropower
d. by capturing heat and light from the Sun.

iii. What type of reaction occurs inside the sun produces the solar energy?

a. Nuclear fission reaction
b. Nuclear fusion reaction
c. Nucleophilic substitution reaction
d. Electrophilic addition reaction

iv. The condition required for nuclear fusion in the Sun is ...

a. Abundance of hydrogen gas in the Sun
b. Extremely high density in the Sun
c. Fossile fuels present in the Sun
d. Heat is high in the Sun

v. Which is not correct –

a. ${}_1H^1 + {}_1H^1 \dashrightarrow {}_1H^2 + {}_1e^0$
b. ${}_1H^1 + {}_1H^1 \dashrightarrow {}_1H^3 + {}_1e^0$
c. ${}_1H^2 + {}_1H^1 \dashrightarrow {}_1H^3$ + energy
d. ${}_1He^3 + {}_2H^3 \dashrightarrow {}_2He^4 + {}_1H^1 + {}_1H^1$ + energy

vi. Which is not correct –

a. Biomass
b. Biofuel
c. Solar energy
d. Fossile fuel

vii. Which is the correct for wind energy –

a. Energy obtained from the heat of the earth present inside
b. Energy obtained from the sunlight
c. Energy produced by fast moving wind
d. Energy obtained from tides of sea and oceans

viii. Which is fossil fuel-

a. Natural gas
b. Biogas
c. Biomass
d. Briquette

ix. Solar energy technologies are-

a. the production of biogas
b. harness the energy of solar irradiance to produce electricity
c. the production of briquette
d. good example of nuclear reaction process.

B. Complete the following sentences:

a. The.................is the energy obtained by capturing heat and light from the Sun.
b. Absorption of energy carrying particles in Sun's rays called ....
c. Solar lights work on the principle of................................
d. ....are being widely used to light up street, lawns, parks, etc.
e. ...., the use of sunlight to heat water or air in buildings.
f. Solar cooker works on the principle that ....the pot, which is used for cooking the food.
g. Bioenergy is one of many diverse ....available to help meet our demand for energy.
h. Bioenergy is a form of renewable energy that is derived from recently living organic materials known as..................
i. ....can be used to produce transportation fuels, heat, electricity, and products.
j. A briquette is a ....block of coal dust or other biomass material such as charcoal, sawdust, or paper used for fuel and to begin a fire.
k. Biogas is produced from ....which biodegrades by means of bacteria in an anaerobic environment.

l. The renewable sources of energy that can be used instead of non-renewable sources of energy are called ....

m. Nepal is a country endowed with high potential for ....energy resources like hydro, solar, wind, biomass etc.

C. Write R (renewable) or NR (non-renewable)

Coal	___________	Biomass	___________
Wind	___________	Uranium	___________
Crude oil	___________	Natural gas	___________
Solar	___________	Water	___________
Geothermal	___________		

D. Differentiate with examples

a. Photovoltaics (PV) and Concentrating solar power (CSP)
b. Biogas and Briquette
c. Solar energy and Bioenergy
d. Renewable energy and Non-renewable energy
e. Solar heater and Solar cooker
f. Fossil fuels and Biofuels

E. Explain the following:

a. The use of hydro electricity should be increased than of fossil fuels.
b. Now a days, goverment has encouraged using the biogas.
c. The development and use of alternative energy sources are necessary in today's world .
d. Firewood problem is related to the 'energy crisis'.
e. The Sun is regarded as a main source of energy.
f. The use of fossil fuels is more than other fuels at present.
g. Nepal has high potentiality of producing hydro electricity and solar energy.

F. Answer the following questions :

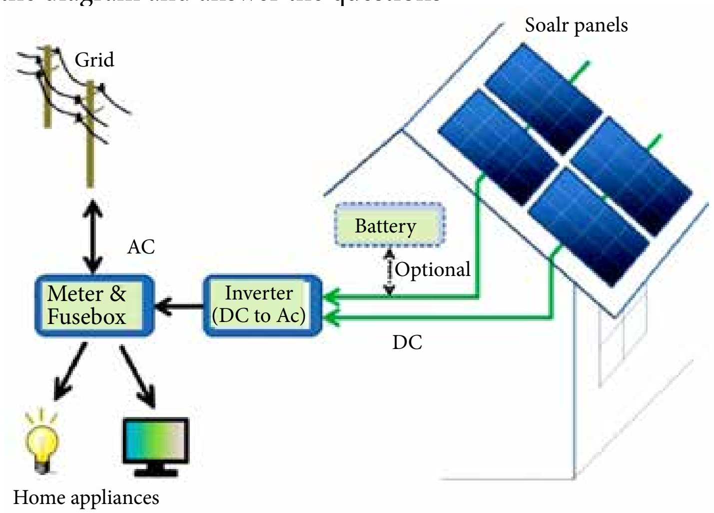
a. What is energy ? What is the main source of solar energy ? Give an example to prove that the light of the sun is also energy based on the definition of energy.
b. Write any two necessary conditions required to take place nuclear fusion reaction in the Sun.
c. How does a nuclear reaction occur in the Sun? Explain with involved chemical reaction.
d. What is the advantage due to presence of hydrogen in large scale in the Sun ?
e. What is biofuels ? In order to solve the energy crisis in Nepal, which source of energy should we use and why ?
f. How biomass is used as a fuel energy ?Write with an example.
g. What is the alternative source of energy ?
h. What are the alternative sources of energy in Nepal?
i. Name any four alternative sources of fuel energy .
j. What is meant by renewable source of energy ? List any four renewable sources of energy.
k. What types of fuel energy must be used in order to minimize energy crisis in Nepal ? Write any two suitable fuel energy with reasons.

G. Write short notes on the following terms:

a. Solar energy
b. Solar Energy Technology
c. Nuclear Reaction
d. Solar heater
e. Solar cooker
f. Biofuels
g. Biogas
h. Biomass
i. Alternative sources of energy
j. Briquette

H. Diagrammatic questions :

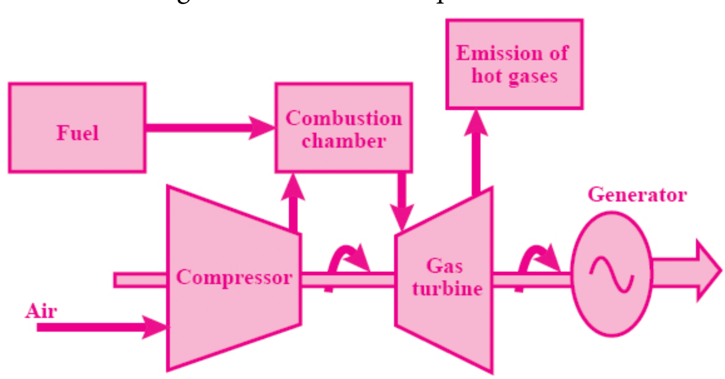
a. Observe the diagram and answer the questions-



Typical grid connected PV solar system

i. Which energy is generated ?
ii. State its source.
iii. Which is more ecofriendly-power generation from fossil fuels or power generation from solar energy ?

b. Observe the diagram and answer the questions-



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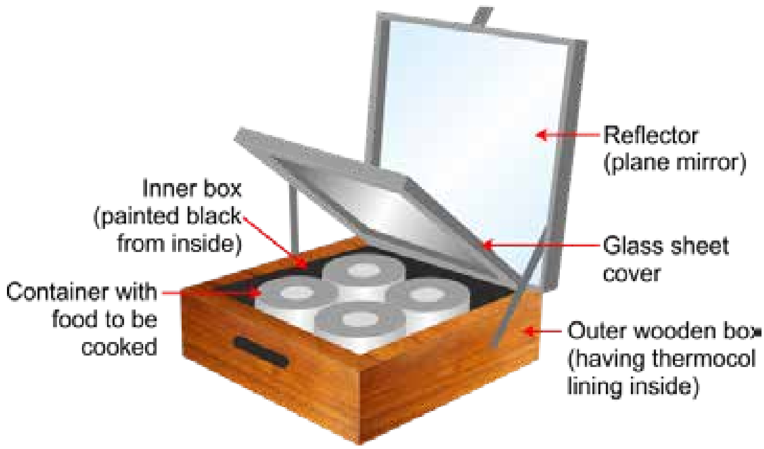


i. What is shown in the figure ?
ii. How does it work?
iii. Write the working principle and application of this equipment.

d. Observe the diagram and answer the questions-
i. What is shown in the figure ?
ii. How does it work?
iii. Write the working principle and application of it.

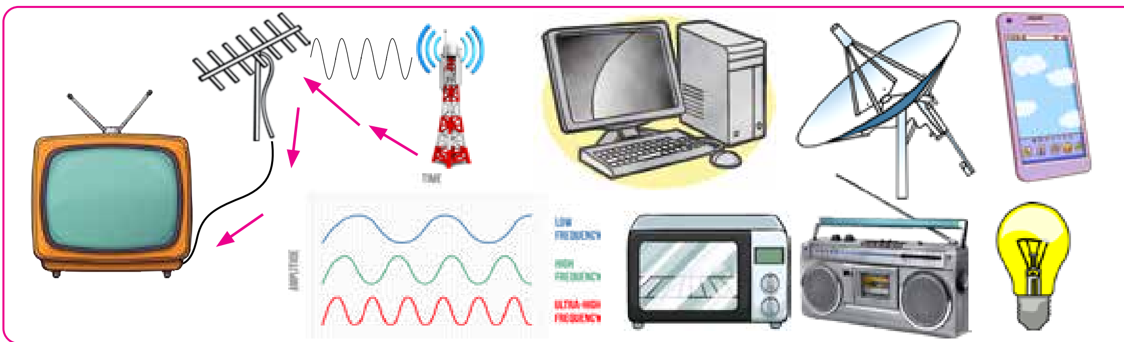
Unit 10 Waves

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- identify longitudinal and transverse waves, mechanical and radiation waves and differentiate between them.
- Introduce electromagnetic/radiation spectrum and give examples of their use of different segments.
- give a brief introduction of X-ray photography and CT scan method.
- demonstrate the reflection of sound waves and to explore the daily uses of reflected sound.
- briefly describe the workings method of ultrasonography technology and its used in health examinations.

Sir Godfrey Newbold Hounsfield, (1919–2004), English electrical engineer who shared the 1979 Nobel Prize for Physiology or Medicine with Allan Cormach for his part in developing the diagnostic technique of computerized axial tomography (CAT), or computerized tomography (CT scan) . In this technique, information obtained from X–rays taken by scanners rotating around the patient are combined by a computer to yield a high-resolution image of a slice of the body.



Look at the pictures above and discuss:

i. What did you see in the picture?
ii. Are these devices interconnected?
iii. What are the factors that play an important role in the operation of these devices?
iv. Is our life possible without these devices?
v. What is the medium of radio and television broadcasting?

As shown in the picture, we are surrounded by different waves. These waves are hitting our body every moment. Identify what those waves might be.

10.1 Wave

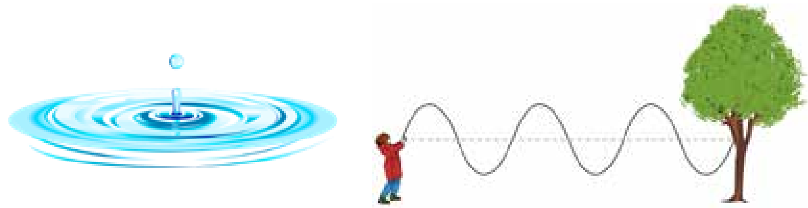


Fig. 10.2

If a stone is dropped into a pond it makes ripples . The ripples spread out from the point where the stone dropped. If a piece of wood is floating nearby, the wood is seen to move up slightly, as the ripples pass by it. Some energy from the stone has been transferred to the piece of wood. Waves on the sea are like ripples.

You can tie a rope tightly to a post or some other end up and down. A wave is seento pass along the rope. This can also be done with a long 'slinky' spring or rubber hose if it is available. Springs are excellent for showing large waves.

Ripples (small wave) on a pond , wave in rope or spring all carry energy from one place to another. Some of the energy from the falling stone produces the ripples, and the energy is carried outwards by the ripples. Energy from your arm is carried along the rope or spring as a wave.

A wave is a vibratory disturbance in a medium which carries energy from one point to another without there being a direct contact between the two point .A wave is produced by the vibration of the particles of the medium through which it passes. When the wave passes through a medium, the medium itself does not move along the direction of the wave, only the particles of the medium vibrate about their fixed positions. For example, when a water wave passes over the surface of water in a pond , it does not drive water to one side of the pond, only the water molecules vibrate up and down about their fixed positions. Similarly, when sound wave produced by a ringing bell come to us through air, there is no actual movement of the air from the bell to our ears. Only the sound energy travels through the vibrations of the air molecules. The light from the sun also comes to us in the form of light waves, there being no direct contact between the sun and the earth.

Sound waves do not pass through vacuum, they need a material medium like solid, liquid or gas for travelling. On the other hand, light waves can travel even through vacuum. From this we conclude that some waves can travel only though a material medium like solids, liquids and gases whereas others can travel even through vacuum. This difference gives us two types of waves: mechanical waves and electromagnetic waves.

Theory of waves

If you drop a little pebble in a pond of still water, the water surface gets disturbed. The disturbance does not remain confined to one place, but propagates outward along a circle. If you continue dropping pebbles in the pond, you see circles rapidly moving outward from the point where the water surface is disturbed. It gives a feeling as if the water is moving outward from the point of disturbance. If you put some cork pieces on the disturbed surface, it is seen that the cork pieces move up and down but do not move away from the centre of disturbance. This shows that the water mass does not flow outward with the circles, but rather a moving disturbance is created. Similarly, when we speak, the sound moves outward from us, without any flow of air from one part of the medium to another. The disturbances produced in air are much less obvious and only our ears or a microphone can detect them. These patterns, which move without the actual physical transfer or flow of matter as a whole, are called ***waves***.

TAKE-HOME EXPERIMENT: WAVES IN A BOWL

Fill a large bowl or basin with water and wait for the water to settle so there are no ripples. Gently drop a cork into the middle of the bowl. Estimate the wavelength and period of oscillation of the water wave that propagates away from the cork. Remove the cork from the bowl and wait for the water to settle again. Gently drop the cork at a height that is different from the first drop. Does the wavelength depend upon how high above the water the cork is dropped?

Name of Wave

Surface wave | Transverse wave | Kelvin wave | Gravity wave | Longitudinal wave | Standing wave

Fig. 10.3

Wave Motion

The formation of ripples on the surface of water is an example of wave motion. The material in which the wave motion is produced is called **medium**. Water surface is the medium of wave motion. The wave motion is produced due to the repeated vibrations of the particles of the medium. For example, water waves are produce by the repeated vibrations (or oscillations) of the water molecules in the pond. When a stone is thrown in the pond, the energy carried by the stone disturbs the water molecules close to it, By gaining the energy from stone, the water molecules near the stone start vibrating up and down. These vibrating water molecules transfer some of the energy to the next set of water molecules which also start vibrating, and so on. In this way, all the water molecules on the surface of a pond start vibrating and give rise to a water wave. We can now say that: Wave motion is a vibratory disturbance travelling through a medium in which energy is transferred from one point to another without there being a direct contact between the two points. It should be noted that only energy is transferred by wave motion, matter is not transferred from one place to another by wave motion. Wave motion transmits energy from one point to another by means of a periodic disturbance between the two points.

When we speak something, the sound energy carried by our speech disturbs the air molecules close to our mouth. By gaining energy, the air molecules start vibrating back and forth. These vibrating air molecules disturb the next set of air molecules also start vibrating, and so on. The sound wave thus travels along its path through the vibrations of air molecules until the air molecules which are close to the listener's ear also start vibrating. When the vibrating air molecules fall on the ear drum, the ear drum vibrates accordingly and reproduces the sound. Thus, the sound energy of our speech reaches the listener's ear through the vibratory motion of the air particles.

Seismic waves from large earthquakes pass throughout the Earth. These waves contain vital information about the internal structure of the Earth. As seismic waves pass through the Earth, they are refracted, or bent, like rays of light bend when they pass through a glass prism. Because the speed of the seismic waves depends on density, we can use the travel-time of seismic waves to map change in density with depth and show that the Earth is composed of several layers.

10.2 Types of Waves

a. Based on the Medium of Propagation

- Mechanical waves (Medium required)
  - Based on vibration of particles of the medium
    - Transverse wave: Particles vibrate parallel to direction of waves propagation
    - Longitudianl wave: Particles vibrate perpendicular to direction of waves propagation
  - Based on energy transfer
    - Standing wave: No transfer of energy and momemtum
    - Prograssive wave: Transfers energy and momemtum
- Non-Mechanical waves (Medium required)

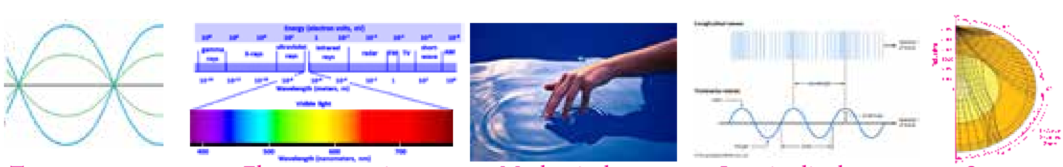
b. Number of Dimensions a Wave Propagates Energy

- One dimensional waves (i.e) Waves produced in a stretched string
- Two dimensional waves (i.e) Ripples on water
- Three dimensional waves (i.e) Propogation of light and sound waves

c. Based on the Transfer of Energy

i. Standing waves (or stationary waves)
ii. Progressive wave

Standing waves remain confined to a region without any transfer of energy and momentum whereas the progressive waves transfer energy and momentum between the particles of the medium.



Transverse wave | Electromagnetic Radiation | Mechanical wave | Longitudianl wave | S wave

Fig. 10.4

Mechanical waves are classified as longitudinal waves and transverse waves. Some examples of longitudinal waves are sound waves, seismic P-waves, and ultrasound waves. Examples of transverse waves include electromagnetic waves and ocean waves.

Longitudinal and transverse wave

The motion of mechanical waves involves oscillations of constituents of the medium. If the constituents of the medium oscillate perpendicular to the direction of wave propagation, we call the wave a **transverse wave**. If they oscillate along the direction of wave propagation, we call the wave a **longitudinal wave.**

Adjoining figure shows the propagation of a single pulse along a string, resulting from a single up and down jerk.

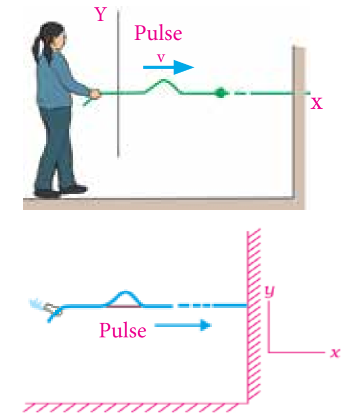


Fig. 10.5

If the string is very long compared to the size of the pulse, the pulse will damp out before it reaches the other end and reflection from that end may be ignored. Adjoining figure shows a similar situation, but this time the external agent gives a continuous periodic sinusoidal up and down jerk to one end of the string. The resulting disturbance on the string is then a sinusoidal wave. In either case the elements of the string oscillate about their equilibrium mean position as the pulse or wave passes through them. The oscillations are normal to the direction of wave motion along the string, so this is an example of **transverse wave**. We can look at a wave in two ways. We can fix an instant of time and picture the wave in space. This will give us the shape of the wave as a whole in space at a given instant. Another way is to fix a location i.e. fix our attention on a particular element of string and see its oscillatory motion in time.

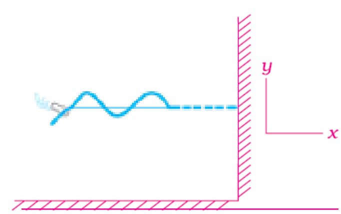


Fig. 10.6

Figure given below, describes the situation for longitudinal waves in the most familiar example of the propagation of sound waves. A long pipe filled with air has a piston at one end. A single sudden push forward and pull back of the piston will generate a pulse of condensations (higher density) and rarefactions (lower density) in the medium (air). If the push-pull of the piston is continuous and periodic (sinusoidal), a sinusoidal wave will be generated propagating in air along the length of the pipe. This is clearly an example of longitudinal wave.

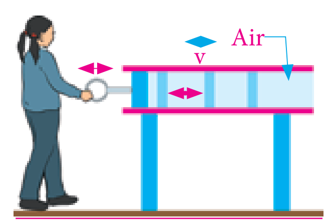


Fig. 10.7

The waves considered above, transverse or longitudinal, are travelling or progressive waves since they travel from one part of the medium to another. The material medium as a whole does not move, as already noted. A stream, for example, constitutes motion of water as a whole. In a water wave, it is the disturbance that moves, not water as a whole. Likewise a wind (motion of air as a whole) should not be confused with a sound wave which is a propagation of disturbance (in pressure density) in air, without the motion of air medium as a whole. In transverse waves, the particle motion is normal to the direction of propagation of the wave. Therefore, as the wave propagates, each element of the medium undergoes a shearing strain. Transverse waves can, therefore, be propagated only in those media, which can sustain shearing stress, such as solids and not in fluids. Fluids, as well as, solids can sustain compressive strain; therefore, longitudinal waves can be propagated in all elastic media. For example, in medium like steel, both transverse and longitudinal waves can propagate, while air can sustain only longitudinal waves. The waves on the surface of water are of two kinds: capillary waves and gravity waves. The former are ripples of fairly short wavelength—not more than a few centimetre—and the restoring force that produces them is the surface tension of water. Gravity waves have wavelengths typically ranging from several metres to several hundred meters.

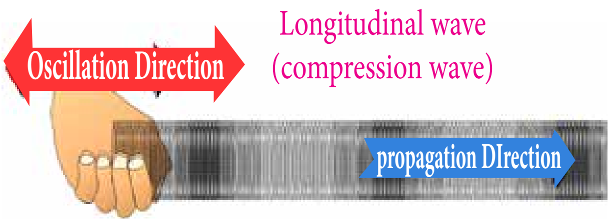


Fig. 10.8

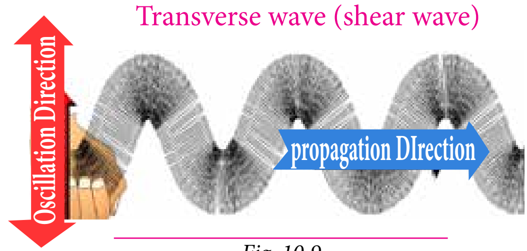


Fig. 10.9

The restoring force that produces these waves is the pull of gravity, which tends to keep the water surface at its lowest level. The oscillations of the particles in these waves are not confined to the surface only, but extend with diminishing amplitude to the very bottom. The particle motion in water waves involves a complicated motion—they not only move up and down but also back and forth. The waves in an ocean are the combination of both longitudinal and transverse waves. It is found that, generally, transverse and longitudinal waves travel with different speed in the same medium.

Activity 10.1

Propagation of a pulse on a rope

You can easily see the motion of a pulse on a rope. You can also see its reflection from a rigid boundary and measure its velocity of travel. You will need a rope of diameter 1 to 3 cm, two hooks and some weights. You can perform this experiment in your classroom or laboratory.

Take a long rope or thick string of diameter 1 to 3 cm, and tie it to hooks on opposite walls in a hall or laboratory. Let one end pass on a hook and hang some weight (about 1 to 5 kg) to it. The walls may be about 3 to 5 m apart.

Take a stick or a rod and strike the rope hard at a point near one end. This creates a pulse on the rope which now travels on it. You can see it reaching the end and reflecting back from it. You can check the phase relation between the incident pulse and reflected pulse. You can easily watch two or three reflections before the pulse dies out. You can take a stopwatch and find the time for the pulse to travel the distance between the walls, and thus measure its velocity. Compare it with that obtained from the formula :–

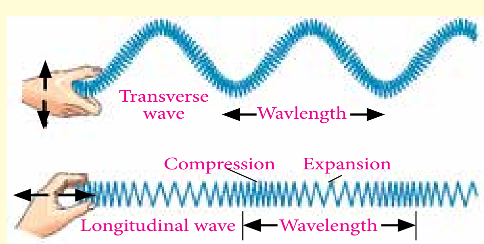
$v = \sqrt{\frac{T}{\mu}}$ Hints: μ=Mass/Length=5kg/0.03m = ...kgm^{-1}, Tension(Force) = m.g =5x9.8=...N

(*Note the important point that the speed v depends only on the properties of the medium. T and μ (T is a property of the stretched string arising due to an external force and μ is the mass per unit lenght). It does not depend on wavelength or frequency of the wave itself.)*

This is also what happens with a thin metallic string of a musical instrument. The major difference is that the velocity on a string is fairly high because of low mass per unit length, as compared to that on a thick rope. The low velocity on a rope allows us to watch the motion and make measurements beautifully.

Examples of Longitudinal Waves

- A sound wave is a significant example of a longitudinal wave. When a speaker speaks some words in front of the microphone, he/she hit the air thousands of time per second at different frequencies. The sound particles travel along with the air particles and enter the mic to produce sound.
- When we clap while singing a birthday song or on any other occasion, do you know, what makes our hand produce that familiar sound of a clap. When we applaud, we compress and displace the air particles between our hands for a part of a second, which produces the sound of a clap we are familiar with.
- All of us are familiar with the sound of a drum, and most of us have also tried hitting the drum in different beats. When we hit the drum with the mallet, drum head vibrates and produce soundwaves. The soundwaves are generated because the drum head moves outward and inward, making air particles to move (vibrate) in the same direction.
- Tsunamis cause damage to coastal regions and that's why people residing in coastal areas are afraid of them. Most people think that sea waves are a transverse wave as they go up and down. However, sea waves, including Tsunami, are the example of both transverse as well as a longitudinal wave. When the waves reach the shore or smaller areas, they become smaller and thinner, and water particles move parallel to the wave, hence making it a longitudinal wave.
- It is said that animals can sense the earthquake waves much before humans. They have the ability to sense the seismic P waves, which travel only in the interior of the earth. Even humans can feel a little bump and rattle of these waves, but they are mostly unnoticeable to us. The P waves are the fastest, and they require a medium to travel (solid and liquid). These waves cause the interior of the earth (tectonic plates) to move back and forth in a longitudinal manner, which leads to the surface waves (seismic S wave), which we can feel.
- Whenever it is raining heavily, and thunders are there, you might have noticed the vibration in window panels of your home; it happens because of sound waves. Lightning causes an increase in the air pressure and temperature, which creates a shock wave of sound that we hear like a loud boom and cause our window panels to vibrate.
- Have you ever noticed the movement of the woofer cone; moving in and out or ever felt air pressure on your hand when you try to cover the mouth of a woofer ? It's because woofers work on the phenomenon of a longitudinal wave. They move the air particles in or out, producing sound.
- **Longitudinal waves** are the waves in which the particles of the medium propagates along the direction of the motion. Simply, particles travel along the direction of the motion or a wave. They are composed of compression (when particles/ wave move close to each other) and rarefaction (when particles/wave move away). They require a medium to travel.



- **Transverse waves** are those in which direction of disturbance or displacement in the medium is perpendicular to that of the propagation of wave.The direction in which a wave propagates is perpendicular to the direction of disturbance.

Activity 10.2

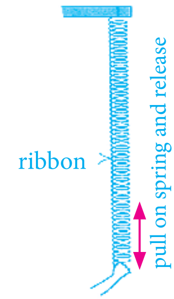
Investigating longitudinal waves

Take a spring and hang it from the ceiling. Pull the free end of the spring and release it. Observe what happens.

In which direction does the disturbance move?

What happens when the disturbance reaches the ceiling?

Tie a ribbon to the middle of the spring. Watch carefully what happens to the ribbon when the free end of the spring is pulled and released. Describe the motion of the ribbon.



Differences between longitudinal wave and transverse wave

Transverse Waves	Longitudinal Waves
1. Transverse waves consist of crests and troughs.	1. Longitudinal waves consist of compressions and rarefactions.
2. There are no pressure variations.	2. There is a pressure variation throughout the medium.
3. They can be propagated through solids and surfaces of liquids but not in gases.	3. They can be propagated through solids, liquids as well as through gases.
4. In transverse waves, the particles of the medium vibrate at right angle to the direction of wave propagation.	4. In longitudinal waves, the particles of the medium vibrate parallel to the direction of the wave propagation.
5. There is no change in the density of medium.	5. There is a change in the density throughout the medium.
6. Light wave is an example of transverse wave.	6. Sound wave is an example of longitudinal wave.

Table 9.1

Relation between frequency, wave motion and wave length

Wavelength, distance between corresponding points of two consecutive waves. 'Corresponding points' refers to two points or particles in the same phase—i.e., points that have completed identical fractions of their periodic motion. Usually, in transverse waves (waves with points oscillating at right angles to the direction of their advance), wavelength is measured from crest to crest or from trough to trough; in longitudinal waves (waves with points vibrating in the same direction as their advance), it is measured from compression to compression or from rarefaction to rarefaction. Wavelength is usually denoted by the Greek letter lambda (λ) .

Wave velocity, distance travelled by a periodic or cyclic, motion per unit time (in any direction). Wave velocity in common usage refers to speed, although, properly, velocity implies both speed and direction. The velocity of a wave is equal to the product of its wavelength and frequency (number of vibrations per second) and is independent of its intensity.

Frequency, the number of waves that pass a fixed point in unit time; also, the number of cycles or vibrations undergone during one unit of time by a body in periodic motion. A body in periodic motion is said to have undergone one cycle or one vibration after passing through a series of events or positions and returning to its original state.

The velocity of a wave is v, time period T, frequency f and wavelength λ.

By the definition of wavelength,

The velocity of a wave is equal to the product of its wavelength and frequency (number of vibrations per second) and is independent of its intensity.

And hence,

Wavelength = Distance travelled by the wave in one time period, i.e., in T second.
Or, wavelength = Wave velocity x Time period
Or, $\lambda = v \times T$
Or, $\lambda = v \times 1/f$ [$T = 1/f$]
Therefore, $v = f\lambda$
Therefore, Wave velocity = Frequency x wavelength

Unit and symbols

Quantity Symbol	Quantity Term	Unit	Unit Symbol
v	wave velocity	meters/second	m/s
λ	wavelength	meter	m
f	frequency	Hertz	Hz

Table 9.2

Sample Problem (i) A wave has frequency of 50 Hz and a wavelength of 10 m. What is the velocity of the wave?

$f = 50$ Hz
$\lambda = 10$ m
$v = ?$
$v = \lambda \cdot f = 10 \text{ m} \times 50 \text{ Hz} = 500 \text{ m/s}$

Mechanical and Radiation/ Electromagnetic Wave

Waves transport energy and the pattern of disturbance has information that propagate from one point to another. All our communications essentially depend on transmission of signals through waves. Speech means production of sound waves in air and hearing amounts to their detection. Often, communication involves different kinds of waves. For example, sound waves may be first converted into an electric current signal which in turn may generate an electromagnetic wave that may be transmitted by an optical cable or via a satellite. Detection of the original signal will usually involve these steps in reverse order. Not all waves require a medium for their propagation. We know that light waves can travel through vacuum. The light emitted by stars, which are hundreds of light years away, reaches us through inter-stellar space, which is practically a vacuum. The most familiar type of waves such as waves on a string, water waves, sound waves, seismic waves, etc. is the so-called **mechanical waves**. These waves require a medium for propagation, they cannot propagate through vacuum. They involve oscillations of constituent particles and depend on the elastic properties of the medium.

Electromagnetic waves do not necessarily require a medium - They can travel through vacuum.

Light, radiowaves, X-rays, are all electromagnetic waves. In vacuum, all electromagnetic waves have the same speed c, whose value is : $c = 299, 792, 458\ ms^{-1}$.

A third kind of wave is the so-called matter waves. They are associated with constituents of matter : electrons, protons, neutrons, atoms and molecules. They arise in quantum mechanical description of nature that you will learn in your later studies. Though conceptually more abstract than mechanical or electro-magnetic waves, they have already found applications in several devices basic to modern technology; matter waves associated with electrons are employed in electron microscopes.

The aesthetic influence of waves on art and literature is seen from very early times; yet the first scientific analysis of wave motion dates back to the seventeenth century. Some of the famous scientists associated with the physics of wave motion are Christian Huygens (1629-1695), Robert Hooke and Isaac Newton. The understanding of physics of waves followed the physics of oscillations of masses tied to springs and physics of the simple pendulum. Waves in elastic media are intimately connected with harmonic oscillations. (Stretched strings, coiled springs, air, etc., are examples of elastic media).

Activity 10.3

Consider a collection of springs connected to one another as shown in Figure. If the spring at one end 'A' is pulled suddenly, what has happened? Discuss with classmates and write down the results.

A collection of springs connected to each other. If the spring at one end is pulled suddenly generating a disturbance, which then propagates to the other end. In this situation, the first spring is disturbed from its equilibrium length. Since the second spring is connected to the first, it is also stretched or compressed, and so on. The disturbance moves from one end to the other; but each spring only executes small oscillations about its equilibrium position. As a practical example of this situation, consider a stationary train at a railway station. Different bogies of the train are coupled to each other through a spring coupling. When an engine is attached at one end, it gives a push to the bogie next to it; this push is transmitted from one bogie to another without the entire train being bodily displaced. Now let us consider the propagation of sound waves in air. As the wave passes through air, it compresses or expands a small region of air. This causes a change in the density of that region, this change induces a change in pressure in that region. Pressure is force per unit area, so there is a restoring force proportional to the disturbance, just like in a spring. In this case, the quantity similar to extension or compression of the spring is the change in density. If a region is compressed, the molecules in that region are packed together, and they tend to move out to the adjoining region, thereby increasing the density or creating compression in the adjoining region. Consequently, the air in the first region undergoes rarefaction. If a region is comparatively rarefied the surrounding air will rush in making the rarefaction move to the adjoining region. Thus, the **compression** or rarefaction moves from one region to another, making the propagation of a disturbance possible in air.

In solids, similar arguments can be made. In a crystalline solid, atoms or group of atoms are arranged in a periodic lattice. In these, each atom or group of atoms is in equilibrium, due to forces from the surrounding atoms. Displacing one atom, keeping the others fixed, leads to restoring forces, exactly as in a spring. So we can think of atoms in a lattice as end points, with springs between pairs of them.

Classical waves transfer energy without transporting matter through the medium. Waves in a pond do not carry the water molecules from place to place, rather the wave's energy travels through the water, leaving the water molecules in place, much like a bug bobbing on top of ripples in water.

Mechanical waves and electromagnetic waves are two important ways that energy is transported in the world around us. Waves in water and sound waves in air are two examples of mechanical waves.

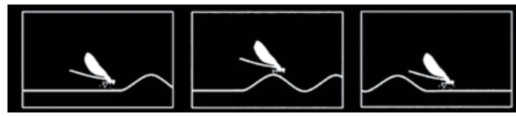


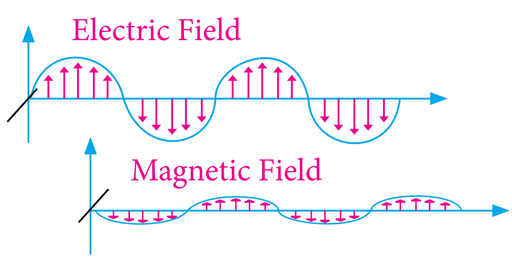
Fig. 10.10

Mechanical waves are caused by a disturbance or vibration in matter, whether solid, gas, liquid, or plasma. Matter that waves are traveling through is called a medium. Water waves are formed by vibrations in a liquid and sound waves are formed by vibrations in a gas (air). These mechanical waves travel through a medium by causing the molecules to bump into each other, like falling dominoes transferring energy from one to the next. Sound waves cannot travel in the vacuum of space because there is no medium to transmit these mechanical waves.

The velocity of mechanical waves varies between solid, liquid and gas medium. For example, under normal conditions the velocity of sound in air, water and iron is 343 m /s, 1481 m/s and 5120 m /s respectively. Mechanical waves are longitudinal waves or transverse waves.

In the 1860's and 1870's, a Scottish scientist named **James Clerk Maxwell** developed a scientific theory to explain electromagnetic waves. He noticed that electrical fields and magnetic fields can couple together to form electromagnetic waves. He summarized this relationship between electricity and magnetism into what are now referred to as "Maxwell's Equations."

Heinrich Hertz, a German physicist, applied Maxwell's theories to the production and reception of radio waves. The unit of frequency of a radio wave -- one cycle per second -- is named the hertz, in honor of Heinrich Hertz.



His experiment with radio waves solved two problems. First, he had demonstrated in the concrete, what Maxwell had only theorized — that the velocity of radio waves was equal to the velocity of light. This proved that radio waves were a form of light! Second, Hertz found out how to make the electric and magnetic fields detach themselves from wires and go free as Maxwell's waves — electromagnetic waves.

Difference Between Mechanical Wave and Electromagnetic Wave

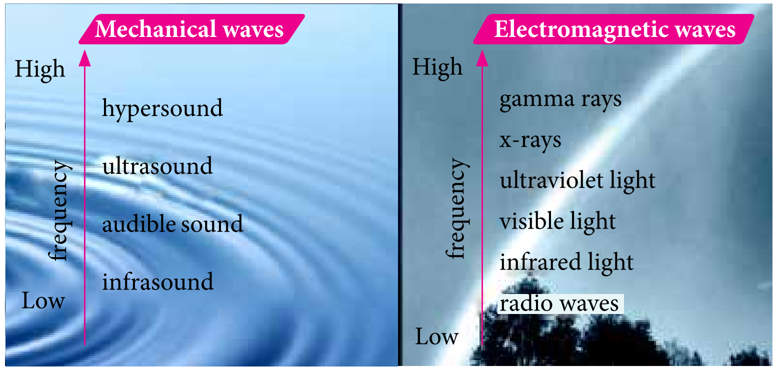


Fig. 10.11

Electricity can be static, like the energy that can make your hair stand on end. Magnetism can also be static, as it is in a refrigerator magnet. A changing magnetic field will induce a changing electric field and vice-versa—the two are linked. These changing fields form electromagnetic waves. Electromagnetic waves differ from mechanical waves in that they do not require a medium to propagate. This means that electromagnetic waves can travel not only through air and solid materials, but also through the vacuum of space. Another stark difference between the two is that the distance traveled by mechanical waves depends upon the elasticity of the medium it uses whereas the characteristics of an electromagnetic wave depend upon acting magnetic and electric fields. A mechanical wave travels much slower than an electromagnetic wave which travels as fast as light whose primary constituents are photons. An example of a mechanical wave is a sound wave whereas a microwave, a radio wave, infrared, ultraviolet rays, X-rays, Visible light, and gamma rays are examples of electromagnetic waves. Mechanical waves are waves that are the result of oscillating matter and their movement is what carries the wave forward whereas Electromagnetic waves are the result of accelerating electrically charged particles.

Comparison between Mechanical wave and Electromagnetic wave in tabular form

Parameter of comparison	Mechanical waves	Electromagnetic Waves
Medium	Cannot travel without a medium	Can travel without a medium
Factors affecting	Elasticity and inertia	magnetic and electric fields
Speed	Travels with the speed of the medium	Travels at the speed of light
Types	Tranverse and longitudinal	Only transverse
Examples	Sound wave, surface waves	Microwaves, Radio waves etc.

Table 9.2

Electromagnetic Waves

- Created by vibrating electric changes
- Can travel through a vacuum (needs NO medium to travel through)
- Have a wide variety of frequencies and wavelengths.
- People can see the wavelengths arounds 400 nanometers to 700 nanometers.
- All travel at the speed of light in a vacuum -300,000 km/s, 670,617,000 mi/hr

10.3 Electromagnetic (EM) Spectrum

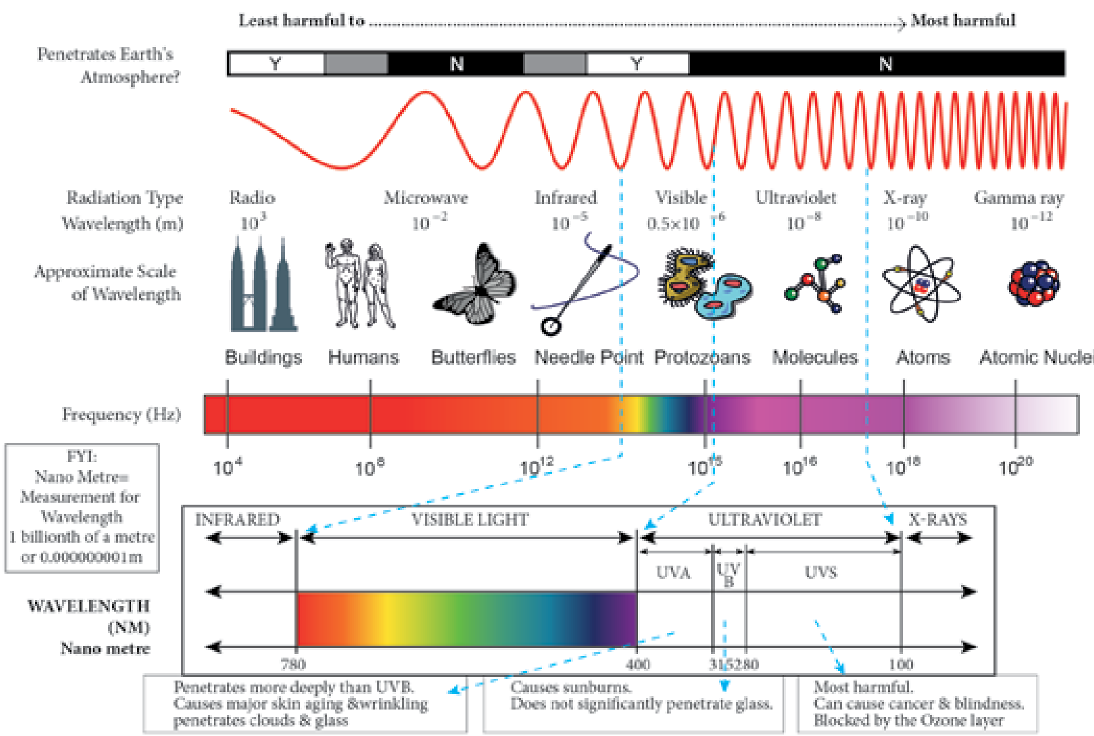


Fig. 10.13

The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of EM radiation that make up the electromagnetic spectrum are microwaves,infrared light,ultraviolet light,X-ray and gamma-rays.

You know more about the electromagnetic spectrum than you may think. The image below shows where you might encounter each portion of the EM spectrum in your day-to-day life.

Application of Electromagnetic Waves

Radio Waves

Radio waves have the longest wavelengths in the electromagnetic spectrum. They range from the length of a football to larger than our planet. Heinrich Hertz proved the existence of radio waves in the late 1880s. He used a spark gap attached to an induction coil and a separate spark gap on a receiving antenna. When waves created by the sparks of the coil transmitter were picked up by the receiving antenna, sparks would jump its gap as well. Hertz showed in his experiments that these signals possessed all the properties of electromagnetic waves.

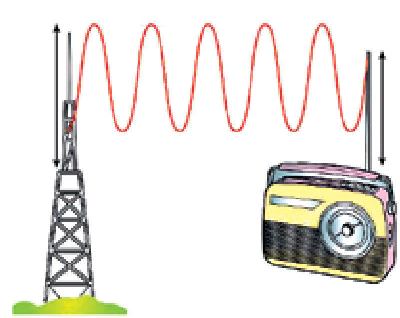


Fig. 10.14

You can tune a radio to a specific wavelength—or frequency—and listen to your favorite music. The radio "receives" these electromagnetic radio waves and converts them to mechanical vibrations in the speaker to create the sound waves you can hear.

Your radio captures radio waves emitted by radio stations, bringing your favorite tunes. Radio waves are also emitted by stars and gases in space.

Radio waves are transmitted easily through air. They do not cause damage if absorbed by the human body, and they can be reflected to change their direction. These properties make them ideal for communications.

Radio waves can be produced by oscillations in electrical circuits. When radio waves are absorbed by a conductor, they create an alternating current. This electrical current has the same frequency as the radio waves. Information is coded into the wave before transmission, which can then be decoded when the wave is received. Television and radio systems use this principle to broadcast information.

Uses of Radio waves

They are used in standard broadcast radio and television, shortwave radio, navigation and air-traffic control, cellular telephony, and even remote-controlled toys.

Microwave

Microwave radiation will cook your popcorn in just a few minutes. It is also used by astronomers to learn about the structure of nearby galaxies. Microwaves are used in radar, radio transmission, cooking and other applications that have become essential in our modern society. Microwaves are electromagnetic waves generally defined as lying within the frequency range of 100 MHz (3 m wavelength) to 300 GHz (1 mm wavelength).

Uses of microwave

Microwave technology is extensively used for point-to-point telecommunications (i.e. non-broadcast uses). Microwaves are used in spacecraft communication, and much of the world's data, TV, and telephone communications are transmitted long distances by microwaves between ground stations and communications satellites. Microwaves are also employed in microwave ovens and in radar technology.

Infrared waves

Infrared waves, or infrared light, are part of the electromagnetic spectrum. People encounter infrared waves every day; the human eye cannot see it, but humans can detect it as heat.

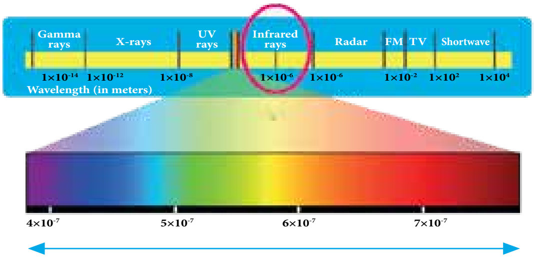


Fig. 10.15

Uses of Infrared waves

A remote control uses light waves just beyond the visible spectrum of light—infrared light waves—to change channels on your TV. This region of the spectrum is divided into near, mid-, and far-infrared. The region from 8 to 15 microns (μm) is referred to by Earth scientists as thermal infrared since these wavelengths are best for studying the longwave thermal energy radiating from our planet. Night vision goggles pick up the infrared light emitted by our skin and objects with heat. In space, infrared light helps us map the dust between stars.

Light Wave

Light wave is an electromagnetic radiation that can be detected by the human eye. Electromagnetic radiation occurs over an extremely wide range of wavelengths, from gamma rays with wavelengths less than about 1×10^{-11} metre to radio waves measured in metres. Within that broad spectrum the wavelengths visible to humans occupy a very narrow band, from about 700 nanometres (nm; billionths of a metre) for red light down to about 400 nm for violet light. The spectral regions adjacent to the visible band are often referred to as light also, infrared at the one end and ultraviolet at the other. The speed of light in a vacuum is a fundamental physical constant, the currently accepted value of which is exactly 299,792,458 metres per second, or about 186,282 miles per second.

Uses of light wave

Visible light is the only of EM wave that we can see. The colours that we see are actually light waves of different wavelengths.

Light is also used by plants for photosynthesis and for high speed data transmission through optical fibres.

Ultraviolet (UV)

Ultraviolet waves, that portion of the electromagnetic spectrum extending from the violet, or short-wavelength, end of the visible light range to the X-ray region. Ultraviolet (UV) radiation is undetectable by the human eye, although, when it falls on certain materials, it may cause them to fluoresce—i.e., emit electromagnetic radiation of lower energy, such as visible light. Many insects, however, are able to see ultraviolet radiation.

Ultraviolet radiation lies between wavelengths of about 400 nanometres (1 nanometre [nm] is 10^{-9} metre) on the visible-light side and about 10 nm on the X-ray side, though some authorities extend the short-wavelength limit to 4 nm

Uses of UV

UV radiation is widely used in industrial processes and in medical and dental practices for a variety of purposes, such as killing bacteria, creating fluorescent effects, curing inks and resins, phototherapy and suntanning. Different UV wavelengths and intensities are used for different purposes.

X-ray

X-ray, electromagnetic radiation of extremely short wavelength and high frequency, with wavelengths ranging from about 10^{-8} to 10^{-12} metre and corresponding frequencies from about 10^{16} to 10^{20} hertz (Hz).X-rays are commonly produced by accelerating (or decelerating) charged particles; examples include a beam of electrons striking a metal plate in an X-ray tube and a circulating beam of electrons in a synchrotron particle accelerator or storage ring. In addition, highly excited atoms can emit X-rays with discrete wavelengths characteristic of the energy level spacings in the atoms. The X-ray region of the electromagnetic spectrum falls far outside the range of visible wavelengths. However, the passage of X-rays through materials, including biological tissue, can be recorded with photographic films and other detectors. The analysis of X-ray images of the body is an extremely valuable medical diagnostic tool.

Uses of X- ray

A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag.

Detects bone fractures, certain tumors and other abnormal masses, pneumonia, some types of injuries, calcifications, foreign objects, dental problems, etc.

Uses X-rays and a fluorescent screen to obtain real-time images of movement within the body or to view diagnostic processes, such as following the path of an injected or swallowed contrast agent.

X-rays and other types of high-energy radiation can be used to destroy cancerous tumors and cells by damaging their DNA. The radiation dose used for treating cancer is much higher than the radiation dose used for diagnostic imaging. Therapeutic radiation can come from a machine outside of the body or from a radioactive material that is placed in the body, inside or near tumor cells, or injected into the blood stream.

Gamma Ray

Gamma rays have the smallest wavelengths and the most energy of any wave in the electromagnetic spectrum. They are produced by the hottest and most energetic objects in the universe, such as neutron stars and pulsars, supernova explosions, and regions around black holes. On Earth, gamma waves are generated by nuclear explosions, lightning, and the less dramatic activity of radioactive decay.

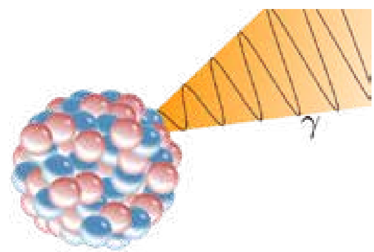


Fig. 10.16

Uses of Gamma Ray

Gamma rays are used in medicine (radiotherapy), industry (sterilization and disinfection) and the nuclear industry. Shielding against gamma rays is essential because they can cause diseases to skin or blood, eye disorders and cancers.

Reflection of Sound

Sound bounces off a solid or a liquid like a rubber ball bounces off a wall. Like light, sound gets reflected at the surface of a solid or liquid and follows the same laws of reflection as you have studied in earlier classes. The directions in which the sound is incident and is reflected make equal angles with the normal to the reflecting surface at the point of incidence, and the three are in the same plane. An obstacle of large size which may be polished or rough is needed for the reflection of sound waves.

Fig. 10.17

If we shout or clap near a suitable reflecting object such as a tall building or a mountain, we will hear the same sound again a little later. This sound which we hear is called an echo. The sensation of sound persists in our brain for about 0.1 s. To hear a distinct echo the time interval between the original sound and the reflected one must be at least 0.1s. If we take the speed of sound to be 344 m/s at a given temperature, say at 22° C in air, the sound must go to the obstacle and reach back the ear of the listener on reflection after 0.1s. Hence, the total distance covered by the sound from the point of generation to the reflecting surface and back should be at least (344 m/s) × 0.1 s = 34.4 m. Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, 17.2 m. This distance will change with the temperature of air. Echoes may be heard more than once due to successive or multiple reflections. The rolling of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds and the land sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation. In an auditorium or big hall excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound-absorbent materials like compressed fibreboard, rough plaster or draperies. The seat materials are also selected on the basis of their sound absorbing properties.

Application of reflected sound

- Megaphones or loudhailers, horns, musical instruments such as trumpets and shehanais, are all designed to send sound in a particular direction without spreading it in all directions. In these instruments, a tube followed by a conical opening reflects sound successively to guide most of the sound waves from the source in the forward direction towards the audience.
- Stethoscope is a medical instrument used for listening to sounds produced within the body, chiefly in the heart or lungs. In stethoscope the sound of the patient's heartbeat reaches the doctor's ears by multiple reflection of sound .
- Generally , the ceilings of concert halls, conference halls and cinema halls are curved so that sound after reflection reaches all corners of the hall . Sometimes a curved soundboard may be placed behind the stage so that the sound, after reflecting from the sound board, spreads evenly across the width of the hall. .

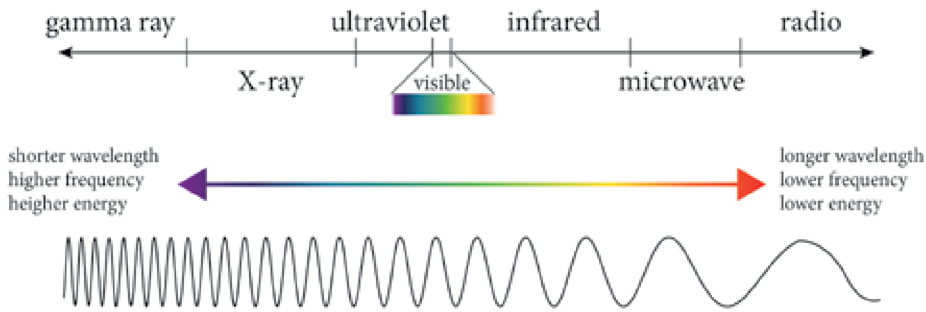
Acoustic Protection

Acoustic protection is the application of soft and porous material to protect individuals against undesirable sounds and noises. Acoustic protection is employed not only for physical health, but for psychological wellbeing as well.

The sound reflection inside the room makes the sound blurred. Sound reflection from smooth surfaces is higher than sound reflection from soft and rough surfaces. Acoustic protection is a technology that absorbs unnecessary sound waves through a soft and smooth surface. It can control the sound reflection in the room, meeting room, sound recording studio etc. Measures such as roughing the wall and sticking foam to the wall can be used for acoustic protection. Holes are used in the walls of sound studios, meeting halls etc.

Measuring Electromagnetic Radiation

Electromagnetic radiation can be expressed in terms of energy, wavelength, or frequency. Frequency is measured in cycles per second, or Hertz. Wavelength is measured in meters. Energy is measured in electon volt. Each of these three quantities for describing EM radiation are related to each other in a precise mathematical way. But why do we have three ways of describing things, each with a different set of physical units?



Comparison of wavelength, frequency and energy for the electromagnetic spectrum

Fig. 10.18

The short answer is that scientists don't like to use numbers any bigger or smaller than they have to. It is much easier to say or write 'two kilometers' than 'two thousand meters.' Generally, scientists use whatever units are easiest for the type of EM radiation they work with.

Astronomers who study radio waves tend to use wavelengths or frequencies. Most of the radio part of the EM spectrum falls in the range from about 1 cm to 1 km, which is 30 gigahertz (GHz) to 300 kilohertz (kHz) in frequencies. The radio is a very broad part of the EM spectrum.

Infrared and optical astronomers generally use wavelength. Infrared astronomers use microns (millionths of a meter) for wavelengths, so their part of the EM spectrum falls in the range of 1 to 100 microns. Optical astronomers use both angstroms (0.00000001 cm, or 10^{-8} cm) and nanometers (0.0000001 cm, or 10^{-7} cm). Using nanometers, violet, blue, green, yellow, orange, and red light have wavelengths between 400 and 700 nanometers. (This range is just a tiny part of the entire EM spectrum, so the light our eyes can see is just a little fraction of all the EM radiation around us.)

The wavelengths of ultraviolet, X-ray, and gamma-ray regions of the EM spectrum are very small. Instead of using wavelengths, astronomers that study these portions of the EM spectrum usually refer to these photons by their energies, measured in electron volts (eV). Ultraviolet radiation falls in the range from a few electron volts to about 100 eV. X-ray photons have energies in the range 100 eV to 100,000 eV (or 100 keV). Gamma-rays then are all the photons with energies greater than 100 keV.

	Wavelength (m)	Frequency (Hz)	Energy (J)
Radio	$>1\times10^{-1}$	$<3\times10^{9}$	$<2\times10^{-24}$
Microwave	1×10^{-3} - 1×10^{-1}	3×10^{9} - 3×10^{11}	2×10^{-24} - 2×10^{-22}
Infrarate	7×10^{-7} - 1×10^{-3}	3×10^{11} - 4×10^{14}	2×10^{-22} - 4×10^{-19}
Optical	4×10^{-7} - 7×10^{-7}	4×10^{14} - 7.5×10^{14}	3×10^{-19} - 5×10^{-19}
UV	1×10^{-8} - 1×10^{-7}	7.5×10^{14} - 3×10^{16}	5×10-^{19} - 2×10^{-17}
X-ray	1×10^{-11} - 1×10^{-8}	3×10^{16} - 3×10^{19}	2×10^{-17} - 2×10^{-14}
Gamma-ray	$<1\times10^{-11}$	$<1\times10^{19}$	$<2\times10^{-14}$

Table 9.3

How big are radio waves?

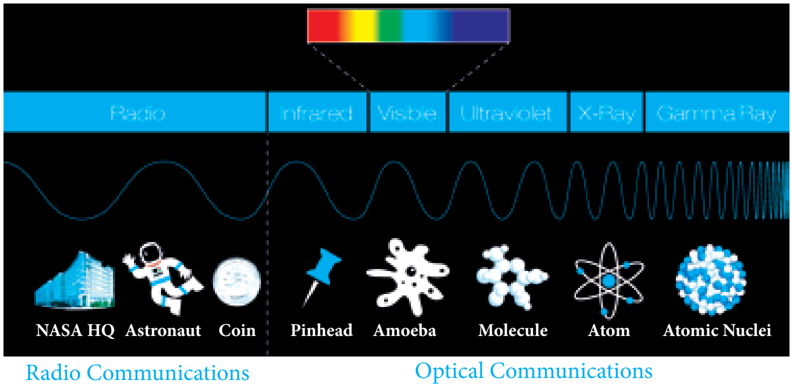


Fig. 10.19

10.4 X-ray Photography

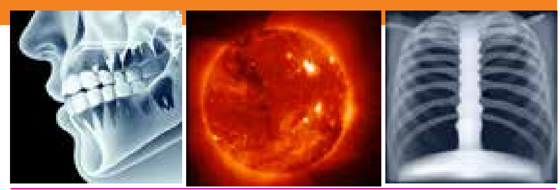


Fig. 9.20

X-rays are types of electromagnetic radiation probably most well-known for their ability to see through a person's skin and reveal images of the bones beneath it. Advances in technology have led to more powerful and focused X-ray beams as well as ever greater applications of these light waves, from imaging teensy biological cells and structural components of materials like cement to killing cancer cells.

X-rays are roughly classified into soft X-rays and hard X-rays. Soft X-rays have relatively short wavelengths of about 10 nanometers (a nanometer is one-billionth of a meter), and so they fall in the range of the electromagnetic (EM) spectrum between ultraviolet (UV) light and gamma-rays. Hard X-rays have wavelengths of about 100 picometers (a picometer is one-trillionth of a meter). These electromagnetic waves occupy the same region of the EM spectrum as gamma-rays. The only difference between them is their source: X-rays are produced by accelerating electrons, whereas gamma-ray are produced by atomic nuclei in one of four nuclear reactions.

Medical science recognizes different types of X-Rays. A few important types of X-rays are given below.

- Standard Computed Tomography
- Chest X-rays
- Abdomen X-rays
- Teeth and bones X-rays
- Lungs X-rays
- Kidney, Ureter, and Bladder X-ray

X rays are produced when high-velocity electrons collide with the metal plates, thereby giving the energy as the X-Rays and themselves absorbed by the metal plate. The X-Ray beam travels through the air and comes in contact with the body tissues,

X-ray absorption differences occur in bones or muscles, which cause differences in the X-rays reaching the film.

Fig. 10.21

and produces an image on a metal film. Soft tissue like organs and skin, cannot absorb the high-energy rays, and the beam passes through them. Dense materials inside our bodies, like bones, absorb the radiation.

Much like a camera, the X-Ray film develops depending on the areas which were exposed to the X-Rays. White areas show the denser tissues, such as bones which have absorbed the X-Rays whereas black areas on an X-Ray represent areas where the X-Rays have passed through soft tissues.

X-rays are a form of radiation like light or radio waves. X-rays pass through most objects, including the body. The technologist carefully aims the x-ray beam at the area of interest. The machine produces a small burst of radiation that passes through your body. The radiation records an image on photographic film or a special detector.

Projectional radiography

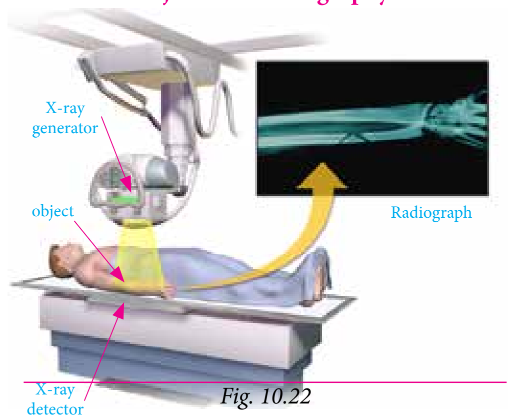


Fig. 10.22

Different parts of the body absorb the x-rays in varying degrees. Dense bone absorbs much of the radiation while soft tissue (muscle, fat, and organs) allow more of the x-rays to pass through them. As a result, bones appear white on the x-ray, soft tissue shows up in shades of gray, and air appears black. Most x-ray images are electronically stored digital files. Your doctor can easily access these stored images to diagnose and manage your condition.

The technologist, an individual specially trained to perform radiology examinations, positions the patient on the x-ray table and places the x-ray film holder or digital recording plate under the table in the area of the body being imaged. When necessary, sandbags, pillows or other positioning devices will be used to help you maintain the proper position. A lead apron may be placed over your pelvic area or breasts when feasible to protect from radiation.

You must hold very still and may need to hold your breath for a few seconds while the tecnologist takes the x-ray. This helps reduce the possibility of a blurred image. The technologist will walk behind a wall or into the next room to activate the x-ray machine.

You may be repositioned for another view and the process is repeated. Two or three images (from different angles) will typically be taken.

An x-ray may also be taken of the unaffected limb, or of a child's growth plate (where new bone is forming), for comparison purposes.

When the examination is complete, the technologist may ask you to wait until the radiologist confirms they have all the necessary images. A bone x-ray examination is usually completed within five to 10 minutes.

X-rays were first observed and documented in 1895 by German scientist Wilhelm Conrad Roentgen. He discovered that firing streams of x-rays through arms and hands created detailed images of the bones inside. When you get an x-ray taken, x-ray sensitive film is put on one side of your body, and x-rays are shot through you. Because bones are dense and absorb more x-rays than skin does, shadows of the bones are left on the x-ray film while the skin appears transparent.

10.5 Introduction, working principle and uses of CT scan

The term 'computed tomography', or CT, refers to a computerized X-ray imaging procedure in which a narrow beam of X-ray is aimed at a patient and quickly rotated around the body, producing signals that are processed by the machine's computer to generate cross-sectional images—or 'slices'—of the body. These slices are called tomographic images and contain more detailed information than conventional X-rays. Once a number of successive slices are collected by the machine's computer, they can be digitally "stacked" together to form a three-dimensional image of the patient that allows for easier identification and location of basic structures as well as possible tumors or abnormalities.

Unlike a conventional X-ray—which uses a fixed X-ray tube—a CT scanner uses a motorized X-ray source that rotates around the circular opening of a donut-shaped structure called a gantry. During a CT scan, the patient lies on a bed that slowly moves through the gantry while the X-ray tube rotates around the patient, shooting narrow beams of X-ray through the body. Instead of film, CT scanners use special digital X-ray detectors, which are located directly opposite the X-ray source. As the X-rays leave the patient, they are picked up by the detectors and transmitted to a computer.

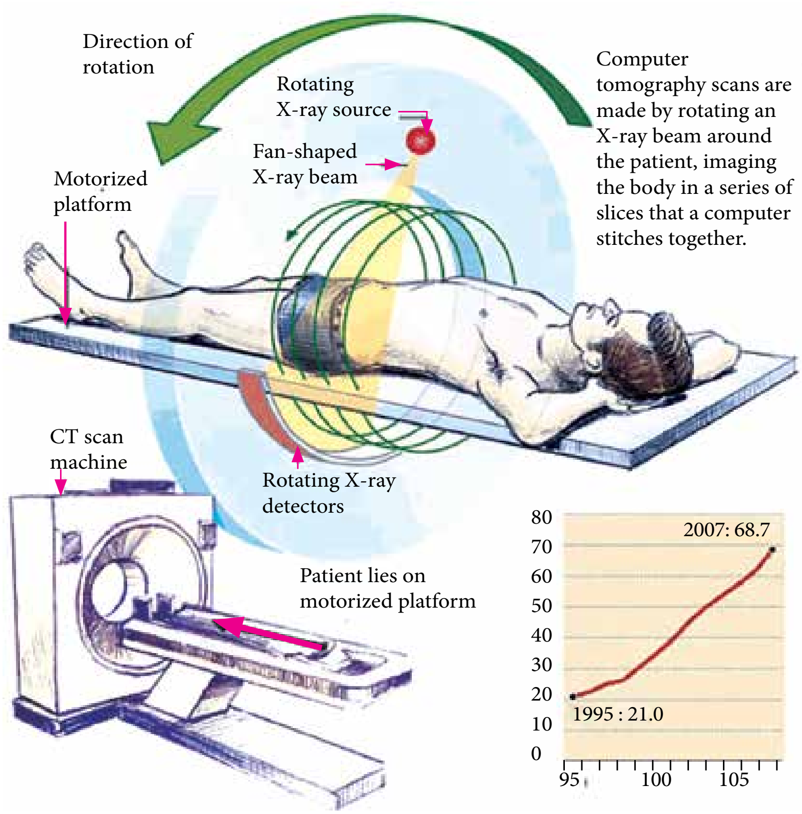


Fig. 10.23

Each time the X-ray source completes one full rotation, the CT computer uses sophisticated mathematical techniques to construct a 2D image slice of the patient. The thickness of the tissue represented in each image slice can vary depending on the CT machine used, but usually ranges from 1-10 millimeters. When a full slice is completed, the image is stored and the motorized bed is moved forward incrementally into the gantry. The X-ray scanning process is then repeated to produce another image slice. This process continues until the desired number of slices is collected.

Image slices can either be displayed individually or stacked together by the computer to generate a 3D image of the patient that shows the skeleton, organs, and tissues as well as any abnormalities the physician is trying to identify. This method has many advantages including the ability to rotate the 3D image in space or to view slices in succession, making it easier to find the exact place where a problem may be located.

CT scans can be used to identify disease or injury within various regions of the body. For example, CT has become a useful screening tool for detecting possible tumors or lesions within the abdomen. A CT scan of the heart may be ordered when various types of heart disease or abnormalities are suspected. CT can also be used to image the head in order to locate injuries, tumors, clots leading to stroke, hemorrhage, and other conditions. It can image the lungs in order to reveal the presence of tumors, pulmonary embolisms (blood clots), excess fluid, and other conditions such as emphysema or pneumonia. A CT scan is particularly useful when imaging complex bone fractures, severely eroded joints, or bone tumors since it usually produces more detail than would be possible with a conventional X-ray.

As with all x-rays, dense structures within the body—such as bone—are easily imaged, whereas soft tissues vary in their ability to stop X-rays and, thus, may be faint or difficult to see. For this reason, intravenous contrast agents have been developed that are highly visible in an X-ray or CT scan and are safe to use in patients. Contrast agents contain substances that are better at stopping X-rays and, thus, are more visible on an X-ray image. For example, to examine the circulatory system, a contrast agent based on iodine is injected into the bloodstream to help illuminate blood vessels. This type of test is used to look for possible obstructions in blood vessels, including those in the heart. Oral contrast agents, such as barium-based compounds, are used for imaging the digestive system, including the esophagus, stomach, and GI tract.

CT scans can diagnose possibly life-threatening conditions such as hemorrhage, blood clots, or cancer. An early diagnosis of these conditions could potentially be life-saving. However, CT scans use x-rays, and all X-rays produce ionizing radiation. Ionizing radiation has the potential to cause biological effects in living tissue. This is a risk that increases with the number of exposures added up over the life of an individual. However, the risk of developing cancer from radiation exposure is generally small.

A CT scan in a pregnant woman poses no known risks to the baby if the area of the body being imaged isn't the abdomen or pelvis. In general, if imaging of the abdomen and pelvis is needed, doctors prefer to use exams that do not use radiation, such as MRI or ultrasound. However, if neither of those can provide the answers needed, or there is an emergency or other time constraint, CT may be an acceptable alternative imaging option.

In some patients, contrast agents may cause allergic reactions, or in rare cases, temporary kidney failure. IV contrast agents should not be administered to patients with abnormal kidney function since they may induce a further reduction of kidney function, which may sometimes become permanent.

Children are more sensitive to ionizing radiation and have a longer life expectancy and, thus, a higher relative risk for developing cancer than adults. Parents may want to ask the technologist or doctor if their machine settings have been adjusted for children.

Ultrasounds

Ultrasounds are high frequency waves, which can travel in defined paths even in the presence of many obstacles .Ultrasonic waves are used to capture the images of the heart and its features and problems associated with the heart, if any (for treatment purpose). This is called echocardiography.

Ultrasound scans/Ultrasonography are very commonly used to get images of internal body organs such as liver, kidney, uterus. It helps the doctor to diagnose and treat problems in the body of the patient. In this method, ultrasound waves are made to travel through the body to the organ under consideration. They get reflected and these are converted to electrical signals which can be monitored on a screen.Ultrasonography is used to observe the growth of the fetus inside the uterus. It can also used to monitor the abnormalities.It is used to break kidney stones into fine grains which later get flushed out through urine.

Ultrasound is used to clean machine parts located in places which are not easily accesible - electronic components, internal parts, spiral parts etc. The objects are placed in a cleaning solution and waves are passed through it. Because of the high frequency of the waves, the dust particles just fall out. It is used to detect defects, flaws, cracks in machine parts, bridges, building etc. Ultrasound waves are passed at one end and monitored using detectors. If there are laws or cracks, then the ultrasound waves are reflected back indicating the presence of a defect.

10.6 Introduction, working principle and uses of Ultrasonography

Ultrasounds are high frequency waves. Ultrasounds are able to travel along welldefined paths even in the presence of obstacles. Ultrasounds are used extensively in industries and for medical purposes.

Ultrasounds can be used to detect cracks and flaws in metal blocks. Metallic components are generally used in construction of big structures like buildings, bridges, machines and also scientific equipment. The cracks or holes inside the metal blocks, which are invisible from outside reduces the strength of the structure. Ultrasonic waves are allowed to pass through the metal block and detectors are used to detect the transmitted waves. If there is even a small defect, the ultrasound gets reflected back indicating the presence of the flaw or defect.

Fig. 10.24

Ordinary sound of longer wavelengths cannot be used for such purpose as it will bend around the corners of the defective location and enter the detector. Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called 'echocardiography'.

Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body. A doctor may image the patient's organs such as the liver, gall bladder, uterus, kidney, etc. It helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumours in different organs. In this technique the ultrasonic waves travel through the tissues of the body and get reflected from a region where there is a change of tissue density. These waves are then converted into electrical signals that are used to generate images of the organ. These images are then displayed on a monitor or printed on a film. This technique is called 'ultrasonography'. Ultrasonography is also used for examination of the foetus during pregnancy to detect congenial defects and growth abnormalities.

Ultrasound may be employed to break small 'stones' formed in the kidneys into fine grains. These grains later get flushed out with urine.

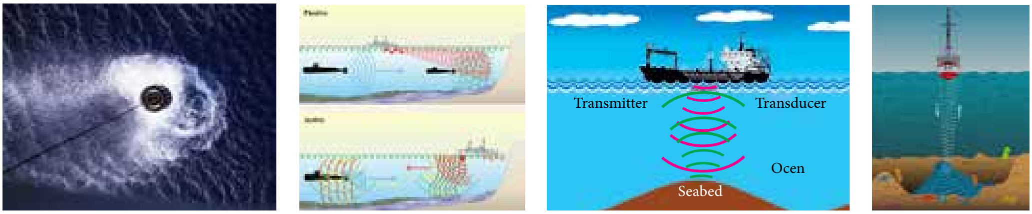


Fig. 10.25

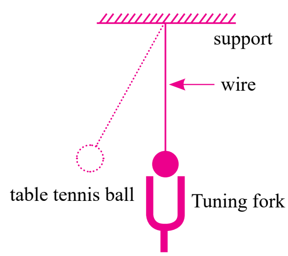
Sonar (sound navigation and ranging) is a technique that use sound propagation (usually underwater, as in submarine navigation) to navigate, measure distance (ranging), communicate with or detect objects on or under the surface of the water, such as other vessels.

Activity 10.4

Take a tuning fork. Strike it on rubber pad and bring near your ear. Is the sound heard? When we touch vibrating tuning fork, we feel vibration. Discuss your feeling among your friends. This activity concludes that sound wave is produced due to vibration of a body.

Activity 10.5

Like in figure, hang the table tennis ball at a particular place with the help of string. Touch the table tennis ball slowly by vibrating tuning fork. What happens? Observe it and discuss. When we hit a body, its molecules start to vibrate and produce sound. Sound wave is produced from the source and propagates through the medium due to vibration of its molecules about their mean state. Molecules vibrate along the direction of propagation of sound wave. Such type of wave is longitudinal wave. Sound wave is longitudinal wave. It is mechanical wave because it needs material medium for its propagation.



Activity 10.6

Put wooden cork on the surface of still water. Drop a piece of stone into the water. Observe the motion of the cork. Is the cork reached to the side of the pond?

When a water wave is produced, the cork starts to vibrate up and down with the water surface. The cork remains where it was placed and is not carried away to another side of the pond. It proves that the water waves do not carry water from one place to another place but only it carries energy from one place to another place.

This activity concludes that when the wave propagates through the medium, the energy transfers from one place to another place but particles of medium not transfer.

Project Works

Write a report about the electromagnetic spectrum with the help of audio-visual materials.

Exercise

A. Choose the correct one and put the tick mark(√)

i. Longitudinal waves are composed of

a. Refraction
b. Troughs and crests
c. Compressions
d. Refraction and compression

ii. In longitudinal waves, how is the displacement of the medium to the propagation of the wave?

a. Against the medium
b. Parallel to the medium
c. Longitudinal waves do not undergo displacement
d. a and b

iii. Examples of longitudinal waves

a. Sesmic P-waves
b. Light wave and electromagnetic wave
c. Sound Wave
d. a and b

iv. This type of wave occurs when the wave motion moves parallel to the material.

a. Transverse Wave
b. Longitudinal Wave
c. Surface Wave
d. Tidal Wave

v. Distance from the rest position to the crest is:

a. amplitude
b. frequency
c. wavelength
d. period

vi. Which type of EM radiation has the shortest wavelength?

a. gamma rays
b. infrared waves
c. blue light
d. microwaves

vi. Which form of EM radiation has the most penetrating ability?

a. red light
b. microwaves
c. gamma rays
d. infrared radiation

vii. Dog would have a hard time stalking and catching a red bird hiding in a field of green grass. Explain this in terms of cone cells and color perception.

a. Dogs are red-green color-blind because they can see only blue and yellow through two kinds of cone cells present in their eyes.
b. Dogs are only red color-blind because they can see only blue and yellow through two kinds of cones cells present in their eyes.
c. Dogs are only green color-blind because they can see only blue and yellow through two kinds of cones cells present in their eyes.
d. Dogs are color-blind because they have only rods and no cone cells present in their eyes.

viii. Examples of electromagnetic waves include

a. radio waves. b. light.

c. X rays. d. all of the above

ix. A vibrating electric field creates a

a. mechanical wave. b. charged particle.

c. magnetic field. d. photon.

x. As an electromagnetic wave travels through space, it

a. becomes stronger. b. keeps changing direction.

c. loses energy to the medium. d. spreads out over a larger area.

B. Give the reason :

i. Ultrasound has many medical and industrial applications

ii. Radio wave is a part of electromagnetic spectrum

iii. Sound travels as a longitudinal wave through a material medium.

iv. Ultrasounds are high frequency waves.

v. Sound wave is called mechanical wave.

C. Differentiate with examples

i. Wave motion and wavelength

ii. Longitudinal wave and transverse wave

iii. Mechanical wave and electromagnetic wave

iv. X-ray and gamma ray

v. Radio wave and microwave

vi. EM and UV

vii. Ultrasound and CT scan

D. Answer the following questions :

i. What is wave ? How is wave produced ?

ii. Write down the type of wave is represented by :

a. Density-distance graph

b. Displacement-distance graph

iii. Give one example of a transverse wave and another of a longitudinal wave, being careful to note the relative directions of the disturbance and wave propagation in each.

iv. What is the difference between propagation speed and the frequency of a wave?

v. Does one or both? affect wavelength? If so, how?

vi. What happens when a pebble is dropped into a pond with still water?

vii. State true or false: Mechanical waves are also known as elastic waves.

viii. Name the condition in which sound waves can travel through the gas.

ix. What are three examples of longitudinal waves?

x. What are the characteristics of longitudinal waves?

xi. Which characteristic of the sound helps you to identify your friend by his voice while sitting with others in a darkroom?

xii. Name an electromagnetic wave which may induce cancer. Justify your answer.

xiii. State two differences between the electromagnetic radiation emitted from a laser and the electromagnetic radiation emitted from a vapour lamp.

xiv. Given below are some examples of wave motion. State in each case if the wave motion is transverse, longitudinal or a combination of both:

   a. Motion of a kink in a longitudinal spring produced by displacing one end of the spring sideways.

   b. Waves produced in a cylinder containing a liquid by moving its piston back and forth.

   c. Waves produced by a motorboat sailing in water.

   d. Ultrasonic waves in air produced by a vibrating quartz crystal.

xv. Radio waves transmitted through space at 3.00×10^8 m/s by the Voyager spacecraft have a wavelength of 0.120 m. What is their frequency?

E. Defined the following terms

i. Wavelength
ii. Wave velocity
iii. Infrared wave
iv. Compression
v. Rarefaction
vi. Reflection of sound
vii. Acoustic protection

F. Write two uses for each

i. Electromagnetic spectrum
ii. Ultrasonography
iii. X-ray photography
iv. CT Scan
v. Acoustic protection

G. Diagrammatic questions

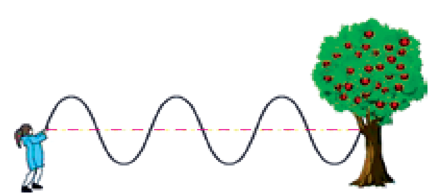
a. Observe the following figure and answer the given questions :

   i. What does this picture indicate?

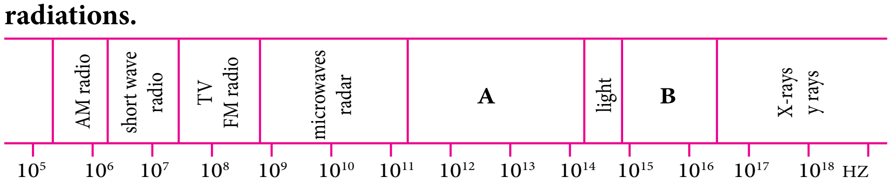
   ii. Write in brief about this wave ?

   iii. What is the medium ?

   iv. Give any three examples of this types wave .



b. The diagram shows a simplified version of the electromagnetic spectrum. Name the sections labelled A and B in the diagram. Describe how to detect each of these radiations.



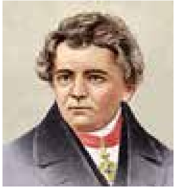
Unit 11 Electricity

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- definition of electric current and formula used for mathematical problem solving.
- introduction of electromotive force and potential difference
- definition of resistance and use of R=V/I formula .
- introduction to types of series combination of resistors/load, its characteristics description and related mathematical problem solving .
- Introduction to electric heating and light effect with practical examples.
- definition of electrical power and simple mathematical problem solving.
- Simple mathematical problem solving for electricity consumption and Electricity Charges.

Georg Ohm, in full **Georg Simon Ohm**, (1789–1854), German physicist and mathematician,who discovered the law, named after him, 'Ohm's Law', which states that the current flow through a conductor is directly proportional to the potential difference (voltage) and inversely proportional to the resistance. The physical unit 'ohm' that measures electrical resistance was also named after him.



11. Electricity

How does electric bulb glow in your home? What makes the television and computer run? Actually, in our home to glow electric bulb, to run radio and computer, etc. electricity is used. Electric current is a type of energy. Electric energy can be easily converted into other energy like mechanical energy, light energy, heat energy, etc. Due to electric energy, we can do any work easily. Thus, electricity is very useful in our daily life.

Electricity and magnet are interrelated to each other. A freely suspended bar magnet always rests pointing geographical south and north pole, Why? It is due to the geomagnetism of earth. We discuss in this lesson about Ohm's law, resistance conductance, magnetic field and elements of earth's magnetism.

11.1 Electric Current

The flow of charges (electrons) through a conductor is called electric current. Mathematically. it can be defined as :

$$\text{Electric current (I)} = \frac{\text{Charge (Q)}}{\text{Time (t)}} \qquad \therefore I = \frac{Q}{t}$$

Fig. 11.1

In SI unit it is measured in ampere (A). The device which is used to measure current in a conductor is called ammeter. But the presence of electric current in a circuit can be detected by galvanometer. These two electric devices are in electric circuit series with load and source because it has negligible resistance.

A device which continuously generates electricity is known as source of electricity. Cell, dynamo, generator etc. are sources of electricity.

Electric current is of two types, viz: direct current (DC) and alternating current (AC).

Direct current (DC)
The current whose polarity does not change and has no frequency is called direct current. We obtain direct current from the cell and battery.

Alternating current (AC)
The current whose polarity changes periodically and has certain frequency. We obtain alternating current from dynamo and generator.

11.2 Electromotive Force (emf) and Potential Different (p.d.)

Potential Difference

Potential difference is defined as the amount of work done in moving a unit positive charge from one point to another point.

Mathematically potential difference is :

$$\text{Potential difference (p.d.)} = \frac{\text{Work done(W)}}{\text{Charge (Q)}} \qquad \therefore \text{p.d.} = \frac{W}{Q}$$

The SI unit of P.d is Volt (V) or Joule per coulomb (JC^{-1})

$$\therefore 1V = \frac{1J}{1C}$$

The 1 V potential difference is the amount of potential difference that exists in between two points in an electric circuit when 1 J of work is done in moving 1 coulomb of charge between that points.

Potential difference is measured by using voltmeter. Voltmeter should be connected in parallel in an electric circuit while measuring potential difference because it has very high resistance.

Electromotive Force (emf)

The potential difference between two terminals of a cell or any source in an open circuit is called electromotive force (emf). It drives the current through the entire circuit. It is also equal to the amount of energy required for the source in taking a unit charge once round the circuit. It is measured in volt (V).

Difference Between p.d. and emf
The name emf at first sight implies that it is a force that causes current to flow. But this is not correct because it is not a force but energy supplied to charge by some active device such as a battery. emf maintains potential difference (p.d. or voltage) while potential difference causes current to flow. When we say that emf of a device (e.g. a cell) is 2V, it means that the device supplies energy of 2 joules to each coulomb of charge. When we say that a potential difference between point a and B of a circuit (suppose point A is at higher potential) is 2V, it means that each coulomb of charge will give up an energy of 2 joules on moving from point A to B.

Comparison Chart Between Voltage and emf.

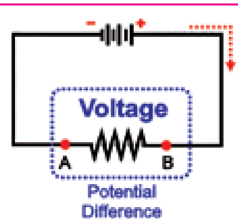
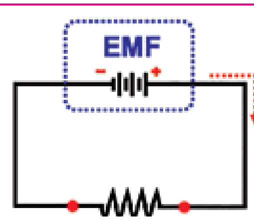
Characteristics	Voltage	emf
Represented Symbol	V	E or ε
Definition	Voltage is the potential difference between two points which causes current to flow. It is the amount of energy per unit charge while moving between two points	emf or electromotive force is the amount of energy supply to the charge by battery cell. It produces voltage inside active battery sources and supplies energy in joules to each coulomb of charge.
Expression	Potential difference or Voltage causes current to flow between two points.	emf maintains potential difference between two electrodes.
Formulas	$V = IR$ Where V = Voltage in Volts I = Current in Amperes R = Resistance in Ohms	$E = I(R + r)$ $E = W/Q$ Where: E or ε = emf in Volts W = Work done energy in Joules Q = Charge in Coulombs r = Internal resistance of the battery cell in ohms
Work Performed	Work performed in moving a charge from one point to another through a conductor wire.	In a source, external forces work performed in moving a charge from one point to another.
Sources	Electric field and magnetic field.	Active devices such as batteries, cell, solar cell, transformer, electrical generators and dynamo, photo diodes etc.
Intensity	The intensity of voltage is lower than emf and non-constant.	emf has constant intensity with higher magnitude.
Resistance	Voltage depends on the circuit resistance.	emf doesn't depends on the circuit resistance.
Force Operation	Voltage is a Non-Coulomb force operation.	emf is a Coulomb force operation.
Cause/Effect	Voltage is the effect of emf.	emf is the cause of Voltage.
Measurement	Voltage can be measured between any two points. It can be measured by Voltmeter.	emf can be measured between the end terminals when there is no current flowing through it. It can be measured by emf meter.
Diagrammatic		

Table 11.1

11.3 Electric Resistance

When an electric current flows through a conductor, it opposes partially the flowing of current. The capacity of opposing the current flowing through the conductor depends nature of the material. So, according to nature of material, different materials have different resistance, Thus, The property of a conductor to oppose the flow of current through it is called resistance. It is measured in ohm (Ω) and represented by R.

Metals have large number of free electrons. Due to this current flows through the metal easily. Metal like copper, aluminium, etc. have negligible resistance. Thus,they are called good conductors.

The substances which conduct electric current easily through them is called good conductor.

The resistors which are found in our market have high resistance. They are used to control the flow of current in the circuit. Rubber, glass, etc. have no free electrons. So, they have very high resistance.These are called insulators.

The substances which do not conduct electric current through them is called insulators. Most of the metals are insulators except graphite.

Some substances like germanium, silicon have a little number of free electrons. They conduct a little current. They are semi conductors. When temperature increases they become like good conductor. The conductivity of semiconductor lies between conductor and insulator.

Resistance (R) : The property of conductor that restricts the movements of free electrons through it is called resistance. It is measured in Ohm (Ω), in SI system and represented by R.

Note : 103 Ω = 1k Ω
106 Ω or 103k Ω = 1M Ω

Factors affecting resistance

1. Resistance of conducting wire is directly proportional to the length of the wire.
   i.e. $R \propto l$
2. Resistance is inversely proportional to the thickness (cross sectional area) of the conductor (conducting wire).
   $R \propto \frac{1}{a}$
3. Conducting wires of different materials have different value of resistance.
4. Resistance is directly proportional to the temperature of the conducting wire.
   Thomas Alva Edison was the greatest inventor in science. He invented more than 2,000 new products almost everything needed for us to use electricity in our daily life such as switches, fuses, socket and meters. He also invented motion picture camera, long lasting electric bulb etc.
   [Electricity can be generated from water (hydroelectricity), wind, tides, the sun, petroleum products and even from animal excreta.]

Activity 11.1

Make an electric circuit using dry cell, electric bulb, switch, ammeter and conducting wire. Take 10cm and 100cm wire.

i. Take two wires having equal diameter and connect them separately between P and Q. Measure the current in the circuit after turning the switch on. Which wire allows more current in circuit? Find it. Obviously 10 cm wire allows more current than 100 cm wire i.e. if both wires have same thickness, longer wire has more resistance than shorter one. In other words, resistance of the wire is directly proportional to the length of the wire.

i.e. $R \propto l$ …………(i)
R = Resistance
L = length

ii. Take two wires of different diameter or thickness having equal length (10 cm). Connect them at point P and Q and measure the current in the circuit. In which wire we get more current? Obviously, thick wire allows more current than thin wire. Thus,

Resistance of wire is inversely proportional to the cross section area of the wire.

$$R \propto \frac{1}{a} \text{ .... (2)}$$

a = cross section area of wire

iii. Take two wires made of different material having same length and cross -sectional area. Here we take copper and nichrome wire. Connect them at points P and Q separately and measure the current in circuit. Which one allows more current? Obviously, copper wire conducts more current than nichrome. Nichrome wire has more resistance than copper. This means that, the resistance of a wire depends upon nature of material by which it is made up.

iv. Again take a nichrome wire and connect it at points P and Q. Note the current in circuit with the help of ammeter. Now, heat the nichrome wire with the help of spirit lamp and again measure the current in circuit. What difference do you get before and after heating the wire? Discuss it.
The current in circuit is more before heating than after heating i.e. when temperature increases, current decreases.
Thus,
Resistance of the conducting wires increases when temperature is increased.
i.e $R \propto T$ T = temperature

From the above activities we can conclude that the resistance of the conducting wire depends upon:

- length of the wire
- thickness or cross selection area of wire.
- temperature
- nature of wire
- form of the wire (coil or straight)

Solved Numerical Problems

1. Find the electric current following through a 4 Ω resistor when a potential difference of 8V is applied across it.

Given,
Resistance (R) = 4 Ω
Potential difference (V) = 8V
and current (I) =?
∵ From Ohm's law, we know,

$$V = IR$$

$$I = \frac{V}{R} \qquad \text{or,} \quad I = \frac{8}{4} = 2A$$

∴ The current in the circuit is 2A.

2. Calculate the resistance of a material that draws 200mA of current at 20V.

Solution,
Given,
Current (I) = 200mA

$$= \frac{200}{1000} = 0.2A$$

Potential difference (V) = 20V
and resistance (R) =?
∴ From Ohm's law we have,

$$V = IR$$

$$R = \frac{V}{I} \qquad \text{or,} \quad R = \frac{20}{0.2} = 100\ \Omega$$

Resistance of material is 100 Ω

Resistivity and conductivity

We know that resistance (R) of a conductor is directly proportional to length (L) of the wire and inversely proportional to cross section area (a) of the wire keeping other physical quantities constant.

i.e $R \propto l$ ……....... (i) [Cross sectional area (a) keeping constant]

$R \propto \frac{1}{a}$ .... (ii) [length of wire keeping constant]

Combining eqn (i) and (ii),

$$R \propto \frac{l}{a}$$

$$\therefore\ R = \frac{\rho\, l}{a} \text{ .... (iii)}$$

Where ρ = proportionality constant called resistivity or specific resistance of conducting wire.

If $a = 1m^2$ and $l = 1m$
then, $\rho = R$ from eqn (iii)

Thus, resistivity of a conductor is defined as the resistance per unit length per unit area of cross - section of the conductor. It is measured in Ohm meter (Ω m). It depends upon nature of material of conductor.

Conductivity of conductor is the reciprocal of its resistivity. Mathematically, conductivity of conductor (σ) is :

$$\sigma = \frac{1}{\rho}$$

s = conductivity

Its SI unit is Ω^{-1} m^{-1}

The conductor having high resistance has low conductivity and the conductor having low resistance has more conductivity. Copper silver and gold have low resistance, so they have high conductivity.

Generally, metals have high conductance and non- metals have low conductance. Conductors have higher conductance but insulators have low conductance.

Ohm's Law

Ohm's law was formulated by a German Scientist George Simon Ohm in 1826 AD.This law is the relationship between potential difference, current and the resistance of a conductor under constant physical conditions.

The law states that the current flowing through a conducting wire is directly proportional to the potential difference across its two ends at constant physical conditions (temperature, length, thinkness, nature of material, etc).

Mathematically,

$I \alpha V$ (V = Pd across two ends)

or $V \alpha I$ (I = Current)

$\therefore$ $V = I R$ ....(i)

R = Proportionally constant called resistance of conducting wire.

From eqn (i)

$$I = \frac{V}{R}$$

$$\text{or,} \quad R = \frac{V}{I} \text{ .... (ii)}$$

The resistance between two ends of a conductor wire is the ratio of p.d across the two ends and current flowing through it. It is measured in Ohm (Ω).

From eqn. (ii), if V = 1V, I = 1A

Then,

$$\therefore R = \frac{1V}{1A} = 1\Omega \qquad \therefore 1\,\Omega = \frac{1V}{1A}$$

Thus, the resistance is said to be 1 Ω if one ampere current is flowing with the applied voltage of one volt.

Activity 11.2

Verification of Ohm's Law

Take four dry cells, a resistance, a voltmeter, an ammeter, a switch and conducting wire and connect them as shown in figure.

Connect a single dry cell and measure voltage and current in the circuit. Again, measure the voltage and current each time by using two cell, three cell and four cell in the circuit. Enter your reading in the observation table and calculate in the observation table and calculate the resistance in each case.

Observation table

S.N.	Voltage (V)	Current (I)	Resistance R = V/I	Result

Plot a graph putting voltage in x - axis and current in y - axis. You will get straight line through origin.

This proves that voltage is directly proportional to the current. Thus, Ohm's law is verified.

The resistance can be combined in two ways:

I. In series, and II. In parallel.

- In Series: When two (or more) resistances are connected end to end consecutively, they are said to be connected in series.
- In Parallel: When two (or more) resistances are connected between the same two points, they are said to be connected in parallel.

Series combination of resistors

A circuit is said to be connected in series when the same amount of current flows through the resistors. In such circuits, the voltage across each resistor is different. In a series connection, if any resistor is broken or a fault occurs, then the entire circuit is turned off. The construction of a series circuit is simpler compared to a parallel circuit.

Fig. 11.2

Resistors in series combination

For the above circuit, the total resistance is given as:

Rtotal = $R_1 + R_2 + \ldots.. + R_n$

The total resistance of the system is just the total of individual resistances.

For example, consider the following sample problem.

A resistor having an electrical resistance value of 100 ohms, is connected to another resistor with a resistance value of 200 ohms. The two resistances are connected in series. What is the total resistance across the system?

Here, $R_1 = 100\ \Omega$ and $R_2 = 200\ \Omega$

$R_{total} = 100 + 200 = 300\ \Omega$

Parallel combination of resistors

A circuit is said to be connected in parallel when the voltage is the same across the resistors. In such circuits, the current is branched out and recombines when branches meet at a common point. A resistor or any other component can be connected or disconnected easily without affecting other elements in a parallel circuit.

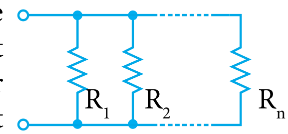


Fig. 11.2

Resistors in parallel combination

The figure above shows 'n' number of resistors connected in parallel. The following relation gives the total resistance here

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

The sum of reciprocals of resistance of an individual resistor is the total reciprocal resistance of the system.

For the problem given above, what if the resistors were connected in parallel instead of in series? What is the total resistance in that case?

$$\frac{1}{R_{total}} = \frac{1}{100} + \frac{1}{200} = \frac{(200+100)}{20000}$$

$$= \frac{300}{20000}$$

Therefore,

$$\frac{1}{R_{total}} = \frac{20000}{300} = 66.66\ \Omega$$

Domestic Electric Circuits: Series or Parallel

When designing an electric circuit, we should consider whether a series circuit or a parallel circuit is better for the intended use. A series circuit is also safer because the current in it is smaller.

Disadvantage of Series Circuits for Domestic Wiring

- In series circuit, if one electrical appliance stops working due to some defect, then all other appliances also stop working.
- In series circuit, all the electrical appliances have only one switch due to which they cannot be turned on or off separately.
- In series circuit, the appliances do not get the same voltage (220 V) as that of the power supply line.
- In the series connection of electrical appliances, the overall resistance of the circuit increases too much due to which the current from the power supply is low.

Advantages of Parallel Circuits in Domestic Wiring

- In parallel circuits, if one electrical appliance stops working due to some defect, then all other appliances keep working normally.
- In parallel circuits, each electrical appliance has its own switch due to which it can be turned on or turned off independently, without affecting other appliances.
- In parallel circuits, each electrical appliance gets the same voltage (220 V) as that of the power supply line.
- In the parallel connection of electrical appliance, the overall resistance of the household circuit is reduced due to which the current from the power supply is high.

11.4 Effects of Electric Current

Current electricity can be transformed into different form of energy. This is called effects of electric current. They are:

i. Heating effect — ii. Lighting effect

iii. Magnetic effect — iv. Chemical effect

i. Heating effect

When electric current is passed through electrical appliances, they change electricity into heat energy. This is called heating effect of electricity. The wire which is used to produce heat by passing electricity through it is called heating element. They have high resistance and melting points. Most of the heating devices have nichrome as heating element. Nichrome is an alloy of nickel (60%) and chromium (40%) metals. Its resistance is very high and it produces heat in a comparatively short period of time. Its melting point is 1400°C. So, it does not react with oxygen and does not melt even when the temperature reaches to about 900°C. It does not show corrosive effect. Electric heater, iron, toaster, kettle, immersion heater etc. are connected with electricity and convert electrical energy into heat energy.

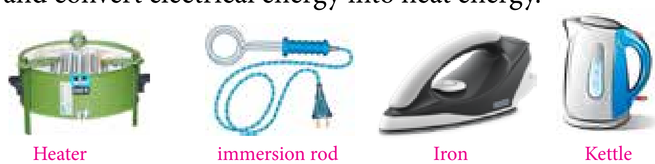


Fig. 11.3

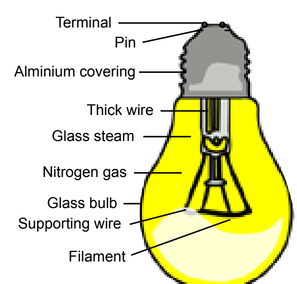
ii. Lighting effect

When electric current is passed through some electrical appliances, they change electrical energy into light energy. This is called lightening effects of electric current. Filament lamp and fluorescent lamp convert electrical energy into light energy.

Filament lamp:

It shows the lightning effect of electricity. It consists of tungsten coil fitted inside a glass bulb. Tungsten wire used in bulb is called filament. It has very high melting point (3400°C) and resistance.

When electricity is passed in the bulb, the filament becomes white, hot and emits heat and light. It converts only 10% of electrical energy into light energy. Its life time is about 1000 hours.



filament lamp

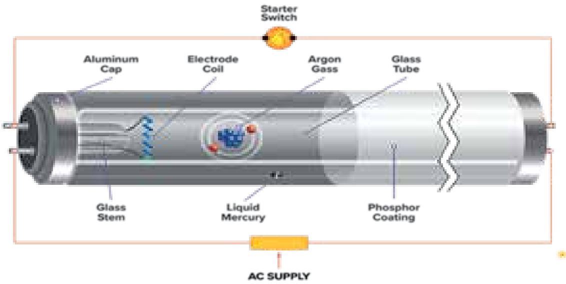
Fig. 11.4

Filament lamps are not efficient. They emit both heat and light energy but about 90% of the electrical energy is emitted as heat and only about 10% of the energy is emitted as light.

Fluorescent lamp:

Fluorescent lamp consists of a long glass tube having two electrodes at its ends. The tube is filled with mercury vapour. The inner surface of the tube is coated with fluorescent powder.

When power is switch on the cathode gets heated and emits electrons. While moving electors towards anode they collide and UV - rays are produced. When the ultraviolet rays fall on the inner wall of the glass tube, visible light is produced. It converts 70% of electrical energy into heat energy and remaining 30% into light energy. Its life time is about 3000 hours.



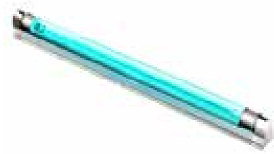



Fig. 11.5

Difference between Filament lamp and Fluorescent lamp

Filament lamp	Fluorescent lamp
i. It converts only 10% electrical energy into light energy.	i. It converts 30% of electrical energy into light energy.
ii. It is filled with nitrogen or argon gas.	ii. It is filled with mercury vapour.
iii. Its life time is about 1,000 hours.	iii. Its life time is about 3,000 hours.
iv. Filament emits light.	iv. Fluorescent powder emits light.
v. It is cheaper to buy.	v. It is expensive to buy.
vi. It consumes more electric power.	v. It consumes less electric power.

Table 11.2

11.5 Electric Power

The important aspect of any electrical or electronic circuit is the power associated with it. It is found that when a current flows through a resistor, electrical energy is converted into heat. This fact is used by electrical heaters which consist of a resistor through which current flows. Light bulbs use the same principle, heating the element up so that it glows white hot and produces light. At other times much smaller resistors and very much smaller currents are used. Here the amount of heat generated may be very small. However if some current flows then some heat is generated. In this instance the heat generated represents the amount of electrical power being dissipated.

Whether power is used in a mechanical environment or an electrical environment, the definition of power is still the same. The way in which it may be discussed may be slightly different, but nevertheless the definition and actuality of it is exactly the same.

Electric power is the rate, per unit time, at which electrical energy is transferred by an electric circuit. It is the rate of doing work.

In terms of an electric circuit, electrical power is the rate, per unit time, at which electrical energy is transferred by an electric circuit.

$$\therefore \text{ Electric power (p)} = \frac{\text{Electrical energy supplied (E)}}{\text{Time taken (t)}}$$

The unit of power is JS^{-1}. It is called watt (W)

$$1\text{ W} = \frac{1\text{J}}{1\text{s}}$$

The electric power of an electrical appliance is 1W if 1J of electrical energy is converted into other forms of energy in 1 second.

The relation between W and bigger units is given below.

1KW = 103W
1MW = 106W
1HP = 746W (approx 750W)

If we observe an electric lamp, it is usually marked 60w, 100W etc. The lamp marked 60W shows that 60J of electrical energy is changed into heat and light energy in one second. Similarly, an electric heater of 3kw converts 3kJ of electrical energy into heat and light energy in one second.

The electrical power (P) of an electrical appliance is determined by multiplying the p.d.(V) across its ends the current (I) through it.

$\therefore \quad P = I \times V$ .... (i)

$P = I \times V$

or, $P = \frac{Q}{t} \times \frac{W}{Q}$ [$\because I = Q/t, V = W/Q$]

$\therefore \quad P = \frac{W}{t}$

or, $P = \frac{V^2}{R}$; by placing the value of V from Ohm's law

[$\because R = \frac{V}{I}$, Ohm's law]

$P = RI^2$; by placing the value of 1 from ohm's law

Example:

A 9V battery is connected to a resistor having a resistance of 10 Ω. What is the current and power across the resistor?

Solution:

I = V/R = 9/100 = 0.9 A

P = VI = 9 × 0.9 = 8.1 J/s or 8.1 W

11.6 Electricity Consumption

Electric meter is a device which measures electricity consumption connected in the house, in kilo-watt hours (Kwh). Kilowatt hour is simply called unit. We pay electric bill according to the information given by electric meter.

1 Kilowatt hour (1 KWh)

It is the amount of electrical energy consumed when an electrical appliance uses 1 kilo watt power for 1 hour.

To calculate electricity consumed (EC) and cost of electricity we can use following formulae.

Electricity consumption (EC) = Power (KW) × Number x Time (hr)

$\therefore \quad EC = PNT$

Cost of electricity = EC x Rate (R)

Related Numerical Problems

i. Calculate the electricity consumed by 8 bulbs of 60 w each used 4 hours daily. Also find out the electricity bill to be paid in a month.
(If the cost of one unit of electricity is Rs. 9. 30)

Solution

Power of bulb (P) = 60 W = $\frac{60}{1000}$ = 0.06 KW

Number of bulb (N) = 8

Time (T) = 4 hours.

∴ Electricity consumed per day (EC) = ?

We know,

EC = P x N x T = 0.06 x 8 x 4 = 1.92 KWh (Units)

Now,

Ec (for 30 days) = 30 x 1.92 = 57. 6 Units.

∴ Electricity bill for a month = EC (Units) x Rate

= 57. 6 x 9.30 = Rs. 535.68

Safety measures while using electricity

Electricity is useful as well as harmful too. It may damage our life and properties if we use it carelessly. So, we should follow safety measures while using it. These measures are:

i. Switch and fuse should be connected in a live wire so that they can cut off the current.
ii. Fuses of suitable capacity should be used so that electrical devices are protected fully.
iii. Colour code of wires should be followed during house wiring.
iv. We should not touch the switch with wet hand and naked ends of wire must be covered using seal tape.
v. Wiring should be done in dry and safe places by using quality wires.
vi. Heavy electrical devices should be earthed properly.

Examples:

Compute the energy consumption in a system that consumes 190 Watts of power and works for 3 hrs a day.

Ans: Given: Power P = 190 W, total number of hours = 3 hrs

$E = P\times\frac{t}{1000}$ $E = 190\times\frac{3\times60\times60}{1000}$ $E =$ 2052 kWh

Therefore, the energy consumption is 2052 kWh

Problem 2: A toy car consumes energy of 500 Watts of power if it works for 2 hrs a day using it. Calculate the energy consumption a day.

Ans: Given: Power P = 500 W, total number of hours= 2 hrs

$E = P\times\frac{t}{1000}$ $E = 500\times\frac{2\times60\times60}{1000}$ $E =$ 3600 kWh

Electricity bill

Anytime we turn on a light, plug in a device, or let our refrigerator run, we are utilizing electricity that has been generated for our use by a company. The electricity produced by this company can be purchased by the Kilowatt-hour to power your household. When the company asks you to pay them back for the electricity you use, they send a letter that lists the electricity you used, the rates they charge, and the amount of money due to the company for using their energy. An electricity bill, in the context of buildings and their owners and/or occupants, is effectively an invoice detailing money that is owed for electrical energy that has been used.

To calculate the consumption of an electrical appliance in kWh, you have to take into account three factors:

the capacity of your electrical appliance, expressed in watt.
the number of hours that the appliance is in use in one day.
the number of days per year when the appliance is in use.

The calculation is as follows:

[number of hours' use] × [number of days' use] × ([capacity of appliance expressed in watt] / 1,000) = number of kWh

The capacity should be divided by 1,000 to convert the number of watts into the number of kilowatts. This finally gives us the number of kWh (kilowatt hours).

Calculation for the energy consumption of a radio alarm

A radio alarm is on all the time and therefore uses energy continuously.

hours / day	24 hours
days / year	365
Capacity of radio alarm	10 watts

Table 11.3

Annual energy consumption of radio alarm: 24 x 365 x (10 watts / 1,000) = ***87.6 kWh***

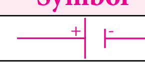
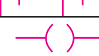
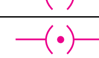
Calculation for the energy consumption of a vacuum cleaner

In the table below we assume that the vacuum cleaner is used for two hours once a week.

hours / day	2 hours
days / year	52 days
Capacity of vacuum cleaner	2000 watts

Table 11.4

Annual energy consumption of vacuum cleaner: 2 x 52 x (2,000 watts / 1,000) = ***208 kWh***

S.No.	Component	Symbol
1	An electric cell	
2	A battery or a combination of cell	
3	Plug key or switch (open)	
4	Plug key or switch (close)	

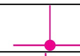
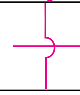
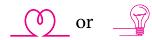
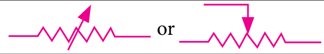
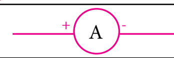
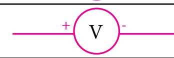
5	A wire joint	
6	Wires crossing without joint	
7	Electric bulb	
8	A resistor of resistance R	
9	Variable resistance or rheostar	
10	Ammeter	
11	Voltmeter	

Table 11.5

Project Works

Survey the daily electricity consumption of five houses around you and complete the following table. After this, you will discuss the results in class.

Exercise

A. Choose the correct one and put the tick mark(√)

i. Electric power is given as?

a. P=VI b. P=V+I
c. P=V–I d. P=V/I

ii. 1 watt is equal to?

a. joule per second b. farad per second
c. meter per second d. ampere per second

iii. What is the unit of electric power?

a. watt b. joule
c. ohms d. volts

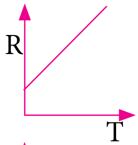
iv. What is the formula of electrical energy?

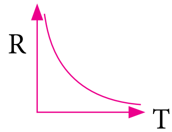
a. E=QV b. E=Q/V
c. E=Q+V d. E=Q–V

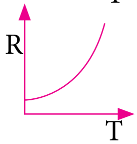
v. Which of the following is the use of electrical energy?

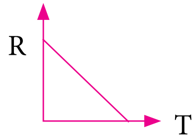
a. public transportation system b. lighting, cooling, heating
c. computers d. all of these

vi. The temperature of a conductor is increased. The graph best showing the variation of its resistance is

a. 

b. 

c. 

d. 

vii. A battery of 10 volt carries 20,000 C of charge through a resistance of 20 Ω. The work done in 10 seconds is

a. 2×10^3 joule b. 2×10^5 joule

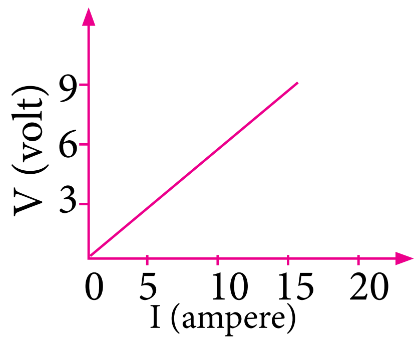
c. 2×10^4 joule d. 2×10^2 joule

viii. A boy records that 4000 joule of work is required to transfer 10 coulomb of charge between two points of a resistor of 50 Ω. The current passing through it is

a. 2 A b. 4 A

c. 8 A d. 16 A

ix. The resistance whose V-I graph is given below is:



a. $\frac{5}{3}\,\Omega$ b. $\frac{3}{5}\,\Omega$

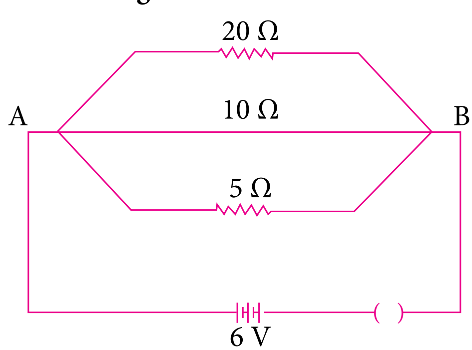
c. $\frac{5}{2}\,\Omega$ d. $\frac{2}{5}\,\Omega$

x. To get 2 Ω resistance using only 6 Ω resistors, the number of them required is

a. 2 b. 3

c. 4 d. 6

xi. Calculate the current flows through the 10 Ω resistor in the following circuit.



a. 1.2 A b. 0.6 A

c. 0.2 A d. 2.0 A

xii. If P and V are the power and potential of device, the power consumed with a supply potential V_1 is

a. $\frac{V_1^2}{V_1^2}P$ b. $\frac{V^2}{V_1^2}P$

a. $\frac{V}{V_1}P$ b. $\frac{V_1}{V}P$

B. Give the reason :

i. If a graph is plotted between the potential difference and the current flowing, the graph is a straight line passing through the origin.

ii. Longer wires have greater resistance and the smaller wires have lesser resistance.

iii. Alloys are commonly used in electrical heating devices, like electrical iron, toasters etc.

iv. When the resistances are connected between the same two points, they are said to be connected in parallel.

v. The resistivity of a substance does not depend on the nature of the substance and temperature.

vi. Tungsten metal is used for making filaments of incandescent lamps. The fuse is placed in series with the device.

vii. In series circuit, if one electrical appliance stops working due to some defect, then all other appliances also stop working.

viii. In series circuit, all the electrical appliances have only one switch .

ix. The wires supplying current to an electric heater are not heated appreciably.

x. In a chain of bulbs, 50 bulbs are joined in series. One bulb is removed now and circuit is completed again. If the remaining 49 bulbs are again connected in series across the same supply, then light gets decreased in the room.

C. Differentiate with examples

i. Electromotive force and potential difference

ii. Series combination of resistor and Parallel combination of resistors

iii. Electric resistance and Electric charge

iv. Electrical energy and electric power

D. Answer the following questions :

i. What is electric current ?

ii. What is emf ?

iii. Name a device that helps to maintain a potential difference across a conductor.

iv. Write the relation between electric power (P) of a device with potential difference (Volt) across it and current (amp) flowing through it.

v. State Ohm's law. Write the necessary conditions for its validity. How is this law verified experimentally? What will be the nature of graph between potential difference and current for a conductor? Name the physical quantity that can be obtained from this graph.

vi. What is meant by electrical resistivity of a material? Derive its S.I. unit. Describe an experiment to study the factor on which the resistance of a conducting wire depends.

vii. Write a short note on the following terms :

a. Potential difference

b. Electic current

c. Electric Power

d. Electricity consumption

e . Heating effect of electric current

f. Resistance

E. Numerical exercise

i. In a hairdryer, a charge of 350 C moves through a potential defference of 20-V for 4 minutes. How much power is transformed?

ii. Calculate the resistance of an electric blanket that draws 9 A to transform 50 W of energy.

iii. How many joules of energy are necessary to run a telecision for 30 munutes if it is hooked up to a 120-V line and has a resistance of 6 ohms?

vii. Three resistors of 10 Ω, 15 Ω and 5 Ω are connected in parallel. Find their equivalent resistance.

v. How much does it cost to run a refridgerator all day, for 6 months (30 days/month) if it requires 3.5 kW and the charge is Rs 2.05 per kWh?

vi. How much does it cost per week to operate a stereo for 3 hours per day if it draws 16 A on a 150-V line and the charge is Rs3.09 per kWh?

vii. 900 C flow through a flashlight with 3 ohms of resistance and is on for 45 minutes. How much power was used?

viii. A 220 V – 60 W solder is used for 4 minutes. How much energy does it require.

ix. The energy used by the iron for 1 minute is 33 kJ, at a voltage of 220 volts. How large the current is in the iron.

x. Someone watches TV on average 6 hours each day. The TV is connected to a 220 Volt voltage so that the electric current flows through the TV is 0.5 Amperes. If the electric company charges Rs3.092 per kWh, then the cost of using electric energy for TV for 1 month (30 days) is…

xi. In a house there are 4 lamps 20 Watt, 2 lamps 10 Watt, 3 lamps 40 Watt, are used 5 hours every day. If the electric company charge 0.092 per kWh, then the cost of using electric energy during 1 month (30 days) is ….

xii. Calculate the electricity bill amount for a month of 31 days, if the following devices are used as specified.

a. 3 bulbs of 40W for 6 hours

b. 4 tube lights of 50W for 8 hours

c. A T.V. of 120W for 6 hours

Given the rate of electricity is Rs. 2.502.50 per unit.

Unit 12

The Universe

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- recognize units that measure the distance between celestial bodies.
- give a general introduction of nebula and black hole.
- give a general introduction of life cycle of the star .
- give a simple introduction of national and international organizations studying astronomy.

Georges Lemaitre, (1894- 1966), Belgian astronomer and cosmologist who formulated the modern big-bang theory, which holds that the universe began in a cataclysmic explosion of a small, primeval "super-atom." A civil engineer, Lemaitre served as an artillery officer in the Belgian Army during World War I. After the war he entered a seminary and in 1923 was ordained a priest. He studied at the University of Cambridge's solar physics laboratory (1923–24) and then at the Massachusetts Institute of Technology, Cambridge (1925–27), where he became acquainted with the findings of the American astronomers Edwin P. Hubble and Harlow Shapley on the expanding universe.

12. The Universe

Fig. 12.1

The universe is everything. It includes all of space, and all the matter and energy that space contains. It even includes time itself and, of course, it includes you.

Earth and the Moon are parts of the universe, as are the other planets and their many dozens of moons. Along with asteroids and comets, the planets orbit the Sun. The Sun is one among hundreds of billions of stars in the Milky Way galaxy, and most of those stars have their own planets, known as exoplanets.

The Milky Way is one of the billions of galaxies in the observable universe — all of them, including our own, are thought to have supermassive black holes at their centers. All the stars in all the galaxies and all the other stuff that astronomers can't even observe are all part of the universe. It is, simply, everything.

Though the universe may seem a strange place, it is not a distant one. Wherever you are right now, outer space is only 62 miles (100 kilometers) away. Day or night, whether you're indoors or outdoors, asleep, eating lunch or dozing off in class, outer space is just a few dozen miles above your head. It's below you too. About 8,000 miles (12,800 kilometers) below your feet — on the opposite side of Earth — lurks the unforgiving vacuum and radiation of outer space.

In fact, you're technically in space right now. Humans say "out in space" as if it's there and we're here, as if Earth is separate from the rest of the universe. But Earth is a planet, and it's in space and part of the universe just like the other planets. It just so happens that things live here and the environment near the surface of this particular planet is hospitable for life as we know it. Earth is a tiny, fragile exception in the cosmos. For humans and the other things living on our planet, practically the entire cosmos is a hostile and merciless environment.

In the late 1920s the American astronomer Edwin Hubble made a very interesting and important discovery. Hubble made observations that he interpreted as showing that distant stars and galaxies are receding from Earth in every direction. Moreover, the velocities of recession increase in proportion with distance, a discovery that has been confirmed by numerous and repeated measurements since Hubble's time. The implication of these findings is that the universe is expanding.

Hubble's hypothesis of an expanding universe leads to certain deductions. One is that the universe was more condensed at a previous time. From this deduction came the suggestion that all the currently observed matter and energy in the universe were initially condensed in a very small and infinitely hot mass. A huge explosion, known as the Big Bang, then sent matter and energy expanding in all directions.

12.1 Units Measure The Distance Between Celestial Bodies

The distance between celestial bodies is extremely large. Therefore, it is very difficult to measure the distance between them in kilometer and meter. The distances between these celestial bodies is called astronomical distance. The following units are used to measure astronomical distance, viz:

i. Light year,
ii. Astronomical unit, and
iii. Parsec

Light Year

The light-year is an indispensable unit of measurement for anyone trying to understand outer space. Get a group of astronomers talking, and you'll hear them say "light-years" about as often as you hear football fans mention "yards."

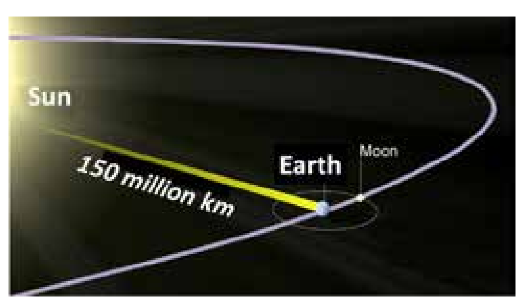


Fig. 12.2

For nonscientists, though, the light-year can be a puzzling concept. It's a unit of distance even though it might sound like a unit of time. Adding to the confusion, sci-fi movies and TV shows routinely bungle the concept.

Even the original "Star Trek" series got light-years wrong. In a 1968 episode, the alien princess Elaan of Troyius tells Captain Kirk she'd rather hide in her room for "10 light-years" than come out and speak to him.

The distance travelled by light in one year is called light year. This is the unit of distance which is used to measure astronomical distance.

Speed of light in vacuum = 3×10^8 m/s

Time = 1 year = 365 days = $365 \times 24 \times 60 \times 60$ seconds

Since, distance = velocity × time

$\therefore$ 1 light year = Speed of light in vacuum x time

$= 3 \times 10^8 \times 365 \times 24 \times 60 \times 60$ m

$= 94608000 \times 10^8$

$= 9.46 \times 10^{15}$ m

$\therefore$ 1 light tear = 9.46×10^{15} m

The nearest star Proxima Centauri is about 4.3 light year far from the solar system.

How far is a light-year?

A light-year is the distance a beam of light travels in a vacuum in one year. It's important to specify a vacuum because light slows as it passes through any kind of matter. (In water, for instance, it travels about 25 percent slower.) Most of the universe is a near-perfect vacuum, so astronomers can generally assume that light is moving at its top speed.

Light travels at 299,792,458 meters (186,282.397 miles) per second. Multiply that number by the number of seconds in a year (31,557,600), and you get your answer: One light-year is 9,460,730,473,000 kilometers, or 5,878,625,373,000 miles.

That's probably more digits than you were looking for. Round it off to 6 trillion miles, and you're still close enough for any in-the-know nerd conversation.

Why do astronomers measure distance in light-years?

Familiar units like kilometers and miles are absurdly small for describing the vastness of the cosmos. Take the example of Proxima Centauri, the nearest star beyond the sun. You could say that it's about 24,900,000,000,000 miles away — or save a lot of breath and call the distance a tidy 4.24 light-years.

Most of the stars you see at night lie within a few hundred light-years of Earth. The Milky Way galaxy in which we live happens to be a nice, round 100,000 light-years across. The Andromeda Galaxy is 2.54 million light-years away — a big number but still a whole lot more manageable than "14 quintillion, 900 quadrillion miles."

So light-years are only a measure of distance, not time?

Strictly speaking, yes. A light-year is a unit of distance, just like feet and inches. If you want to avoid any confusion, you can stop right here.

But there's another fascinating side to the light-year story. Since light moves at a finite speed, everything you see is outdated: Your view of the world is actually an image of what things looked like at the instant their light began traveling toward you.

If you're staring across a room, the lag is just billionths of a second — utterly imperceptible. Look at the moon, and you see it as it was about a second-and-a-half ago. Watch a sunset, and you're seeing the sun of 8.3 minutes ago.

Astronomical Unit

An Astronomical Unit (AU) is the average distance between Earth and the Sun, which is about 93 million miles or 150 million kilometers. It's approximately eight light minutes Astronomical units are usually used to measure distances within our Solar System. For example, the planet Mercury is about 1/3 of an AU from the sun, while the farthest planet, Pluto, is about 40 AU from the sun (that's 40 times as far away from the Sun as Earth is).

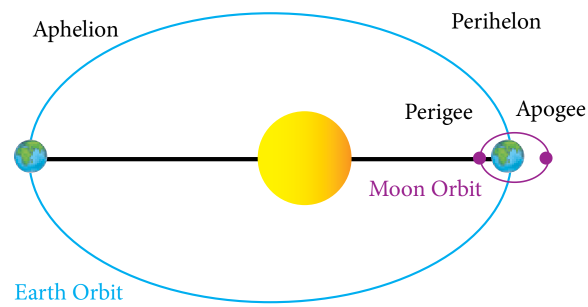


Fig. 12.3

According to the prevailing astronomical convention, 1 astronomical unit is equal to 149,597,870.7 kilometres (or 92,955,807 miles). As the earth orbits the sun with a varying orbital distance, we need to consider the average distance, therefore, one astronomical unit is the average distance between the Earth and the Sun. In other words, the Earth and the Sun mid-distance varies in a single year. The varying distance between the earth and the sun is maximum at the aphelion (152,100,000 km or 94,500,000 miles or 1.016 AUs) and the minimum at the perihelion (147,095,000 km or 91,401,000 miles or 0,983 AUs).

1 astronomical unit value = 149597870700 metres (exactly)

$\approx$ 92955807 miles $\approx$ 499.00478384 light-seconds

$\approx 4.8481368\times10^{-6}$ parsecs $\approx 1.5812507\times10^{-5}$ light-years

The speed of light can be represented in terms of astronomical units. As we know 299792458 m/s is the speed of light which is equal to precisely 299792458 × 86400 ÷ 149597870700 or about 173.144632674240 AU/d, some 60 parts per trillion less than the 2009 estimate.

Development of Astronomical Unit

The earliest documented example of astronomers calculating the distance between the Earth and the Sun dates back to Classical Antiquity. In the 3rd century BCE, Greek mathematician Aristarchus of Samos imputed that the distance was estimated to be between 18 and 20 times the distance between the Earth and the Moon.

According to the oldest Chinese mathematical writing, Zhoubi Suanjing the 1st century BCE treatise also estimates the distance between the Earth and Sun. According to the anonymous exposition, the distance is calculated by conducting geometric measures of the length of noontime shadows formed by objects aligned at specific distances. However, the predictions were based on the belief that the Earth was flat.

By the 19th century, ascertainments of the speed of light and the constant deviation of light resulted in the first direct measurement of the Earth-Sun distance in kilometres. By 1903, for the first time, the term "astronomical unit" emerged. Developments in precision have always been a key to developing astronomical understanding. Throughout the twentieth century, measurements became more precise and ever more reliant on accurate observation of the effects described by Einstein's theory of relativity and upon the analytical tools it used.

Astronomical Unit Modern Usage

The astronomical unit finds great applicability in the measurement of the stellar distance of extraterrestrial objects. It can be used to calculate the heliocentric distance of an asteroid or measure the distance of a planet's orbiting moon. In the solar system, it finds usage in the development of mathematical and numerical methods for computational purposes. Also, it can be used in general to measure the distance between planetary systems and understand the extent of gaseous clouds around planets. However, an astronomical unit is an inept way of measuring distance when it comes to interstellar objects. For interstellar purposes, it is best to use measures such as light-years and parsec. While fabricating a numerical model of the Solar System, the astronomical unit proffers a relevant scale that minimizes floating-point calculations errors.

Astronomical unit (AU)

The average distance between sun and earth is called astronomical unit.

i. e: $1 \text{ AU} = 1.496 \times 10^{11}$ m

Quick Question

i. What is astronomical unit?
ii. What are examples of an astronomical unit?
iii. What are astronomical units measured in?

Parsec

The distance of a star from the earth which has an apparent shift (parallax) of one second of an arc due to earth's motion around the sun is called parsec (Para lactic second).

$\therefore$ 1 parsec = 3.08×10^{16} m

$\therefore$ 1 parsec = 3.26 light year

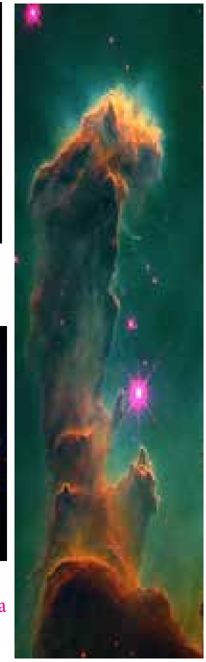
12.2 Nabula and Black hole

A. Nabula

A nebula (Latin for 'cloud' or 'fog', is a distinct body of interstellar clouds (which can consist of cosmic dust, hydrogen, helium, molecular clouds; possibly as ionized gases). Originally, the term was used to describe any diffused astronomical object, including galaxies beyond the Milky Way. Some nebulae (more than one nebula) come from the gas and dust thrown out by the explosion of a dying star, such as a supernova. Other nebulae are regions where new stars are beginning to form. For this reason, some nebulae are called "star nurseries."

Hubble image of planetary nebula IC 418, also known as the Spirograph Nebula.

Chandra X-ray image of supernova remnant Cassiopeia A. The colors show different wavelengths of X-rays being emitted by the matter that has been ejected from the central star. In the center is a neutron star.



Hubble image of the Eagle Nebula, a stellar nursery.

Fig. 12.4

Nebulae are made of dust and gases—mostly hydrogen and helium. The dust and gases in a nebula are very spread out, but gravity can slowly begin to pull together clumps of dust and gas. As these clumps get bigger and bigger, their gravity gets stronger and stronger.

Eventually, the clump of dust and gas gets so big that it collapses from its own gravity. The collapse causes the material at the center of the cloud to heat up-and this hot core is the beginning of a star.

Nebulae exist in the space between the stars—also known as interstellar space. The closest known nebula to Earth is called the Helix Nebula. It is the remnant of a dying star—possibly one like the Sun. It is approximately 700 light-years away from Earth. That means even if you could travel at the speed of light, it would still take you 700 years to get there!

Astronomers use very powerful telescopes to take pictures of faraway nebulae. Space telescopes such as NASA's Spitzer Space Telescope and Hubble Space Telescope have captured many images of faraway nebulae.

The Andromeda Galaxy, for instance, was once referred to as the Andromeda Nebula (and spiral galaxies in general as "spiral nebulae") before the true nature of galaxies was confirmed in the early 20th century by Vesto Slipher, Edwin Hubble and others. Edwin Hubble discovered that most nebulae are associated with stars and illuminated by starlight. He also helped categorize nebulae based on the type of light spectra they produced.

Most nebulae are of vast size; some are hundreds of light-years in diameter. A nebula that is visible to the human eye from Earth would appear larger, but no brighter, from close by. The Orion Nebula, the brightest nebula in the sky and occupying an area twice the angular diameter of the full Moon, can be viewed with the naked eye but was missed by early astronomers. Although denser than the space surrounding them, most nebulae are far less dense than any vacuum created on Earth – a nebular cloud the size of the Earth would have a total mass of only a few kilograms. Many nebulae are visible due to fluorescence caused by embedded hot stars, while others are so diffused that they can be detected only with long exposures and special filters.

Quick Question

i. How do stars form in a nebula?
ii. Where are nebulae?
iii. How do we know what nebulae look like?

B. Black hole

Black hole is a cosmic body of extremely intense gravity from which nothing, not even light, can escape. A black hole can be formed by the death of a massive star. When such a star has exhausted the internal thermonuclear fuels in its core at the end of its life, the core becomes unstable and gravitationally collapses inward upon itself, and the star's outer layers are blown away. The crushing weight of constituent matter falling in from all sides compresses the dying star to a point of zero volume and infinite density called the singularity.

Details of the structure of a black hole are calculated from Albert Einstein's general theory of relativity. The singularity constitutes the centre of a black hole and is hidden by the object's "surface," the event horizon. Inside the event horizon the escape velocity (i.e., the velocity required for matter to escape from the gravitational field of a cosmic object) exceeds the speed of light, so that not even rays of light can escape into space. The radius of the event horizon is called the Schwarzschild radius, after the German astronomer Karl Schwarzschild, who in 1916 predicted the existence of collapsed stellar bodies that emit no radiation. The size of the Schwarzschild radius is proportional to the mass of the collapsing star. For a black hole with a mass 10 times as great as that of the Sun, the radius would be 30 km (18.6 miles).

Only the most massive stars—those of more than three solar masses—become black holes at the end of their lives. Stars with a smaller amount of mass evolve into less compressed bodies, either white dwarfs or neutron stars.

Black holes usually cannot be observed directly on account of both their small size and the fact that they emit no light. They can be "observed," however, by the effects of their enormous gravitational fields on nearby matter. For example, if a black hole is a member of a binary star system, matter flowing into it from its companion becomes intensely heated and then radiates X-rays copiously before entering the event horizon of the black hole and disappearing forever. One of the component stars of the binary X-ray system Cygnus X-1 is a black hole. Discovered in 1971 in the constellation Cygnus, this binary consists of a blue supergiant and an invisible companion 14.8 times the mass of the Sun that revolve about one another in a period of 5.6 days.

Some black holes apparently have nonstellar origins. Various astronomers have speculated that large volumes of interstellar gas collect and collapse into supermassive black holes at the centres of quasars and galaxies. A mass of gas falling rapidly into a black hole is estimated to give off more than 100 times as much energy as is released by the identical amount of mass through nuclear fusion. Accordingly, the collapse of millions or billions of solar masses of interstellar gas under gravitational force into a large black hole would account for the enormous energy output of quasars and certain galactic systems.

One such supermassive black hole, Sagittarius A*, exists at the centre of the Milky Way Galaxy. Observations of stars orbiting the position of Sagittarius A* demonstrate the presence of a black hole with a mass equivalent to more than 4,000,000 Suns. (For these observations, American astronomer Andrea Ghez and German astronomer Reinhard Genzel were awarded the 2020 Nobel Prize for Physics.) Supermassive black holes have been detected in other galaxies as well. In 2017 the Event Horizon Telescope obtained an image of the supermassive black hole at the centre of the M87 galaxy. That black hole has a mass equal to six and a half billion Suns but is only 38 billion km (24 billion miles) across. It was the first black hole to be imaged directly. The existence of even larger black holes, each with a mass equal to 10 billion Suns, can be inferred from the energetic effects on gas swirling at extremely high velocities around the centre of NGC 3842 and NGC 4889, galaxies near the Milky Way.

The existence of another kind of nonstellar black hole was proposed by the British astrophysicist Stephen Hawking. According to Hawking's theory, numerous tiny primordial black holes, possibly with a mass equal to or less than that of an asteroid, might have been created during the big bang, a state of extremely high temperatures and density in which the universe originated 13.8 billion years ago. These so-called mini black holes, like the more massive variety, lose mass over time through Hawking radiation and disappear. If certain theories of the universe that require extra dimensions are correct, the Large Hadron Collider could produce significant numbers of mini black holes.

Quick Question

i. What is a black hole ?

ii. What is the structure of a black hole ?

iii. How is black hole formed ?

iv. What are some examples of black hole ?

12.3 Life Cycle of Stars

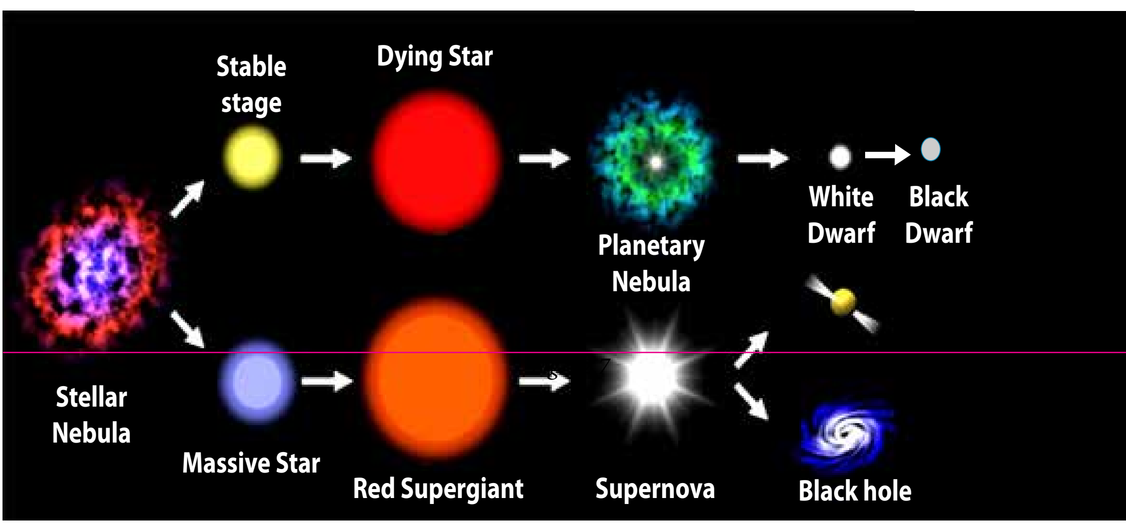


Fig. 12.4

A star's life is a constant struggle against the force of gravity. Gravity constantly works to try and cause the star to collapse. The star's core, however is very hot which creates pressure within the gas.

This pressure counteracts the force of gravity, putting the star into what is called hydrostatic equilibrium. A star is okay as long as the star has this equilibrium between gravity pulling the star inwards and pressure pushing the star outwards.

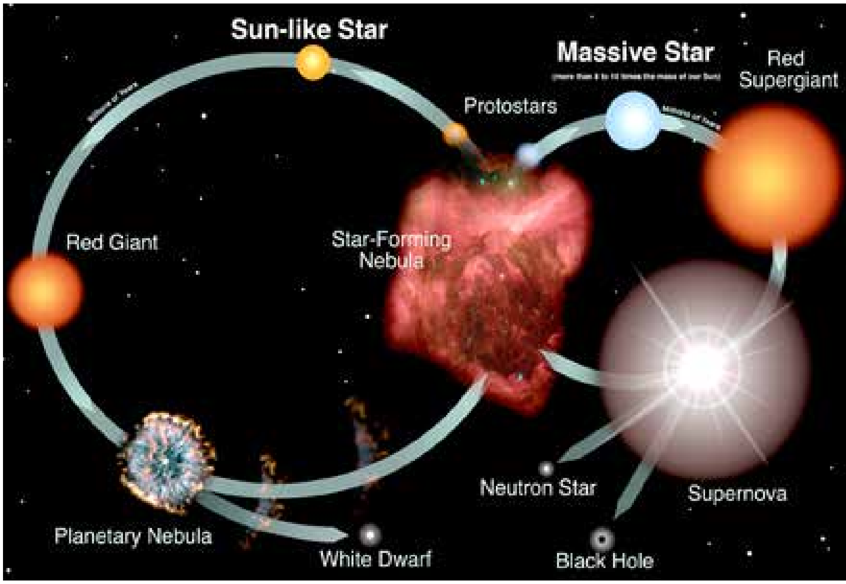


Fig. 12.5

During most a star's lifetime, the interior heat and radiation is provided by nuclear reactions in the star's core. This phase of the star's life is called the main sequence.

Before a star reaches the main sequence, the star is contracting and its core is not yet hot or dense enough to begin nuclear reactions. So, until it reaches the main sequence, hydrostatic support is provided by the heat generated from the contraction.

At some point, the star will run out of material in its core for those nuclear reactions. When the star runs out of nuclear fuel, it comes to the end of its time on the main sequence. If the star is large enough, it can go through a series of less-efficient nuclear reactions to produce internal heat. However, eventually these reactions will no longer generate sufficient heat to support the star agains its own gravity and the star will collapse.

A star is born, lives, and dies, much like everything else in nature. Using observations of stars in all phases of their lives, astronomers have constructed a lifecycle that all stars appear to go through. The fate and life of a star depends primarily on it's mass.

All stars begin their lives from the collapse of material in a giant molecular cloud. These clouds are clouds that form between the stars and consist primarily of molecular gas and dust. Turbulence within the cloud causes knots to form which can then collapse under it's own gravitational attraction. As the knot collapses, the material at the center begins to heat up. That hot core is called a protostar and will eventually become a star.

The cloud doesn't collapse into just one large star, but different knots of material will each become it's own protostar. This is why these clouds of material are often called stellar nuseries – they are places where many stars form.

Stars go through a natural cycle, much like any living beings. This cycle begins with birth, expands through a lifespan characterized by change and growth, and ultimately leads to death. The time frame in the life cycle of stars is entirely different from the life cycle of a living being, lasting in the order of billions of years.

Did you know that some of the stars we see in the sky may already be dead! Their light travels millions and millions of kilometres, and by the time it reaches us, the star would have died. So the distance between our planet and the stars further away is unimaginable, but measurable still. Watch and learn how these distances can be measured and the secrets hiding among the stars.

Massive stars transform into supernovae, neutron stars and black holes while average stars like the sun, end life as a white dwarf surrounded by a disappearing planetary nebula.

Main Stages of a Star

Stars come in a variety of masses and the mass determines how radiantly the star will shine and how it dies. Massive stars transform into supernovae, neutron stars and black holes while average stars like the sun, end life as a white dwarf surrounded by a disappearing planetary nebula. All stars, irrespective of their size, follow the same following stage cycle, they start as a gas cloud and end as a star remnant.

i. Giant Gas Cloud

A star originates from a large cloud of gas. The temperature in the cloud is low enough for the synthesis of molecules. The Orion cloud complex in the Orion system is an example of a star in this stage of life.

ii. Protostar

When the gas particles in the molecular cloud run into each other, heat energy is produced. This results in the formation of a warm clump of molecules referred to as the Protostar. The creation of Protostars can be seen through infrared vision as the Protostars are warmer than other materials in the molecular cloud. Several Protostars can be formed in one cloud, depending on the size of the molecular cloud.

iii. T-Tauri Phase

A T-Tauri star begins when materials stop falling into the Protostar and release tremendous amounts of energy. The mean temperature of the Tauri star isn't enough to support nuclear fusion at its core. The T-Tauri star lasts for about 100 million years, following which it enters the most extended phase of development – the Main sequence phase.

iv. Main Sequence

The main sequence phase is the stage in development where the core temperature reaches the point for the fusion to commence. In this process, the protons of hydrogen are converted into atoms of helium. This reaction is exothermic; it gives off more heat than it requires and so the core of a main-sequence star releases a tremendous amount of energy.

v. Red Giant

A star converts hydrogen atoms into helium over its course of life at its core. Eventually, the hydrogen fuel runs out, and the internal reaction stops. Without the reactions occurring at the core, a star contracts inward through gravity causing it to expand. As it expands, the star first becomes a subgiant star and then a red giant. Red giants have cooler surfaces than the main-sequence star, and because of this, they appear red than yellow.

vi. The Fusion of Heavier Elements

Helium molecules fuse at the core, as the star expands. The energy of this reaction prevents the core from collapsing. The core shrinks and begins fusing carbon, once the helium fusion ends. This process repeats until iron appears at the core. The iron fusion reaction absorbs energy, which causes the core to collapse. This implosion transforms massive stars into a supernova while smaller stars like the sun contract into white dwarfs.

vii. Supernovae and Planetary Nebulae

Most of the star material is blasted away into space, but the core implodes into a neutron star or a singularity known as the black hole. Less massive stars don't explode, their cores contract instead into a tiny, hot star known as the white dwarf while the outer material drifts away. Stars tinier than the sun, don't have enough mass to burn with anything but a red glow during their main sequence. These red dwarves are difficult to spot. But, these may be the most common stars that can burn for trillions of years.

The above were the seven main stages of the life cycle of a star. Whether big or small, young or old, stars are one of the most beautiful and lyrical objects in all of creation. Next time you look up at the stars, remember, this is how they were created and how they will die.

Activity 12.1

Low Mass Star

This model shows the discrete stages that a low mass star goes through over billions of years, from its beginnings as a gas cloud, to its death as a black dwarf.

Materials:

tape, tissue paper and cotton batting

string of indoor Christmas lights with white, red, orange, and yellow bulbs

different-sized spherical light globes either clear or white (ranging from 1 to 5 inches in

diameter; these can be found in any store selling light fixtures)

opaque black ball (or you could paint a light globe)

Procedure:

Punch 6 holes in a piece of cardboard or cotton batting and insert one of the lights through each hole. You might need to tape them in place.

To show the birth of a star as a hot gas cloud, wrap the outside of a globe in cotton and place it over the first bulb of the string of lights.

For a newborn star, have an orange light inside a 3-inch globe.

For a steady star, have a yellow light inside a 2-inch globe.

For a red giant, have a red light inside a 5-inch globe.

For a planetary nebula, have a red light inside a 3-inch globe. Wrap crumpled tissue paper around the outside of the globe.

For a white dwarf, have a white light inside a 1-inch globe.

For a black dwarf, have a 1 inch black opaque globe. No lights should be used for the black dwarf.

The globes used for the various stages are not to scale. Do a simple calculation to see why...if a steady star is 1.4 million km in diameter (and represented by a 2-inch globe), how big would the red giant globe have to be on the same scale?

Activity 12.2

Model a Black Hole

This demonstration allows for a visual depiction of the effect of a large mass on the fabric of spacetime. In particular, what effect a black hole does or does not have on the other stars around it and how that effect depends on the mass of the black hole.

Materials:

- large latex balloon cut open and pulled flat, or sheet of latex
- round bowl, 4"- 5" in diameter
- tape
- package of small round beads
- 1" solid ball bearing (the eraser end of a pencil can be used as a replacement)

Procedure:

- Tape the sheet of latex (this represents space-time) tightly across the top of some round object...such as a bowl. The sheet should not be so tight that it will tear if stretched further, but should be taut enough that there are not any wrinkles!
- Scatter a few beads on the sheet of latex (this represents matter that is near the black hole). Make sure they are spread out to all parts of the sheet.
- Gently drop the ball bearing onto the sheet of latex (this represents the black hole). Try not to let it bounce! If you don't have a ball bearing, gently push down on the center of the sheet with the eraser end of a pencil.
- Explain what happened to the matter when the black hole was put into place. Why did this occur?
- What would happen if the ball bearing was heavier (or if you push harder on the pencil)? What physical analogy to the black hole may be made?

12.4 General Introduction of National and International Organizations Studying Astronomy :

Astronomy is the study of the sun, moon, stars, planets and other objects and phenomena in space. It has a long, rich history. Every night, using the science of astronomy, the entire universe can be revealed above us. Although at some point we've all had that "blanket of stars" moment, it is an illusion. The visible planets and the bright stars you can see with your eyes are mostly very close to us — in cosmic terms — but the night sky has incredible, almost unfathomable depth. Not only can our own galaxy, the Milky Way, be navigated and known but other galaxies can be probed using telescopes, on Earth and in space, and in various wavelengths of light from all kinds of cosmic objects.

Astronomy is the study of everything in the universe that's beyond our own planet's atmosphere. The planets in our own solar system, our own star, the Sun, and the bright stars can all be seen with the naked eye. However, astronomy can go much deeper, taking advantage of telescopes and other scientific instruments to study other stars and their planets in our galaxy, as well as distant galaxies beyond our own. It can gather clues about the nature of the physical, chemical and biological universe itself.

People very often confuse astronomy with astrology. Astrology and astronomy are not the same thing, but they used to be. Observational astronomy can be traced back to Ancient Egypt and Mesopotamia as far back as 3,000 B.C., but the calculating of solar eclipses, the movements of the planets and theories about how the night sky works was the job of ancient astrologers who presumed that celestial events and alignments had a direct impact on human affairs. Modern astrologers attempt to do something similar, making predictions about human lives based on pseudoscience. Astrology is not a science.

In the past century or so, astronomy has been broadly split into two camps — observational astronomy (using telescopes and cameras to collect data about the night sky) and theoretical astronomy (using that data to analyze, model and theorize about how objects and phenomena work).

They complement each other, yet within these two broad categories modern astronomy includes many subsets, from astrometry to exoplanetology, that intrinsically overlap yet help explain the many things astronomers do.

Some national and international associations and institutions are also active in this field. These organizations have been making significant contributions to astronomy. Here is a general introduction to some of these contributing organizations:–

I. Nepal Academy of Science and Technology (NAST)

Nepal Academy of Science and Technology (NAST) is an autonomous apex body established in 1982 to promote science and technology in the country. The Academy is entrusted with four major objectives: advancement of science and technology for all-round development of the nation; preservation and further modernization of indigenous technologies; promotion of research in science and technology; and identification and facilitation of appropriate technology transfer.

Fig. 12.6

NAST's headquarters is in Khumaltar Lalitpur . Lately, NAST has been active in the field of astronomy. It has conducted workshops, seminars, and other activities related to astronomy. In addition, NAST is moving ahead with plans to develop a nano-satellite and is working on the prospect of astronomy. NAST also plans to set up a space research center. It has prioritized infrastructure development. Some work has been done in this field at the BP Planetarium in Kirtipur. NAST is moving ahead with the goal of motivating young people in the field of astronomy.

II. The National Aeronautics and Space Administration (NASA)

The National Aeronautics and Space Administration, commonly known as NASA, is an independent agency of the United States Federal Government. NASA is responsible for the U.S. civilian space program, along with aeronautics and aerospace research.

Fig. 12.7

NASA was established in 1958, succeeding the National Advisory Committee for Aeronautics (NACA). The new agency was to have a distinctly civilian orientation, encouraging peaceful applications in space science. Since its establishment, most US space exploration efforts have been led by NASA, including the Apollo Moon landing missions, the Skylab space station, and later the Space Shuttle. NASA is supporting the International Space Station and is overseeing the development of the Orion spacecraft, the Space Launch System, Commercial Crew vehicles, and the planned Lunar Gateway space station. The agency is also responsible for the Launch Services Program, which provides oversight of launch operations and countdown management for uncrewed NASA launches.

NASA's Headquarters is in Washington, D.C. The agency has nine centers, the Jet Propulsion Laboratory and seven test and research facilities located in several states around the country. More than 17,000 people work for NASA. Many more people work with the agency as government contractors. These people are hired by companies that NASA pays to do work. The combined workforce represents a variety of jobs. Astronauts may be the best-known NASA employees, but they only represent a small number of the total workforce. Many NASA workers are scientists and engineers. But people there hold many other jobs, too, from secretaries to writers to lawyers to teachers.

NASA's science is focused on better understanding Earth through the Earth Observing System, advancing heliophysics through the efforts of the Science Mission Directorate's Heliophysics Research Program, exploring bodies throughout the Solar System with advanced robotic spacecraft such as New Horizons, and researching astrophysics topics, such as the Big Bang, through the Great Observatories and associated programs.

In February 2016, NASA formally started the top Astro2010 decadal recommendation, the Wide Field Infrared Survey Telescope (WFIRST). In spring of 2020, WFIRST was renamed the Nancy Grace Roman Space Telescope. Roman will aid researchers in their efforts to unravel the secrets of dark energy and dark matter, and explore the evolution of the cosmos. It will also discover new worlds outside our solar system and advance the search for worlds that could be suitable for life.

In January 2017, NASA selected the new Small Explorer (SMEX) mission IXPE (Imaging X-ray Polarimetry Explorer) which uses the polarization state of light from astrophysical sources to provide insight into our understanding of X-ray production in objects such as neutron stars and pulsar wind nebulae, as well as stellar and supermassive black holes.

In March 2017, NASA selected the Explorer Mission of Opportunity GUSTO (Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory) to measure emissions from the interstellar medium to help scientists determine the life cycle of interstellar gas in our Milky Way, witness the formation and destruction of star-forming clouds, and understand the dynamics and gas flow in the vicinity of the center of our galaxy.

Since the 2001 decadal survey, the way the universe is viewed has changed dramatically. More than 3800 planets have been discovered orbiting distant stars. Black holes are now known to be present at the center of most galaxies, including the Milky Way galaxy. The age, size and shape of the universe have been mapped based on the primordial radiation left by the big bang. And it has been learned that most of the matter in the universe is dark and invisible, and the universe is not only expanding, but accelerating in an unexpected way.

III. The International Astronomical Union (IAU)

Fig. 12.8

International Astronomical Union (IAU), senior body governing international professional astronomical activities worldwide, with headquarters in Paris. It was founded in 1919. It is a non-governmental organization with the mission of promote and safeguard the science of astronomy in all its aspects, including research, communication, education and development, through international cooperation. Its individual Members — structured into Divisions, Commissions, and Working Groups — are professional astronomers from all over the world, at the Ph.D. level and beyond, who are active in professional research, education and outreach in astronomy. The IAU also has Junior Members. The IAU has a total membership of 12110. The Individual and Junior Members Directory contains 11775 names in 90 countries worldwide. These Members are labeled as "active" in the IAU database meaning they have a valid email (are able to vote and stay connected to the IAU activities) and are affiliated to at least one Division. IAU membership spans 90 countries. Out of those countries, 85 are National Members. In addition, the IAU collaborates with various scientific organizations all over the world.

The long-term policy of the IAU is defined by the General Assembly and implemented by the Executive Committee, while day-to-day operations are directed by the IAU Officers. The focal point of its activities is the IAU Secretariat, hosted by the Institut d'Astrophysique de Paris in France. The scientific and educational activities of the IAU are organized by its 9 Scientific Divisions and, through them, its 38 specialized Commissions covering the full spectrum of astronomy, along with its 46 Working Groups.

The key activity of the IAU is the organization of scientific meetings. Every year the IAU sponsors 9 international IAU Symposia. The *IAU Symposium Proceedings* series is the flagship of the IAU publications. Every three years the IAU holds a General Assembly, which offers 6 IAU Symposia, some 15 Focus Meetings, and individual business and scientific meetings of Divisions, Commissions, and Working Groups and Offices. The proceedings of Focus Meetings are published in the *Astronomy in Focus* series. The triennial reports of the Divisions and Commissions are published in the *Transactions of the IAU* - A series.The reports of the GA business meetings are published in the *Transactions of the IAU* - B series.

Among the other tasks of the IAU are the definition of fundamental astronomical and physical constants; unambiguous astronomical nomenclature and informal discussions on the possibilities for future international large-scale facilities. Furthermore, the IAU serves as the internationally recognized authority for assigning designations to celestial bodies and surface features on them.

The IAU also works to promote research, education and public outreach activities in astronomy for the public. These activities culminated with the organization of the UNESCO International Year of Astronomy in 2009, which reached out to over 800 million people from 148 countries. Following this effort, the IAU has also established in 2015 the Office of Young Astronomers (OYA) , a joint venture with the Norwegian Academy of Sciences and Letters. In 2011 the IAU created the Office of Astronomy for Development (OAD), a joint venture with the South African National Research Foundation where Astronomy is used as a tool for stimulating capacity building. The IAU has also established in 2012 the Office for Astronomy Outreach (OAO), a joint venture with the National Astronomical Observatory of Japan. Furthermore, the IAU has also established the Office of Young Astronomers (OYA), a joint venture with the Norwegian Academy of Sciences and Letters. The IAU has recently launched an international call to establish the Office of Astronomy for Education (OAE) in 2019. Regional nodes have been created in other countries as well. In 2015 actively participated in the International Year of Light. The IAU also carries out joint educational activities associated with COSPAR and UNESCO.

Project Works

i. Prepare separate reports on black holes and nebulae using audio-visual aids and present them in the classroom.

ii. Prepare a report on the star's life using audio-visuals aids.

iii. Make a model of the life chart of the stars with the help of the internet and stick it on the wall of the classroom.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Which is not the correct unit to measure astronomical distance ?

a. Light year　　b. Astronomical unit

c. Kilometer　　d. Parsec

ii. 1 light year is equal to-

a. 1.496×10^{11} m　　b. 1.46×10^{15}m

c. 1.496×10^{13} m　　d. 1.08×10^{16} m

iii. 1 AU is equal to-

a. 1.496×10^{11} m　　b. 1.46×10^{15}m

c. 1.496×10^{13} m　　d. 1.08×10^{16} m

iv. 1 parsec is equal to-

a. 1.496×10^{11} m　　b. 1.46×10^{15}m

c. 1.496×10^{13} m　　d. 1.08×10^{16} m

v. The period of one revolution of sun around the centre of galaxy is called __

a. Parsec　　b. Astronomical year

c. Cosmic year　　d. Light year

vi. Super Nova is ________

a. An asteroid　　b. A black hole

c. A comet　　d. A dying star

vii. A nebula consists primarily of which element?

a. Helium　　b. Nitrogen

c. Oxygen　　d. Hydrogen

viii. Which sequence below is correct?

a. Red Giant, Nebula, Main Sequence, Protostar

b. Nebula, Protostar, Main Sequence, Red Giant

c. Nebula, Main Sequence, Protostar, Red Giant

d. Red Giant, Nebula, Protostar, Main Sequence

ix. At which stage does a star swell up many times larger than its normal size?

a. Protostar　　b. Nebula

c. Main Sequence　　d. Red Giant

x. Less massive stars turn into ___ when they die

a. White Dwarfs　　b. Black Hole

c. Neutron Star　　d. Either a black hole or a neutron star

xi. **Which stage in a stars life is similar to "old age" in humans?**
   a. Nebula b. Main Sequence
   c. Red Giant d. White Dwarf

xii. **Which is the national organization working on prospect of astronomy?**
   a. NARC b. NASA
   c. NAST d. NOC

xiii. **Which is the international organization responsible for aeronautics and aerospace research?**
   a. NARC b. NASA
   c. NAST d. NOC

xiv. **Which is correct full form of NAST**
   a. Nepal Association of Science and Technology
   b. Nepal Academy of Science and Technology
   c. Nepal Academy of Social and Technology
   d. Nepal Academic Science and Technology

B. Give the reason :

i. It is very difficult to measure the distance between celestial bodies in kilometer and meter.
ii. Nebula is also called Stellar Nursery.
iii. Nebulae are made of dust and gases.
iv. A star converts hydrogen atoms into helium over its course of life at its core
v. Black holes cannot be seen.

C. write difference between

i. Light year and Astronomical unit ii. Nebula and Black hole
iii. Black hole and supernova iv. Astronomy and astrology
v. NAST and NASA

D. Answer the following questions :

i. What is the Universe ?
ii. Write down any three units related to astronomical distance.
iii. What is a light year?
iv. What is an astronomical unit?
v. How did the Red Star form?
vi. How does the life cycle of a star work ?
vii. State three facts on stars .
viii. What Is a Supernova? Define a Nebula
ix. Why do we need to study astronomy?
x. Write down the name of any three organizations working an advancement of astronomy.
xi. How is NAST working on astronomy?
xii. How is NASA working on astronomy?
xiii. How is IAU working on astronomy?

E. Write short note :

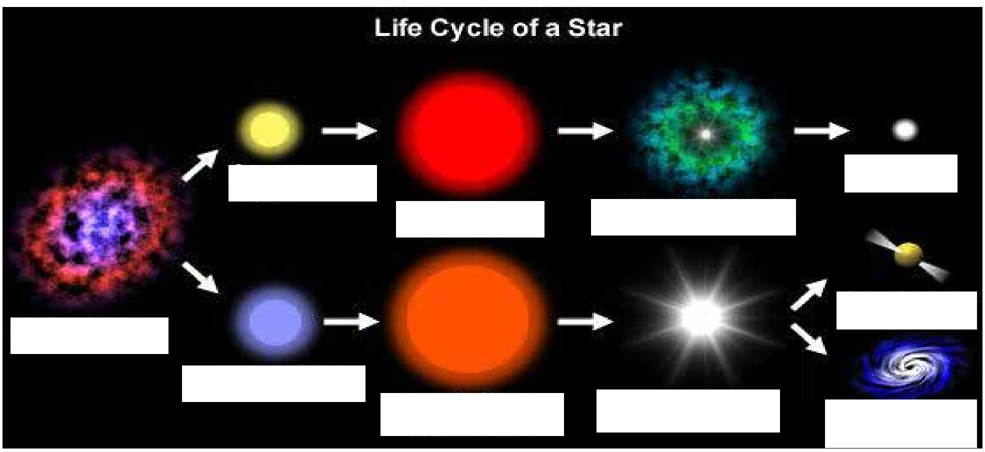
i. Light year ii. Astronomical unit
ii. Life cycle of stars iii. Birth of star
iv. Death of star v. NAST
vi. NASA vi. IAU
vii. Black hole viii. Nebula

F. For each of the following NEWLY DISCOVERED celestial bodies, below, the mean distance from the sun is given in kilometers. Fill in the data table by expressing these distances in AU's, using three significant figures for each result.

Celestial Body	Distance(kilometers)	Distance (Astronomical Units)
Planet Z	0.58×10^8	
Comet Y	1.8×10^8	
Star X	2.27×10^8	
Moon W	7.78×10^8	

G. Diagrammatic questions

i. Fill in the appropriate word in the box.



ii. Life cycles of stars

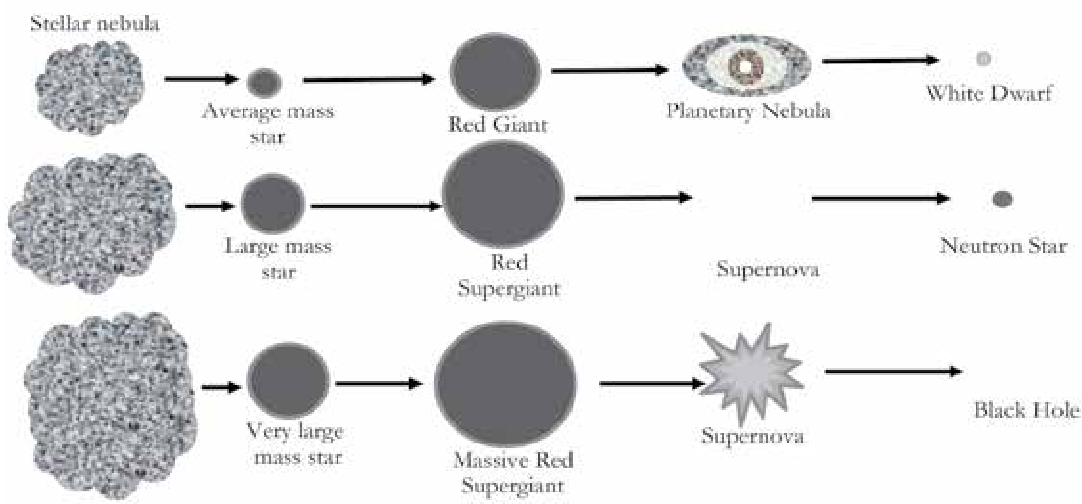
Why?

Most people love to gaze at stars in the night sky. In early childhood when we learn songs like "Twinkle, Twinkle Little Star," we begin to wonder what they are. Just as people pass through recognizable stages of life from birth to death, so do stars! We experience stars as unchangeable bright specks of light. Despite our personal experience, stars actually change over time – but on a time scale so huge that our lives are just a tiny moment compared to a star's life. In this activity we will explore the ways stars change over their lives.

As you work through the following questions, be sure to follow your team role(s).

Model 1 - Three Stars from Birth to Death

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Birth	Type of Star			Death



Note: The relative scale of objects is not accurate in this diagram.

Use the information in Model 1 to answer questions 1 – 6.

Reach agreement with your team before writing down your consensus answer.

1. How many different types of stars are included in Model 1?
2. Describe what the symbol  represents in Model 1.
3. What is the name of the first stage of life for all three types of stars?

Read This!

Stella is the Latin word for star. **Nebula** is the Latin word for cloud.

4. Explain why you think astronomers used the term "Stellar nebula." Cite specific information from Model 1 and the information in the Read This! box as part of your answer.
5. Look carefully at Model 1. Compare the different stages of life for all three types of stars. Which stages are very similar?

   a. only Stage 1   b. Stages 1, 2, and 3

   c. all of the stages   d. none of the stages

6. Analyze Model 1 to determine the life story of each of the three stars shown in Model 1. Complete the paragraphs below to describe the life cycles of stars. Base your answers on the labels in Model 1.

   An average mass star like our sun begins its life in a ________________ ______________________. After it has spent a time as a star, it expands to form a _________ ________________. Next, it expands to form a _______________________ __________________. In its last stage of life, it contracts to form a very small __________________ ______________ star.

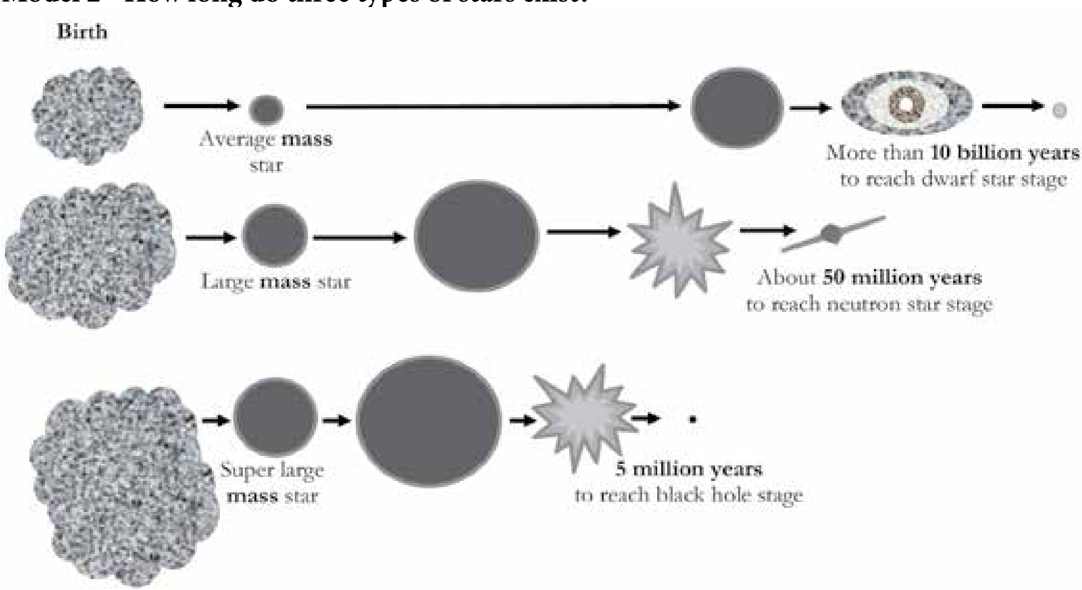
   A large mass star begins its life in a ________________ ______________________. After it has spent a time as a star, it expands to form a _________ _______________________________. Next, it explodes into a _________________________. In its last stage of life, it contracts to form a very small _________________ star.

very large mass star begins its life in a ______________ ________________. After it has spent a time as a star, it expands to form a ________________ ________ ______________________________. Next, it explodes into a ______________________________. In its last stage of life, it contracts to form an invisible ______________ ____________.

iii. Read This

Astronomers sometimes use the term Stellar Evolution for the processes you have described above.

Model 2 - How long do three types of stars exist?



Note: Relative scale is not accurate in this diagram.

Use the information in Model 2 to answer questions 7 – 12.

Reach agreement with your team before writing down your consensus answer.

7. In Model 2, identify the characteristic of stars that is represented by the different sizes of these objects.
   Age Color Mass Type Volume

STOP Check with your teacher before you continue.

8. As you move from the top to the bottom of Model 2, the mass of the stars…
   increases decreases remains the same

9. Highlight all of the numbers and their units shown in Model 2.
10. Circle all the units that are used with numbers in Model 2.
    Hundreds of Years Thousands of Years
    Millions of Years Billions of Years
    Trillions of Years

11. Identify the pattern that exists as you move from the top to the bottom ↓ of Model 2.
As you move from top to bottom of Model 3, the number of years a star exists…
increases decreases remains the same

Read This!'

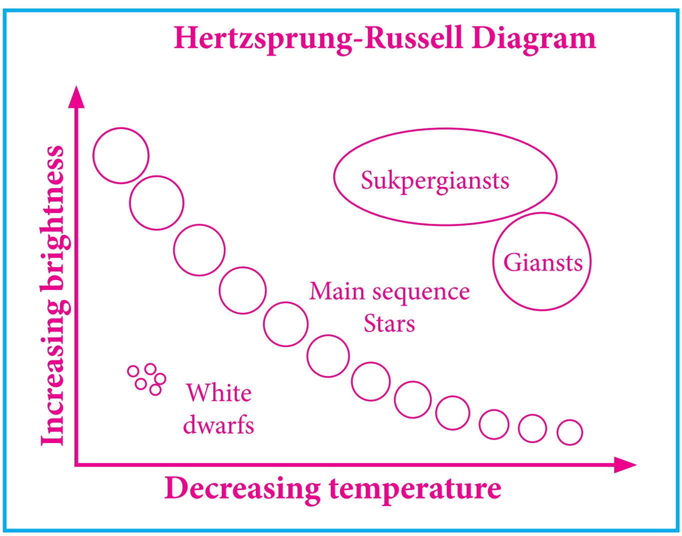
Astronomers use the term lifespan to describe how long a star exists, from birth to death.

12. How does the lifespan of a star relate to the mass of the star?
    a. Complete the sentence below.
    As the mass of a star increases, the lifespan of the star _______________
    b. Cite three specific pieces of evidence from Model 2 to support your claim.
13. The sun in our solar system is considered to be an average mass star.
    a. Based on Model 1, predict the last stage of life for our sun.
    white dwarf neutron star black hole
    b. Based on Model 2, predict the lifespan of our sun.
    5 million years 50 million years more than 10 billion years

What I Still Wonder…

14. Write one question you have about the life cycles of stars.

i. Use the following information to answer the question .
When compared with supergiants, white dwarfs are ? Give the reason too.



a. righter and colder
b. brighter and hotter
c. dimmer and colder
d. dimmer and hotter

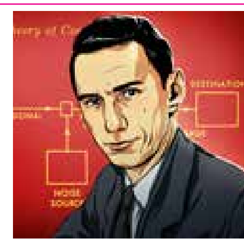
Unit 13 Information and Communication Technology

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- Introduction to ICT
- Introduction to Telecommunication
- Introduction to tools or components of telecommunication
- Introduction to satellite system
- Introduction to Internet and its importance in modern technology
- Online security

Claude Shannon, in full **Claude Elwood Shannon,** (1916-2001) American mathematician and electrical engineer who laid the theoretical foundations for digital circuits and information theory, a mathematical communication model.After graduating from the University of Michigan in 1936 with bachelor's degrees in mathematics and electrical engineering, Shannon obtained a research assistant's position at the Massachusetts Institute of Technology (MIT).



Introduction

ICT is the technology required for information processing, in particular, the use of electronic computers, communication devices and software application to convert, store, protect, process, transmit, receive and retrieve information from anywhere anytime in world. ICT have provided society with a vast array of new communication capabilities. For example people can communicate in real-time with others in different location using technologies such as internet messaging, voice over internet protocol (VOIP), video-conferencing, social network such as facebook allows people from all over the world to remain in contact and communicate on a regular basis. Communication technologies have created a 'Global village' in which people can communicate with others across the world as if they were living next door.

The 21st century is an age of science and technology or information. Due to the great impact of computers and computer networks in everyday of life, this period is correctly called the "information age". The information age is equally dependent on the computer and the network. Network exits to meet one goal namely, the transfer and exchange of data between the computers and workstations.

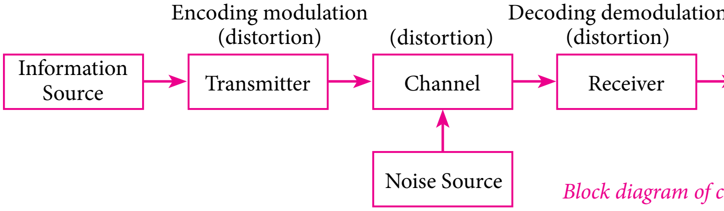
13.1 Introduction to Tele-Communication

The word communication is derived from Latin word 'communicare' which means to share any things. The process of transferring information or exchanging ideas, news between two or more persons or one place to another is called communication. It is the way of connecting people each other common. People can communicate each other from various ways such as e-mail, radio, newspaper, TV etc. It is the way of making a people near. You can share any information through any person or machine.

The word Tele-Communication is made by combination of two words 'Tele' and Communication. Tele means "Distance" and Communication means exchange of different information such as news, views, and ideas from one to another. It is the collection of electronic communication devices which is used to send and receive information from long distance that can stay in far. In other word, electronic communication refers to the Tele-communication. It consists of radio, TV, Telephone, fax, mobile phone, Wi-Fi, GPS, E-mail, network and internet.

Working Principle of Telecommunication

The primary function of telecommunication systems is that it transmits information to far distance and establish an interface between sender and receiver by some means of transmission mode or way. A telecommunication system includes a transmitter to take information and convert it to a signal, a transmission medium to carry the signal and a receiver to take the signal and convert it back into usable information.



Block diagram of communication system

Fig. 13.1

Analog & Digital Signals

In the tele-communication system, data and information can be sent and received in analog and digital signal.

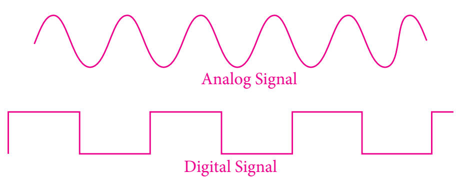


Fig. 13.2

Analog Signal

In this signal data and information send or receive continuous value. Analog technology information is transmitted into electronic pluses of varying amplitude. Analog signal is constant. It is used in various systems such as radio, TV, telephone calls etc. Analog signal is the most cheaper than a digital signal.

Digital Signal

In this signal, all the data and information transfer in discontinuous order. Digital signals are signals that represent data in the binary form such as '1' or '0'. It isn't constant. It provides fast and clear signal. It is used in the computer system for data communication.

Modulation

Modulation is the process of encoding information from a message source in a way that is suitable for transmission. Modulation is the addition of information to an electronic or optical carrier signal. In electronics and telecommunications, modulation is the process of varying one or more properties of a periodic waveform, the carrier signal, with a modulating signal that typically contains information that is to be transmitted. The different form of modulations are:

- Amplitude Modulation (AM)
- Phase Modulation (PM)
- Frequency Modulation(FM)

Amplitude Modulation (AM)

In order that a radio signal can carry audio or other information for broadcasting or for two way radio communication, it must be modulated or changed in some way. Although there are a number of ways in which a radio signal may be modulated, one of the easiest is to change its amplitude in line with variations of the sound.

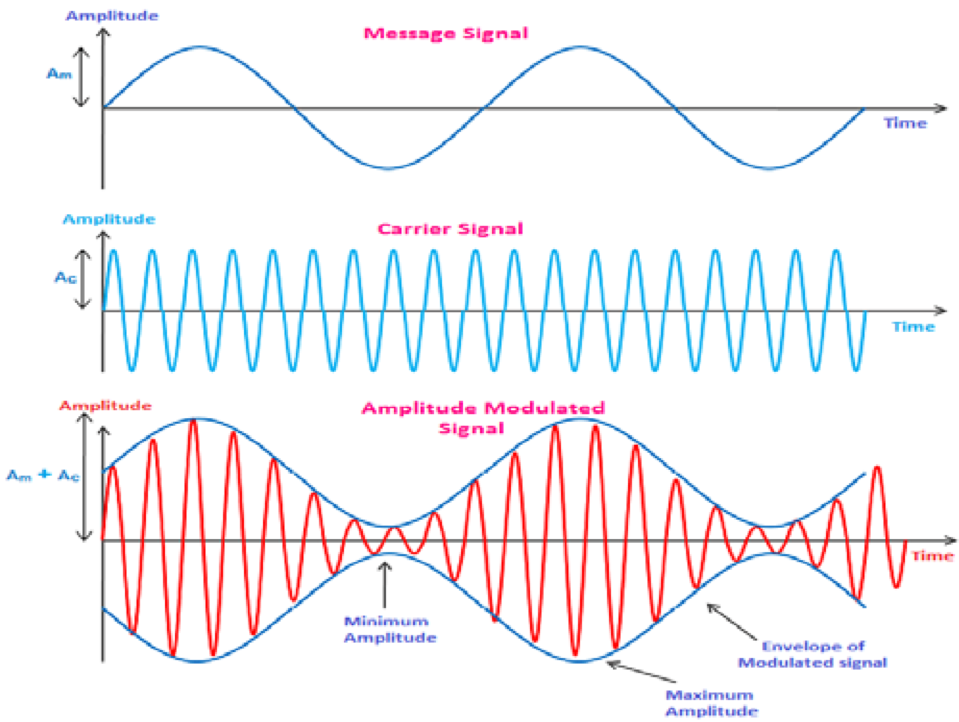


Fig. 13.3

Frequency Modulation (FM)

As with any form of modulation, it is necessary to be able to successfully demodulate it and recover the original signal. The FM demodulator may be called a variety of names including FM demodulator, FM detector or an FM discriminator. There are a number of different types of FM demodulator, but all of them enable the frequency variations of the incoming signal to be converted into amplitude variations on the output. These are typically fed into an audio amplifier, or possibly a digital interface if data is being passed over the system.

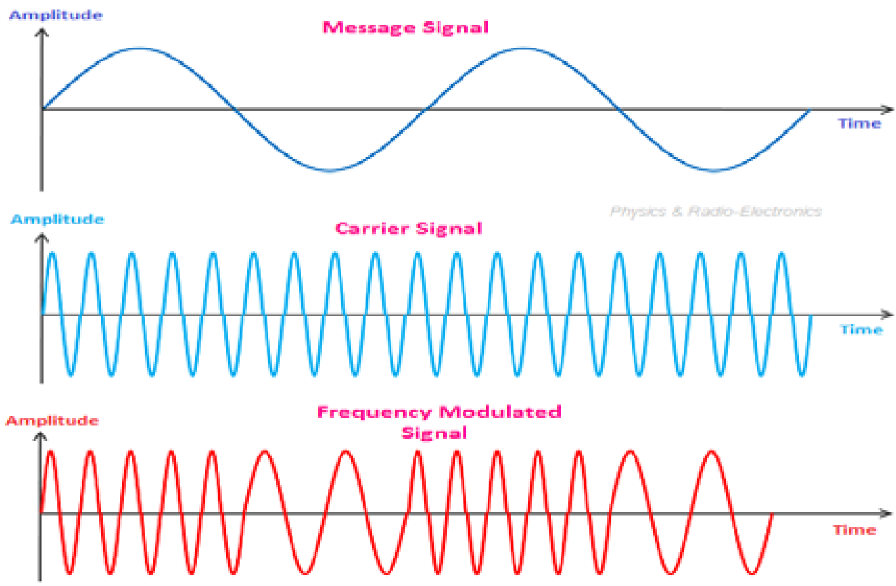


Fig. 13.4

13.2 Introduction to Artificial Satellites

Fig. 13.5

An artificial satellite is a man-made body placed in orbit round the earth or another planet in order to collect information about it or for communication purposes. There are currently over a thousand active satellites orbiting the Earth. The size, altitude and design of a satellite depend on its purpose. The International Space Station is an example of an artificial satellite. Artificial Satellites are those devices that are made and launched by humans to study the universe and provide the service for betterment of human life standards. It is placed at earth orbits by rockets. In the present scenario, the satellites are playing vital roles in our daily lives and our technologies. Satellites help us to study the Earth, Planets, to help us communicate and even to observe the distant universe to protect the earth from any asteroid impact. Artificial satellites can collect more data at once than any other device present on earth. It can collect data so quickly. Satellites can see space better than any telescope present on earth.

Satellite communication media is an amplifier or repeater that receives any data and information from any place of earth. They do not use any physical device but data and information through the air. The satellite communication media is a very fast communication media of the other media.

Importance of Artificial satellites in telecommunication

The artificial satellites play vital role in telecommunication. It is the basic components for telecommunication. It can be used to communicate. They provide radio and television and allow us to make a phone call to long distances present on earth from anywhere. It also provides fax and internet to send fax and emails.

In telecommunications, the use of artificial satellites to provide communication links between various points on Earth. Satellite communications play a vital role in the global telecommunication system. Approximately 3,000 artificial satellites orbiting Earth relay analog and digital signals carrying voice, video, and data to and from one or many locations worldwide.

Satellite communication has two main components: the ground segment, which consists of fixed or mobile transmission, reception, and ancillary equipment, and the space segment, which primarily is the satellite itself. A typical satellite link involves the transmission or up-linking of a signal from an Earth station to a satellite. The satellite then receives and amplifies the signal and retransmits it back to Earth, where it is received and re-amplified by Earth stations and terminals. Satellite receivers on the ground include **Direct-To-Home (DTH)** satellite equipment, mobile reception equipment in aircraft, satellite telephones, and handheld devices.

Working Principle of Satellite Communication

A satellite is basically a self-contained communications system with the ability to receive signals from Earth and to retransmit those signals back with the use of a transponder an integrated receiver and transmitter of radio signals. The main components of a satellite consist of the communication system, which includes the antennas and transponders that receive and retransmit signals. There are three stages of working of satellite communications. These are:

- Uplink
- Transponders
- Downlink

In the first stage, the signal from the television broadcast on the other side of the earth is first beamed up to the satellite from the ground station on the earth. This process is known as uplink.

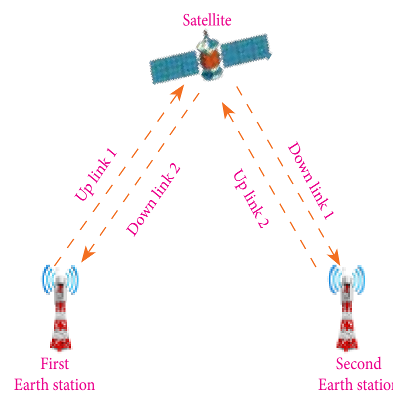


Fig. 13.6

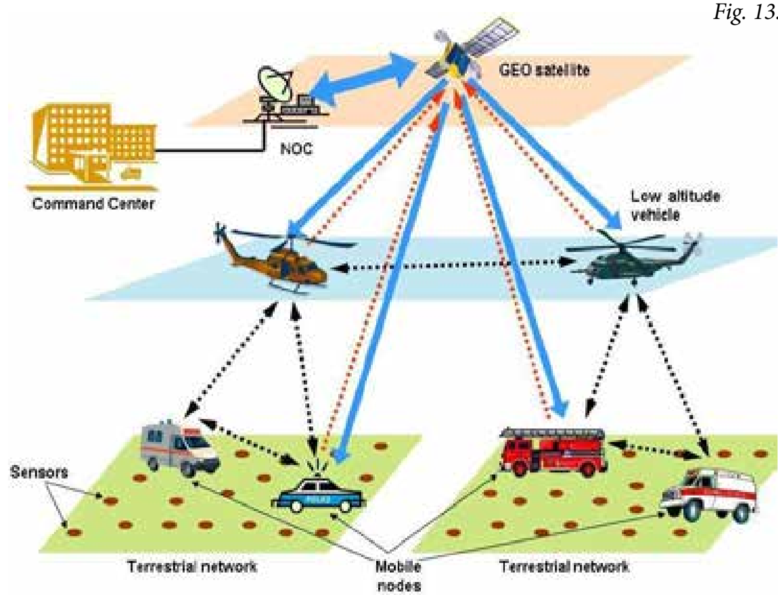


Fig. 13.7

The second stage involves transponders such as radio receivers, amplifiers, and transmitters. These transponders are used for boosting the incoming signal and to change their frequency so that the outgoing signals are not altered.

The final stage involves a downlink in which the data is sent to the other end of the receiver on the earth. It consists one uplink and multiple downlinks.

There are three types of communication services that satellites provide. They are:

- Telecommunications
- Broadcasting
- Data Communications

Telecommunications

Telecommunication services include telephone calls and services provided to telephone companies, as well as wireless, mobile, and cellular network providers.

Broadcasting

Broadcasting services include radio and television delivered directly to the consumer and mobile broadcasting services. DTH or satellite television services are received directly by households. Cable and network programming is delivered to local stations and affiliates largely via satellite. Satellites also play an important role in delivering programming to cell phones and other mobile devices, such as Personal Digital Assistants and laptops.

Data Communications

Data communications involve the transfer of data from one place to another. Corporations and organizations that require financial and other information to be exchanged between their various locations use satellites to facilitate the transfer of data through the use of very small-aperture terminal (VSAT) networks. With the growth of the Internet, a significant amount of Internet traffic goes through satellites, making ISPs one of the largest customers for satellite services.

Satellite communications technology is often used during natural disasters and emergencies when land-based communication services are down. Mobile satellite equipment can be deployed to disaster areas to provide emergency communication services.

Application of Satellite

Some of the basic applications of satellite are:

- In Radio broadcasting.
- In TV broadcasting such as DTH.
- In Internet applications such as providing Internet connection for data transfer, GPS applications, Internet surfing, etc.
- For voice communications.
- For research and development sector, in many areas.
- In military applications and navigations.
- Weather Forecasting, etc.

Project Work

- Visit any radio station, TV broadcasting station, Telecom and find how to work telecommunication system.

13.3 Introduction to Internet

Today is the ICT (Information Communication Technology) age. It is possible to develop or invent the internet. It is the most popular mode of communication in todays world. Internet provides easy and cheapest way of communication services. In the age of information technology, internet has become a very popular mode of communication. It has spread to diverse places and is now used in all spheres of life. Internet is for anyone who wants to remain in touch with anybody else, though virtually.

The internet is a global connection of computer linked through cables and telephone lines, making communication possible with each other in a common language for specific purpose. The internet allows computer users to share computer equipment, programs, messages, and information available at one computer all over the world. Internet is a network of network.

Importance of Internet

Today, the internet has become very important in our daily life. It makes our life easy, fast and simple. It helps us with facts and figures, information and knowledge for personal, social and economic development. There are many uses of the internet; however, the use of the internet in our daily life depends on individual requirements and goals. Internet is considered important means of communication in modern life, as we can send and receive messages and share our ideas and opinion and also know others perspective. Some of the points to explain why internet is important in our life are given below:

1. **Internet in Education**
   Internet is a great platform for students to learn throughout their lifetime. They can use the internet to learn new things and even acquire degrees through online education programs. Teachers can also use the internet to teach students around the world anytime anywhere.
2. **Speed up Daily Tasks**
   Internet is very much useful in our daily routine tasks. For example, it helps us to see our notifications and emails. Apart from this, people can use the internet for money transfers, shopping order online food, etc.
3. **Internet for Shopping**
   With the help of the internet, anybody can order products online. The increase in online shopping has also resulted in companies offering a huge discount for their customers. It helps to grow business worldwide.
4. **Internet for Research & Development**
   Internet plays a pivotal role in research and development as it is propelled through internet research. The benefit of the internet is enjoyed by small businessmen to big universities.
5. **Business Promotion and Innovation**
   Internet is also used to sell products by using various e-Commerce solutions. The result is new services and businesses starting every-day thereby creating job opportunities and reducing unemployment.
6. **Communication**
   Internet is the most powerful medium of communication at present. It connects people across different parts of the world free and fast. It is the easiest means of communication. It provides worldwide communication facilities like e-mail, VOIP, social media etc.

7. Digital Transactions

The internet facilitates internet banking, mobile banking, and e-wallets. Since all digital transactions are stored in a database, it helps the government to track income tax details or income reports in the ITR.

8. Tour & Travel

During tour and travel, the use of the internet is highly effective as it serves as a guide. People browse the internet before they start visiting the places. Tour bookings can also be done using the internet.

Search Engines

A search engine is a special types of a program that searches for all types of document on the web sites. It also searches files, document, audio, video and games and software on the internet. There are many types of search engines such as: www.yahoo.com, www.google.com, www.altavisita.com, www.lycos.com, www.msn.com, etc. Instead of typing to guess where certain information may be located on the web site, search engines allow you to search both the web.

Search Engine for a www.google.com

Fig. 13.8

Step for searching information on internet

- Vary your search engine. Search engines sort through about 625 million more active websites to provide you with content.
- Use specific keywords.
- Simplify your search terms.
- Use quotation marks.
- Remove unhelpful words.
- Refine your search using operators.
- Avoid search pitfalls.

Check the accuracy of information

- Author: The author should be clearly identified and their credentials should be relevant to the topic.
- Fact checking: In general, websites with more citations and links will provide you with better information.
- Website sponsor.
- Web address.
- Published date
- Comments

13.4 Online Security

Today is the age of computer and information or ICT (information communication technology). It is growing at very high speed day-by-day. Development of ICT facilitates greater access, transparency, comfort and ease of operation different activities. It provides lot of activities for making life better and enjoyable. ICT has greater advantages and features as well as risk (danger) and challenges such as cybercrime (Hacking, Cracking, phishing, cyber-attack, stalking, pornography, harassment etc.).

Cyber security is the practice of defending computers, servers, mobile devices, electronic systems, networks, and data from different types of threats such as virus, hacking, phishing, cyber-attack etc. It's also known as information technology security or electronic information security. It is the process to secure or protect computer, internet, network, website and information from different types of threats. It is the practice to secure online resources.

Online Safety Tips

The following tips will help you to stay as safe as possible online:

- **Use strong passwords-** We cannot emphasize enough how important it is to use complex passwords. Use a system to create strong and memorable passwords and change them regularly.
- **Enable multi-factor authentication –** Two-factor or multi-factor authentication adds another level to your personal security online.
- **Make sure your network is secure –** Remember that public Wi-Fi is often unsecured, leaving your device and information vulnerable to hackers.
- **Make sure you use a firewall –** Even on secure networks, you should still use a firewall.
- **Protect your identity –** Don't share personal information publicly. The less information that is 'out there' the safer you are.
- **Be scam aware –** Check all emails carefully before clicking on any links or opening any files.
- **Do necessary updates –** It can be annoying to keep updating devices and software but they often contain critical security updates.

Antivirus Software

A computer virus is the main problems or threats to computers and information or ICT society today. A computer virus is the small program design to damage or destroy the data, information, files, folders and software without your knowledge. It can spread itself when you run the computer system and destroy the whole parts of computer system such as data, software and even hardware. We need to prevent the virus infection in the computer system by using the latest technology or technique and by using the latest antivirus software to scan the computer system. You can secure the computer system from the infection of virus. To prevent the virus attack in the computer system, we can use the following techniques:

- To use latest antivirus software and regular scan the computer system.
- To stop the physical access to your system by persons or by network.
- Do not download unnecessary files and program in the internet.
- Do not use virus infection devices such as hard disk, pen drive, CD or DVD.
- Always check removable disk for viruses before using it.
- Do not access unknown e-mail files.

Firewalls

A firewall is a system designed to prevent unauthorized access to or from a private network. You can implement a firewall in either hardware or software form, or a combination of both. Firewalls prevent unauthorized internet users from accessing private networks connected to the internet, especially intranets. It can help protect your network by filtering traffic and blocking outsiders from gaining unauthorized access to the private data on your computer.

Digital Footprint

Today is the age of information communication technology (ICT) which provides easy and quick accessing any kind of information or the resources available throughout the global. We live in the world of digital era of social networking and online information exchange. There are different online services used by users. Digital footprint help web service provider to target appropriate user for their web content and services. Data or information can be access or share through the vast network which will remain there knowingly or unknowingly along with the technology; this shared information is referred as digital footprint. Digital footprint means the recording of interaction with the digital world. The information about a particular person that exists on the internet as a result of their online activity is known as digital footprint.

Digital footprint is all the stuff you leave behind as you use the Internet. Comments on social media, Skype calls, app use and email records are part of your online history and can potentially be seen by other people, or tracked in a database. Digital footprint or digital shadow refers to your unique set of traceable digital activities, actions, contributions and communications manifested on the Internet or on digital devices. A digital footprint is a unique data trace of a user's activities, actions, communications or transactions in digital media. This data trace can be left on the internet, computers, mobile devices or other mediums. There are two main classification of digital footprint. They are:

- Passive Digital Footprint
- Active Digital Footprint

Passive Digital Footprint

A passive digital footprint is data collected without the owner knowing. Website visits and actions, searches and online purchases, online reviews and feedback are among the activities that add passive data traces to your digital footprint.

Active Digital Footprint

An active digital footprint are created when personal data is released deliberately by a user for the purpose of sharing information about oneself by means of websites or social media. Facebook, Twitter, blog posts, social network connections, image and video uploads all are among the ways individual's create active digital footprints for themselves.

Advantages of digital footprint:

Some of the advantages of digital footprint are:

- Fraudulent activities can be tracked down using digital footprints.
- Companies can recommend items to users based on the customers' preferences.
- Personalization services to add value to our use of the internet.
- The convenience of stored information that can be retrieved quickly.
- Recruiters can find the right candidates for job positions using digital footprints.

Disadvantages of digital footprint:

Some of the disadvantages of digital footprint are:

- It can potentially lead to identity or data thefts.
- Digital footprints often cannot be deleted and are permanent.
- Loss of privacy.
- It creates unwanted illegal action.

Exercise

A. Choose the correct one

i. ICT is the ....required for information processing .

a. science | b. method
c. technology | d. study

ii. The information age is equally dependent on the computer and the ....

a. network | b. science
c. technology | d. email

iii. Examples of electronic communication is

a. TV | b. mouse
c. Keyboard | d. Monitor

iv. The stage of working of satellite is

a. internet | b. transponder
c. Wi-Fi | d. GPS

v. Which is the most popular mode of communication in the today ?

a. Radio | b. Television
c. Internet | d. Fax

B. State whether the following statements are True or False:

a. Communication is the process of exchanging information between peoples.
b. Telecommunication is the process of sending and receiving information at the limited geographical area.
c. Radio broadcasting in an example of telecommunication.
d. An artificial satellite is used to various applications.
e. In satellite there is only one downlink.
f. Internet is slow medium of communication.
g. Virus is the useful program.
h. Firewall is used to protect computer network through unauthorized access.

C. Fill in the blanks with suitable word:

a. ....technology information is transmitted into electronic pluses of varying amplitude.
b. ....signals are signals that represented data in the binary form such as '1' or '0'.
c. An .... is a man-made body placed in orbit round the earth or another planet in order to collect information about it or for communication purposes.
d. ....services include radio and television delivered directly to the consumer and mobile broadcasting services.
e. The ....allows computer users to share computer equipment, programs, massages, and information available at one computer all over the world. Internet is a network of network.
f. .... is the practice of defending computers, servers, mobile devices, electronic systems, networks, and data from different types of threats.

D. Answer the following questions:

a. What is telecommunication?

b. How telecommunications work?

c. What is artificial satellite? Write its importance.

d. Write down the application area of artificial satellite.

e. What is internet? Write down the importance of internet.

f. What is online security?

g. Write down the methods of online security.

h. What is digital footprint? Write its types.

i. Write down the advantages and disadvantages of digital footprint.

j. What is antivirus? Explain with examples.

Lab Activities:

Go to the computer lab, do the following:

- **Open computer system, open any web browser and search more information about artificial satellite and check the information is correct or not with the help of our teacher.**
- **To make the report about finding about satellite.**

Unit 14

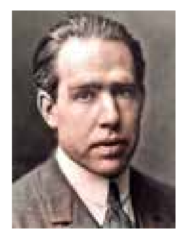
Atomic Structure and Chemical Bond

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- describe the atomic structure of Neil Bore
- give a general introduction to radioactive emissions (nuclear fusion and nuclear fusion). To mention the conditions required for these processes.
- give examples of the usefulness of nuclear energy.
- illustrate the state of chemical bond formation and reaction on the basis of octet and duplicate with examples.
- explain the general concept of valence and ions and write the molecular formula of compounds.
- write the molecular formula of simple compounds using the Criscross method and to find the molecular weight.

Niels Bohr, in full **Niels Henrik David Bohr**, (1885- 1962) Danish physicist who is generally regarded as one of the foremost physicists of the 20th century. He was the first to apply the quantum concept, which restricts the energy of a system to certain discrete values, to the problem of atomic and molecular structure. For that work he received the Nobel Prize for Physics in 1922. His manifold roles in the origins and development of quantum physics may be his most-important contribution, but through his long career his involvements were substantially broader, both inside and outside the world of physics.



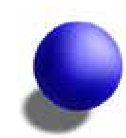
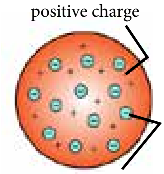
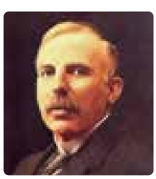
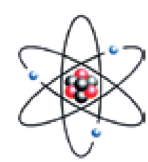
14. Introduction

We are surrounded by a variety of substances. Some of them are elements and the rest are compounds. Till now, 118 elements have been discovered, 92 natural and 26 artificial. Gold, silver, carbon, hydrogen, oxygen, helium, etc are some elements found in our surroundings. The smallest particle of an element is called **atom**. An atom is made up of electron, proton and neutron. Gold, silver, copper, steel, etc. are metals whereas carbon, hydrogen, oxygen, chlorine, etc. are non metals. Due to the number of electrons present in this atom and its situation, there is difference in their characters. During chemical reactions, whether an atom transfers electrons or shares electrons also brings difference in characters.

Activity 1

Introductory Atomic Theory

The following table gives information about early atomic theory. Study it and discuss the following questions.

Scientist	Relevant Experiments and Contributions to Atomic Theory	Atomic Model
Dalton, 1808 	**Studied ratios in which elements combine in chemical reactions:** • All elements are composed of tiny, indivisible particles called atoms. • All atoms of element X are identical. All atoms of element X are different than atoms of any other element. • Atoms can chemically combine together in whole number ratios. • Chemical reactions occur when atoms are separated, joined, or rearranged. Atoms of one element are never changed into atoms of another element.	
Thomson, 1897 	**Passed electric current through gases at low pressure using a cathode ray tube:** • Used a positively charged plate to demonstrate that atoms contain negatively charged subatomic particles called electrons. • Electrons are extremely small. One electron is about 1/2000 the mass of a hydrogen atom. • Model called the "plum-pudding" model, named after the British cuisine, with negatively charged electrons floating in a positively charged "broth."	
Rutherford, 1911 	**Directed a beam of alpha particles at a thin sheet of gold foil:** • Demonstrated that the atom is mostly empty space, with a very dense core called a nucleus. • Nucleus of atom is composed of positively charged particles called protons. • Protons are large subatomic particles. One proton is equal to one atomic mass unit. • The space between the nucleus and orbiting electrons is completely empty.	

(i) What are the similarities and differences between these three principles?
(ii) Whose principle is this:' Atoms can chemically combine together in whole number ratios ?'
(iii) Whose atomic principle is this: 'Protons are large subatomic particles'?
(iv) Collect facts about the biographies of these three scientists on the Internet and share them with your classmates.

14.1 Atomic Structure

Atomic structure refers to the structure of an atom comprising a nucleus (centre) in which the protons (positively charged) and neutrons (neutral) are present. The negatively charged particles called electrons revolve around the centre of the nucleus. The history of atomic structure and quantum mechanics dates back to the times of Democritus, the man who first proposed that matter is composed of atoms. The study about the structure of an atom gives a great insight into the entire class of chemical reactions, bonds and their physical properties. The first scientific theory of atomic structure was proposed by John Dalton in the 1800s.

The atomic structure of an element refers to the constitution of its nucleus and the arrangement of the electrons around it. Primarily, the atomic structure of matter is made up of protons, electrons and neutrons. The protons and neutrons make up the nucleus of the atom, which is surrounded by the electrons belonging to the atom. The atomic number of an element describes the total number of protons in its nucleus. Neutral atoms have equal numbers of protons and electrons. However, atoms may gain or lose electrons in order to increase their stability and the resulting charged entity is called an ion. Atoms of different elements have different atomic structures because they contain different numbers of protons and electrons. This is the reason for the unique characteristics of different elements.

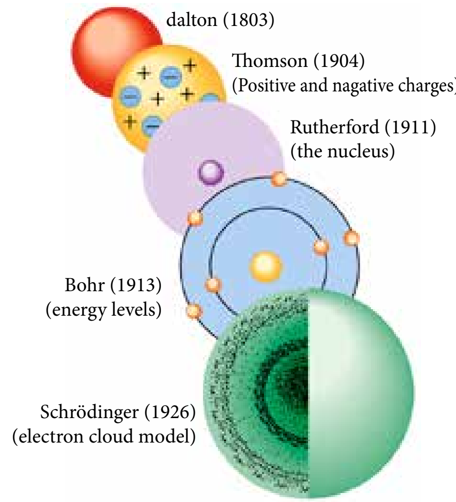


Fig. 14.1

Introduction to an Atom

Atom is the smallest unit into which matter can be divided without the release of electrically charged particles. It is the smallest unit of matter that has the characteristic properties of a chemical element. As such, the atom is the basic building block of chemistry.

Most of the atom is empty space. The rest consists of a positively charged nucleus of protons and neutrons surrounded by a cloud of negatively charged electrons. The nucleus is small and dense compared with the electrons, which are the lightest charged particles in nature. Electrons are attracted to any positive charge by their electric force; in an atom, electric forces bind the electrons to the nucleus.

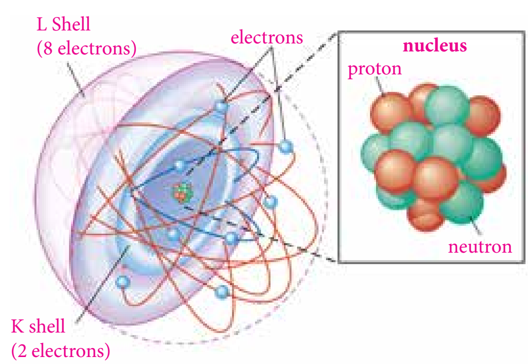


Fig. 14.2

Because of the nature of quantum mechanics, no single image has been entirely satisfactory at visualizing the atom's various characteristics, which thus forces physicists to use complementary pictures of the atom to explain different properties. In some respects, the electrons in an atom behave like particles orbiting the nucleus. In others, the electrons behave like waves frozen in position around the nucleus. Such wave patterns, called orbitals, describe the distribution of individual electrons. The behaviour of an atom is strongly influenced by these orbital properties, and its chemical properties are determined by orbital groupings known as shells.

Structure of an Atom

Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons in shells. The numbers of subatomic particles in an atom can be calculated from its atomic number and mass number. An atom has a central nucleus. This is surrounded by electrons arranged in shells.

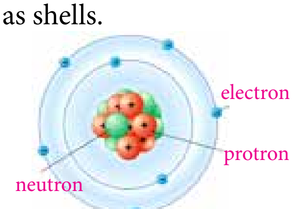


Fig. 14.3

The nucleus is tiny compared to the atom as a whole:

- the radius of an atom is about 0.1 nm (1×10^{-10} m)
- the radius of a nucleus (1×10^{-14} m) is less than 110,000 of the radius of an atom

For comparison, the radius of a typical bacterium is 1×10^{-6} m and the radius of a human hair is about 1×10^{-4} m.

Subatomic particles of an atom

The nuclei of all atoms contain subatomic particles called protons. The nuclei of most atoms also contain neutrons.

The masses of subatomic particles are very tiny. Instead of writing their actual masses in kilograms, we often use their relative masses. The relative mass of a proton is 1, and a particle with a relative mass smaller than 1 has less mass.

Subatomic particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron	Very small	-1

The mass of an electron is very small compared to a proton or a neutron. Since the nucleus contains protons and neutrons, most of the mass of an atom is concentrated in its nucleus.

Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons in shells. The numbers of subatomic particles in an atom can be calculated from its atomic number and mass number.Protons and electrons have electrical charges that are equal and opposite. Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons in shells.

Neil Bohr Atomic Model

In the Bohr model of the atom, electrons travel in defined circular orbits around the nucleus. The orbits are labeled by an integer, the quantum number n. Electrons can jump from one orbit to another by emitting or absorbing energy. The inset shows an electron jumping from orbit n=3 to orbit n=2, emitting a photon of red light with an energy of 1.89 eV.

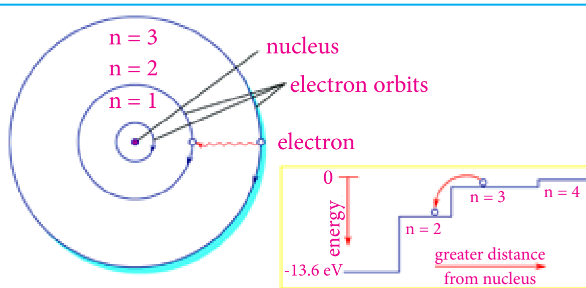


Fig. 14.4

Niels Bohr proposed the Bohr Model of the Atom in 1915. Because the Bohr Model is a modification of the earlier Rutherford Model, some people call Bohr's Model the Rutherford-Bohr Model. The modern model of the atom is based on quantum mechanics. The Bohr Model contains some errors, but it is important because it describes most of the accepted features of atomic theory without all of the high-level math of the modern version. Unlike earlier models, the Bohr Model explains the Rydberg formula for the spectral emission lines of atomic hydrogen.

The Bohr Model is a planetary model in which the negatively charged electrons orbit a small, positively charged nucleus similar to the planets orbiting the sun (except that the orbits are not planar). The gravitational force of the solar system is mathematically akin to the Coulomb (electrical) force between the positively charged nucleus and the negatively charged electrons.

Postulates:

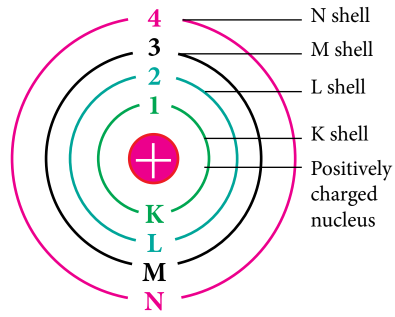


Fig. 14.5

- In an atom, electrons (negatively charged) revolve around the positively charged nucleus in a definite circular path called orbits or shells.
- Each orbit or shell has a fixed energy and these circular orbits are known as orbital shells.
- The energy levels are represented by an integer (n=1, 2, 3…) known as the quantum number. This range of quantum number starts from nucleus side with n=1 having the lowest energy level. The orbits n=1, 2, 3, 4… are assigned as K, L, M, N…. shells and when an electron attains the lowest energy level, it is said to be in the ground state.
- The electrons in an atom move from a lower energy level to a higher energy level by gaining the required energy and an electron moves from a higher energy level to lower energy level by losing energy.

Quick Question

a. How do electrons move in Bohr's model?
b. How did Bohr discover electrons?
c. Who discovered electrons?

Octet and Duplet Rule

When chemical bond is formed between atoms by transferring or sharing the electrons between them, number of electrons become eight in their outer most shell.

In this way the state of eight electrons in outermost shell of atoms is called octet.

The tendency of an atom of element to acquire eight electrons in its outer most orbit is called octet rule. Elements like neon, argon, krypton, xenon, etc. have octet state called inert gases.

The tendency of atom of element to maintain two electrons in K shell is called duplet rule. Only hydrogen, lithium, beryllium and boron have tendency to gain duplet by gaining or losing electron. Helium is duplet state and called inert gas. By becoming octet or duplet state, atoms become inert state. All the chemical reaction of atoms are for its duplet or octet state. For more information, study the following table.

Element	Electron number	Electronic configuration	Valence shell	Valence electron	Valency	Remark
He	2	$1s^2$	$1s^2$	2	0	duplet
Ne	10	$1s^2$, $2s^22p^6$	$2s^22p^6$	8	0	octet
Ar	18	$1s^2$, $2s^22p^6$, $3s^23p^6$	$3s^23p^6$	8	0	octet

Fig. 14.1

The above gases do not react with other atoms. It is because their outer most shell are in duplet or octet state. Valence shell is completely filled. They do not loss or gain or share the electrons. Therefore, they are inert gases.

Helium is an inert gas having K-shell only and has two electrons in K shell. This arrangement of two electrons in the K-shell is said to be duplet. Helium is chemically inactive as it consists of complete number of electrons in its valence K-shell. Hence, the presence of two electrons in the K-shell of an atom is called duplet. Four other elements such as hydrogen, lithium, beryllium and boron have the tendency to attain stable electronic configuration similar to that of helium-atom, which is called duplet rule.

Therefore, the tendency of an atom to attain two electrons in their K-shell is known as duplet rule.

Octel and Octel Rule

Since we know that, except helium, other inert gases like Ne, Ar, Kr, Xe and Rn have 8 electrons in their valence shell. These elements do not take part in chemical bonding called octet.

All the atoms of the elements try to lose or gain electrons from their valence shell in order to attain stable electronic configuration of the nearest inert gases except H, Li, Be and B. This is called octet rule. Therefore, the natural tendency of an atom of element to make 8 electrons in their valence shell either by gaining or losing of electrons or by sharing electrons between the combining atoms during the formation of molecule is called octet rule.

For example,

i. Potassium

$K \xrightarrow{-1e^-} K^+$

$(2, 8, 8, 1) \xrightarrow{-1e^-} (2, 8, 8)$ [Valence electron is lost]

ii. Chlorine

$Cl \xrightarrow{+1e^-} Cl^-$

$(2, 8, 7) \xrightarrow{+1e^-} (2, 8, 8)$ [One electron is gained to attain stable electronic configuration like that of Argon].

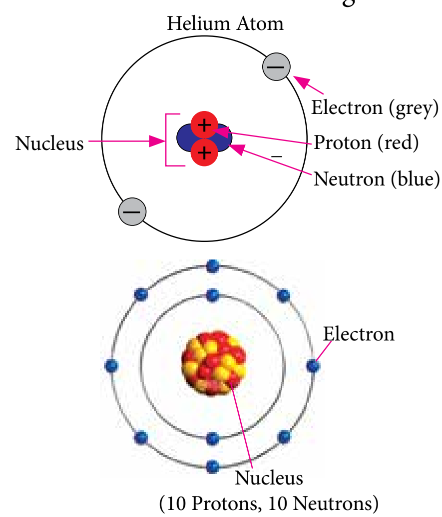


Fig. 14.6

14.1.1 Emission of Radioactivity

Atomic theory in the nineteenth century presumed that nuclei had fixed compositions. But in 1896, the French scientist Henri Becquerel found that a uranium compound placed near a photographic plate made an image on the plate, even if the compound was wrapped in black cloth. He reasoned that the uranium compound was emitting some kind of radiation that passed through the cloth to expose the photographic plate. Further investigations showed that the radiation was a combination of particles and electromagnetic rays, with its ultimate source being the atomic nucleus. These emanations were ultimately called, collectively, ***radioactivity.***

Following the somewhat serendipitous discovery of radioactivity by Becquerel, many prominent scientists began to investigate this new, intriguing phenomenon. Among them were Marie

Curie (the first woman to win a Nobel Prize, and the only person to win two Nobel Prizes in different sciences—chemistry and physics), who was the first to coin the term "radioactivity," and Ernest Rutherford (of gold foil experiment fame), who investigated and named three of the most common types of radiation. During the beginning of the twentieth century, many radioactive substances were discovered, the properties of radiation were investigated and quantified, and a solid understanding of radiation and nuclear decay was developed.

The spontaneous change of an unstable nuclide into another is ***radioactive decay***. The unstable nuclide is called the ***parent nuclide***; the nuclide that results from the decay is known as the ***daughter nuclide***. The daughter nuclide may be stable, or it may decay itself. The radiation produced during radioactive decay is such that the daughter nuclide lies closer to the band of stability than the parent nuclide, so the location of a nuclide relative to the band of stability can serve as a guide to the kind of decay it will undergo

A nucleus of uranium-238 (the parent nuclide) undergoes α decay to form thorium-234 (the daughter nuclide). The alpha particle removes two protons (green) and two neutrons (gray) from the uranium-238 nucleus.

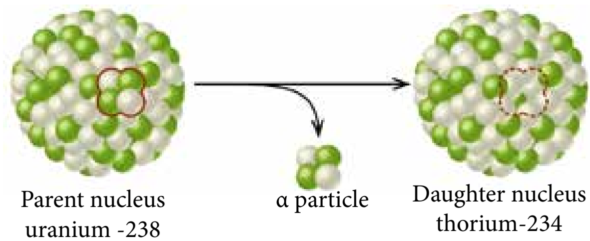


Fig. 14.7

Radioactivity is the spontaneous emission of radiation in the form of particles or high energy photons resulting from a nuclear reaction. It is also known as radioactive decay, nuclear decay, nuclear disintegration, or radioactive disintegration. While there are many forms of electromagnetic radiation, they are not always produced by radioactivity. For example, a light bulb may emit radiation in the forms of heat and light, yet it is not radioactive. A substance that contains unstable atomic nuclei is considered to be radioactive.

Major emission of Radioactivity

Alpha Particle (α)

Rutherford's experiments demonstrated that there are three main forms of radioactive emissions. The first is called an ***a****lpha particle,* which is symbolized by the Greek letter α. An alpha particle is composed of two protons and two neutrons and is the same as a helium nucleus. (We often use $_2^4He$ to represent an alpha particle.) It has a 2+ charge. When a radioactive atom emits an alpha particle, the original atom's atomic number decreases by two (because of the loss of two protons), and its mass number decreases by four (because of the loss of four nuclear particles).

Alpha particles have the least penetration power but the greatest ionization power. They cannot penetrate the skin but this does not mean that they are not dangerous. Since they have a great ionization power, so if they get into the body they can cause serious damage. They have the ability of ionizing numerous atoms from a short distance. It is due to this reason that the radioactive substance that releases alpha particles needs to be handled with rubber gloves. It should not be inhaled, eaten or allowed near open cuts.

Beta Particle (β)

The second type of radioactive emission is called a *beta particle,* which is symbolized by the Greek letter β. A beta particle is an electron ejected from the nucleus (not from the shells of electrons about the nucleus) and has a -1 charge. We can also represent a beta particle as $_{-1}^{0}e$. The net effect of beta particle emission on a nucleus is that a neutron is converted to a proton. Beta particles have a greater penetration power than the alpha particles and can easily travel through the skin. Though beta particles have less ionization power than the alpha particles but still they are dangerous and so their contact with the body must be avoided.

Gamma Particle (γ)

The third major type of radioactive emission is not a particle but rather a very energetic form of *electromagnetic radiation* called *gamma rays or particles*, symbolized by the Greek letter γ. Electromagnetic radiation can be characterized into different categories based on the wavelength and photon energies. Some electromagnetic radiation with very short wavelengths are active enough that they may knock out electrons out of atoms in a sample of matter and make it electrically charged. The types of radiation that can do this are termed *ionizing radiation.* X-rays and Gamma rays are examples of ionizing radiation. Some radioactive materials, emit gamma radiation during their decay. These particles carry huge amount of energy and can even travel through thin lead and thick concrete. Gamma particles can pass completely through the human body; as they pass through, they can cause ionizations that damage tissue and DNA.

Alpha, beta, and gamma emissions have different abilities to penetrate matter. The relatively large alpha particle is easily stopped by matter (although it may impart a significant amount of energy to the matter it contacts). Beta particles penetrate slightly into matter, perhaps a few centimeters at most. Gamma particle can penetrate deeply into matter and can impart a large amount of energy into the surrounding matter..

The Three Main Forms of Radioactive Emissions

Characteristic	Alpha Particles	Beta Particles	Gamma Rays
Symbols	α, $_{2}^{4}He$	β, $_{-1}^{0}e$	γ
Identity	Helium nucleus	electron	Electromagnetic radiation
Charge	2+	1-	0
Mass Number	4	0	0
Penetrating Power	Minimal (will not penetrate skin)	Short (will penetrate skin and some tissues slightly)	Deep (will penetrate tissues deeply)

Table 14.2

Illustration of the relative abilities of three different types of ionizing radiation **to penetrate solid matter.** Typical alpha particles (α) are stopped by a sheet of paper, while beta particles (β) are stopped by an aluminum plate. Gamma radiation (γ) is damped when it penetrates lead.

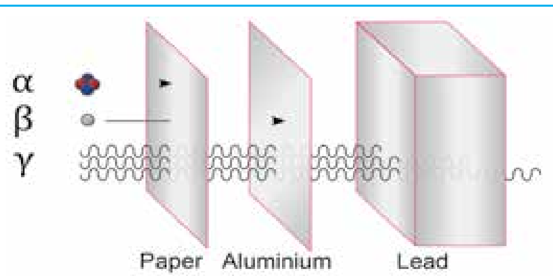


Fig. 14.8

14.1.2 Nuclear Fission and Nuclear Fusion

Fission and fusion are two processes that alter the nucleus of an atom. Nuclear fission provides the energy in modern day nuclear power plants and fusion is the source of the sun's energy. The use of fission in power plants can help conserve or one day possibly eliminate the need for fossil fuels. Without the energy produced by fusion of hydrogen in the sun, the Earth would quickly change into a cold planet that could not support life as we know it.

Transmutation can be accomplished through many types of reactions, including fission. Nuclear transmutations always obey two fundamental conservation laws:

- Mass number is conserved
- Electrical charge is conserved

Energy and mass are not conserved, but can be interconverted according to Einstein's equation:

$E = mc^2$

Where E = energy, m = mass, and c = the speed of light

Nuclear Fission

The process of fission occurs when a nucleus splits into smaller pieces. Fission can be induced by a nucleus capturing slow moving neutrons, which result in a highly unstable nucleus. The figure given below shows nuclear fission . Uranium-235 combines with a neutron to form an unstable intermediate, which quickly splits into barium-144 and krypton-89 plus three neutrons in the process of nuclear fission .

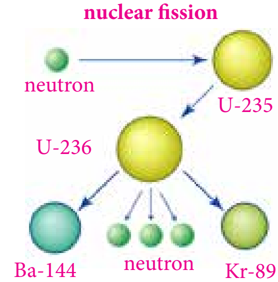


Fig. 14.9

Nuclear Fusion

Fusion occurs when 2 nuclei join together to form a larger nucleus. For a fusion reaction to occur, the atoms of hydrogen must be heated to millions of degrees and subjected to high pressure.

When done properly, the positively charged nuclei of the hydrogen isotopes, which naturally repel each other, combine. The figure given below shows nuclear fusion.Deuterium and tritium combine by nuclear fusion to form helium plus a neutron.

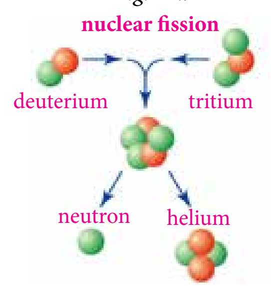


Fig. 14.10

14.1.3 Introduction to Nuclear Energy

Nuclear energy is a form of energy that released in significant amounts in processes that affect atomic nuclei, the dense cores of atoms. It is also called atomic energy. It is distinct from the energy of other atomic phenomena such as ordinary chemical reactions, which involve only the orbital electrons of atoms. One method of releasing nuclear energy is by controlled nuclear fission in devices called reactors, which now operate in many parts of the world

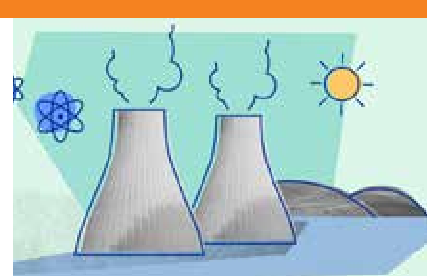


Fig. 14.11

for the production of electricity. Nuclear energy has been released explosively by both nuclear fusion and nuclear fission. Nuclear power is created by harnessing the energy from the reaction. Nuclear energy is itself created during the reaction.

Example of the usefulness of nuclear energy

Nuclear energy and its byproducts, like cobalt-60, have several uses. These include not only in the creation of power and weapons, but also for medicine, space exploration and more. Explore these examples of nuclear energy uses.

- **Electricity**

  When you think of nuclear power, you're thinking of how nuclear fission heat is used to generate electricity. This is done in a nuclear power plant, when uranium is split within a reactor. The energy created heats water to spin turbines. The spinning of the turbines produces electricity much like the turbines on windmills.

- **Space Exploration**

  Nuclear energy can be used in generators for exploring deep space. The Cassini-Huygens probe explored Saturn with the use of a Radioactive Isotope thermoelectric generator (RTG) before being destroyed in 2017..

- **Nuclear Medicine**

  Some of the byproducts that are created during nuclear fission in reactors are important for areas of medicine. For example, cobalt-60 is used by hospitals to sanitize equipment like implants, catheters and scalpels, along with complex medical devices and other technology. It is also used in medical radiotherapy for cancer treatment and in medical imaging.

- **Food Treatments**

  Nuclear energy and technology are used within food and agriculture to make processes safer and more effective. For example, nuclear-related technologies are used in sterilizing agricultural pests to reduce the use of pesticides. This makes it impossible for the bugs to reproduce, gradually eliminating them.Nuclear energy techniques are also used to test foods to ensure harmful contaminants aren't lingering on products. These techniques can also improve yields from livestock.

14.2 Valence Shell and Valence Electron

The electrons present in the outermost shell of an atom are known as valence electrons (or valency electrons) because they decide the valency (combining capacity) of the atom.

For Example: - The atomic number of sodium is 11, which means sodium atom has 11 electrons in it.

So the electronic configuration K (2), L (8), M (1). In the sodium atom, M shell is the outermost shell or valence shell. .

There is 1 electron in the outermost shell of sodium atom; therefore, sodium atom has 1 valence electron.

Those electrons of an atom which take part in chemical reactions are called valence electrons.

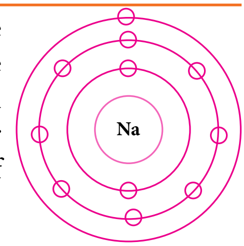
Valence electrons are located in the outermost shell of an atom.

In order to find out the number of valence electrons in an atom of the element, we should write down the electronic configuration of the element by using its atomic number. The outermost shell will be the valence shell and the number of electrons present in it will give us the number of valence electrons.

Valency of a metal = No. of valence electrons in the atom

Valency of a non-metal = (8 – No. of valence electrons in its atom)

Valency



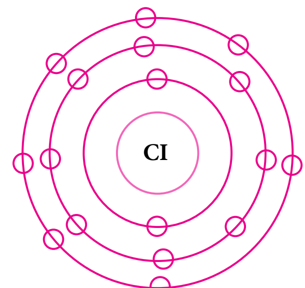
Valency = 1

Fig. 14.12

Valency is the ability of an atom to gain or lose electron in order to achieve the noble gas configuration. It refers to the ability of an element to combine with other element. It is obtained by determining the number of electrons in the outermost shell (also called valence shell) of each atom of an element. For instance, sodium has 1 electron in its outermost shell and hence valency of sodium is 1.

Atomic number of sodium is 11. So the electronic configuration stands out to be 2,8,1 i.e. there is one electron in the outermost shell. In order to gain inert gas configuration it is better for sodium to lose one electron and achieve the nearest noble gas configuration of neon with atomic number 10.

On the other hand, atomic number of chlorine is 17. So electronic configuration stands out to be 2,8,7. In order to achieve noble gas configuration to become stable it requires one electron then it will acquire the configuration of neon (noble gas). Therefore valency of chlorine is1.



Valency = 1

Fig. 14.13

That means the every element tries to attain stability by acquiring noble gas configuration for which it tries to either gain electron or donate electron. Na donates 1 electron in its outermost shell to attain noble gas configuration whereas chlorine acquires 1 electron in its outermost shell to acquire noble gas configuration.

Metals are electropositive because they have tendency to lose electrons. E.g. Na^+ whereas non-metals are electronegative since they have a tendency to gain electrons. E.g. Cl^-

We can find the valency of an element through its atomic number and its electronic configuration. For instance,

- In Boron with atomic number 5, the configuration stands out to be 2,3 and it has 3 electrons in its outermost shell. Being a metal Boron has a tendency to lose its electrons to gain noble gas configuration and shows its valency 3.
- Whereas in Fluorine with atomic number 9, the configuration stands out to be 2,7 and it has 7 electrons in its valence shell and needs to gain 1 more electron to achieve noble gas configuration and hence its valency is 1.

Fundamental particles in Atom

Name of Elements	Symbol	Atomic Number	Number of Electrons	Number of Protons	No. of Neutrons	Atomic Mass	Electronic Configuration				Valency
							K	L	M	N	
Hydrogen	H	1	1	1	-	1	1	-	-	-	1+,-
Helium	He	2	2	2	2	4	2	-	-	-	0
Lithium	Li	3	3	3	4	7	2	1	-	-	1+
Beryllium	Be	4	4	4	5	9	2	2	-	-	2+
Boron	B	5	5	5	6	11	2	3	-	-	3+
Carbon	C	6	6	6	6	12	2	4	-	-	4+
Nitrogen	N	7	7	7	7	14	2	5	-	-	3-
Oxygen	O	8	8	8	8	16	2	6	-	-	2-
Heroine	F	9	9	9	10	19	2	7	-	-	1-
Neon	Ne	10	10	10	10	20	2	8	-	-	0
Sodium	Na	11	11	11	12	23	2	8	1	-	1+

Magnesium	Mg	12	12	12	12	24	2	8	2	-	2+
Aluminum	Al	13	13	13	14	27	2	8	3	-	3+
Silicon	Si	14	14	14	14	28	2	8	4	-	4
Phosphorus	P	15	15	15	16	31	2	8	5	-	3-
Sulphur	S	16	16	16	16	32	2	8	6	-	2-
Chlorine	Cl	17	17	17	18	35.5	2	8	7	-	1-
Argon	Ar	18	18	18	22	40	2	8	8	-	0
Potassium	K	19	19	19	20	39	2	8	8	1	1+
Calcium	Ca	20	20	20	20	40	2	8	8	2	2+

Table 14.3

Some elements with more than one valency

Name and symbols of elements	Valency
Iron (Fe)	2,3
Copper (Cu)	1,2
Silver(Ag)	1,2
Gold (Au)	1,3
Mercury	1,2

Table 14.4

14.3 Ions

An ion can be defined as a chemical species which holds a positive or negative charge of some magnitude. The term 'ion' can be used to refer to atoms or molecules that have non-zero net charges associated with them. Therefore, all ions have either a greater number of protons than electrons in their overall atomic or molecular structure, or they have a greater number of electrons than protons in their atomic/molecular structures. The ions that contain a greater number of protons than electrons are known to hold a net positive charge. These ions are commonly referred to as cations. On the other hand, the ions that contain a greater number of electrons than protons are known to hold a net negative charge. These ions are commonly known as anions.

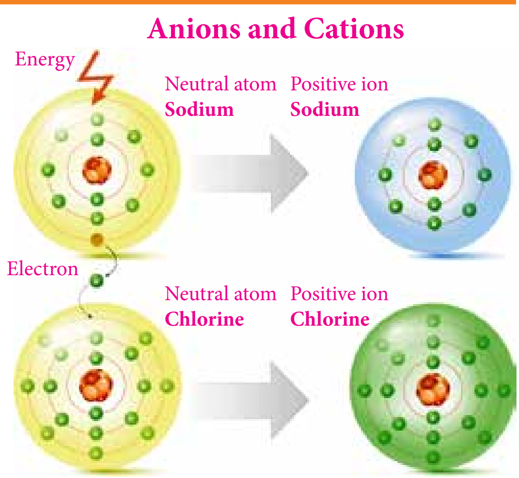


Fig. 14.14

It is important to note that the electrostatic forces of attraction that can arise between positively charged cations and negatively charged anions are the driving force behind the formation of ionic bonds. When two oppositely charged ions form an ionic bond with each other, the resulting type of compound is commonly referred to as an ionic compound.

If an ion is made up of only one type of atom (each holding some net charge, positive or negative), it can be referred to as an atomic ion or a monoatomic ion. On the other hand, if an ion is made up of two or more atoms, it can be referred to as a polyatomic ion or a molecular ion.

How are Ions Created?

Several methods exist for the preparation of ions. For example, spontaneous collisions between the molecules of a liquid or gaseous fluid can result in one of the electrons being knocked off an atom/molecule. This results in the formation of a positively charged ion and a free electron. This type of ionization is commonly referred to as physical ionization. The free-electron may even go on to attach itself to another atom or molecule, resulting in the formation of a new negatively charged anion.

Another important process through which ions can be created is through chemical interactions. For example, when an ionic compound such as salt is dissolved in a suitable solvent (such as water), the atoms that constitute the salt undergo dissociation and form free ions. When common salt, also known as sodium chloride, is dissolved in water, it undergoes dissociation to yield sodium cations and chloride anions. It can be noted that the sodium cations are denoted by the symbol Na^+ and the chloride anions are denoted by the symbol Cl^-.

Other notable processes through which ions can be formed include the passage of direct currents through certain conducting solutions, which results in the formation of ions in the solution. It can also be noted that the dissolving of anodes via the process of ionization also yields large amounts of free ions.

Representing the Charge on an Ion

In order to represent an ion and the charge held by it, the chemical formula of the ion must be written first. Then, the symbol of the type of charge held by the ion ('+' for positive charges and '-' for negative charges) must be written in superscript, followed by the magnitude of the charge held by the ion (also in superscript). It is important to note that the sign is written after the magnitude of the charge for anions that hold charges whose magnitudes are greater than -1. It can also be noted that the magnitude of the charge is omitted if its value is equal to one. Therefore, the sodium cation, whose charge is +1, can be represented simply as Na+.

Solved Examples on Ion Notation

The Carbonate Anion

The chemical formula of the carbonate anion is CO_3. The magnitude of the negative charge held by it is 2. Therefore, the effective charge held by the ion is -2. The carbonate ion can, therefore, be represented by the symbol CO_3^{2-}

The Lithium Cation

The symbol of the lithium atom is Li. Since the lithium cation holds a net charge of +1, the monoatomic ion can be represented as Li^+.

The Oxide Anion

The symbol of oxygen is O. The charge held by the oxide anion is equal to -2. Therefore, the oxide anion can be denoted by the symbol O^{2-}.

The Zinc Cation

The symbol of zinc is Zn. The positive charge held by the zinc cation has a magnitude of 2. Therefore, the zinc cation can be denoted by the symbol Zn^{2+}.

Examples of Ions

Examples of Simple Cations (Monoatomic Cations)

Five common examples of monoatomic cations are provided below.

- The aluminium cation, denoted by the chemical formula Al^{3+}.

- The calcium cation, denoted by the chemical formula Ca^{2+}.
- The Iron(II) cation, denoted by the chemical formula Fe^{2+}. It can also be noted that iron also has the ability to form the Fe^{3+} cation.
- The manganese(II) cation, denoted by the chemical formula Mn^{2+}. It is important to note that manganese also has the ability to form the Mn^{3+} and Mn^{4+} cations.
- The hydrogen cation, commonly known as a proton, denoted by the chemical formula H^+.

Examples of Polyatomic Cations (Molecular cations)

Three common examples of polyatomic cations are provided below.

- The hydronium cation, denoted by the chemical formula H_3O^+.
- The ammonium cation, denoted by the chemical formula NH_4^+.
- The mercurous cation, denoted by the chemical formula Hg_2^{2+}.

Examples of Simple Anions (Monoatomic Anions)

Five common examples of monoatomic anions are provided below.

- The fluoride anion, denoted by the chemical formula F^-.
- The chloride anion, denoted by the chemical formula Cl^-.
- The bromide anion, denoted by the chemical formula Br^-.
- The iodide anion, denoted by the chemical formula I^-.
- The sulfide anion, denoted by the chemical formula S^{2-}.

Examples of Polyatomic Anions (Molecular Anions)

Five common examples of polyatomic anions are provided below.

- The nitrate anion, denoted by the chemical formula NO_3^-.
- The nitrite anion, denoted by the chemical formula NO_2^-.
- The hydroxide anion, denoted by the chemical formula OH^-.
- The carbonate anion, denoted by the chemical formula CO_3^{2-}.
- The sulfate anion, denoted by the chemical formula SO_4^{2-}.

Examples of Anions Formed by Organic Compounds

Some anions are formed via the deprotonation of certain organic acids. Other anions are known to be derived from certain organic compounds. Common examples of anions that are derived from organic compounds are listed below.

- The formate anion, denoted by the chemical formula $HCOO^-$.
- The acetate anion, denoted by the chemical formula CH_3COO^-.
- The cyanide anion, denoted by the chemical formula CN^-.

Some positive charged ions or radicals and their valency

Radicals with valency 1		Radicals with valency 2		Radicals with valency 3	
Radicals	**Symbol**	**Radicals**	**Symbol**	**Radicals**	**Symbol**
Hydrogen	H^+	Beryllium	Be^{++}	Boron	B^{+++}
Lithium	Li^+	Magnesium	Mg^{++}	Aluminium	Al^{+++}
Sodium	Na^+	Calcium	Ca^{++}	Ferric	Fe^{+++}
Potassium	K^+	Manganese	Mn^{++}	Auric	Au^{+++}
Ammonium	NH_4^+	Cupric	Cu^{++}		

Cuprous	Cu^{+}	Mercuric	Hg^{++}
Silver	Ag^{+}	Ferrous	Fe^{++}
Mercurous	Hg^{+}		
Aurus	Au^{+}		

Table 14.5

Some Negative charged ions or radicals and their valency

Radicals with valency 1		Radicals with valency 2		Radicals with valency 3	
Radicals	**Symbol**	**Radicals**	**Symbol**	**Radicals**	**Symbol**
Fluoride	F^{-}	Oxide	O^{--}	Nitride	N^{---}
Chloride	Cl^{-}	Sulphide	S^{--}	Phosphate	PO_4^{---}
Bromide	Br^{-}	Sulphate	SO_4^{--}		
Iodide	I^{-}	Carbonate	CO_3^{--}		
Nitrate	NO_3^{-}				
Hydroxide	OH-				
Bicarbonate	HCO_3^{-}				
Bisulphite	HSO_4^{-}				
Chlorate	ClO_3^{-}				
Nitrite	NO_2^{-}				

Table 14.6

14.4 Chemical Bond

All the atoms of element except inert gases try to become stable by gaining, losing or sharing electrons. This is the main cause of chemical reaction. During sharing, losing or gaining the electrons between atoms, it develops an attractive force that binds the atoms to form molecule of compound. Thus, "the force of attraction between two or more than two atoms in compound is called chemical bond". A chemical bond can be formed by gaining, losing or mutual sharing of electrons.

Chemical bonding

The force which is responsible to hold the atoms in a molecule is called chemical bond.

Therefore, the force of attraction due to which atoms or groups of atoms are combined together forming a molecule or a compound is called a chemical bond.

For example, methane is a compound by a chemical bond one atom of carbon and four atoms of hydrogen.
There are three types of bonds.

i. Electrovalent or Ionic bond.
ii. Covalent bond
iii. Co-ordinate bond

Here we discuss about only electrovalent and covalent bond. Coordinate bond will be discussed in higher classes.

1. Electrovalent bond or ionic bond

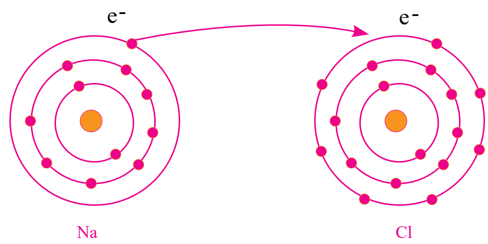


Fig. 14.15

The elements take part in chemical reaction and form chemical bond except noble gas. Some elements loss or gain valence electron. In this way, the bond formed by gaining or losing the electrons between atoms is called electrovalent bond. Thus, the bond formed by the complete transfer of electrons from one atom to another during a chemical reaction is called electrovalent bond.

It is also known as ionic bond because ions are formed in this chemical reaction. The compound having ionic bond are called ionic compound.

Electrovalent bonding in Nacl

Let's study the formation of common salt or sodium chloride.

Sodium (Na)	Chlorine (Cl)
11 protons = +11 charge	17 protons = +17 charge
11 electrons = -11 charge	17 electrons = -17 charge
Net charge = 0	Net charge = 0

Table 14.7

Among 11 electrons of sodium atom, one electron lies at outermost shell of the atom. Therefore, sodium element is very active. In chemical reaction, sodium atom gives its electron from its outermost shell to another atom of element and becomes sodium ion (Na^+) which has 8 electrons in its outermost shell. Then the electronic configuration of sodium ion (Na^+) is like electronic configuration of neon. Number of electrons is less than number of protons by 1 electron in sodium ion. So, it becomes positive charge.

In chlorine atom, 7 electrons lie in its outermost shell. If chlorine atom gains 1 electron, its outer most shell will be octet state like argon. After gaining one electron, chlorine atom becomes chlorine ion (Cl^-). Now chlorine produces one positive (+1) charges.

When, sodium and chlorine atoms are brought close to each others, sodium atom gives one electron to chloride atom. So, sodium ions (Na^+) and chlorine ion (Cl^-) are formed. These opposite charged ions attract to each other due to attraction force between them. In this way, electrovalent bond is formed in sodium chloride molecule.

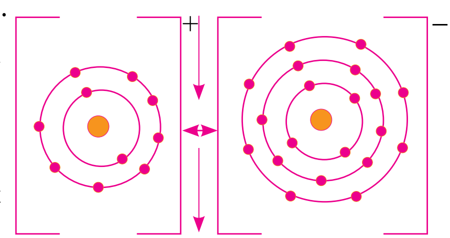


Fig. 14.16

Na^+ (sodium ion)	attractive force	Cl^- (chlorine ion)
11 protons = +11 charge 10 electrons = - 10 charge	attractive force bet^n the ions	17 protons = +17 charge 18 electrons = -18 charge
Net charge = +1 charge	called ionic bond	Net = - 1 charge

Generally, when metal and non-metal react, electrovalent bond is formed. Ionic compounds are in crystalline, solid state. They have high melting point but they are brittle. They are easily soluble in water. In molten state or in solution state, they conduct electricity.

Characteristics of Ionic compound

i. They have high boiling and melting points.
ii. They are usually found in solid state.
iii. In molten or aqueous solution they conduct electricity.
iv. They are soluble in water but insoluble in organic solvents.

2. Covalent bond

How are compounds formed when atoms can't lose or gain electrons? Think about it. The atoms which can't lose or gain electrons, they share electrons between two or more than two atoms in their valence shell and attain octet or duplet state. In this way, covalent bond is formed by sharing the electrons. Thus, the bond which is formed by the mutual sharing of electrons between the combining atoms during chemical reaction is called covalent bond.

The compounds which have covalent bond are called covalent compound. For example, water molecule.

Covalent bonding in H_2O

Let's discuss how can covalent bond be formed in water molecule.

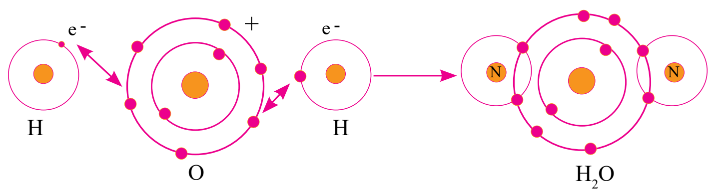


Fig. 14.17

The electronic configuration of Hydrogen and oxygen atom needs 2 electrons to be octet state in its valence shell. In this condition two hydrogen atom and an oxygen atom share their valence electrons between them. They share two pairs of electrons and form a molecule of water (H_2O). In this combination two hydrogen atoms contribute one electron each for sharing two electrons from oxygen.

Charecteristics of Covalent Bond

Covalent compounds are found in solid, liquid and gas state. The solid compounds are soft and brittle. They have low melting point. Generally, they are insoluble in water and can not conduct electricity.

Water, ammonia, carbon dioxide, hydrochloric acid etc. are covalent compounds.

Electrovalent bonding in MgO

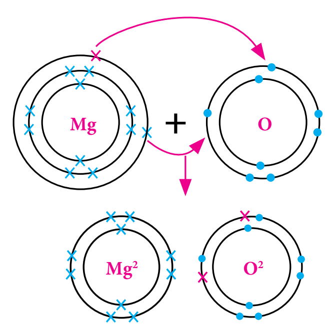


Fig. 14.18

In the magnesium oxide (MgO) molecule, the type of bond that is formed between Mg and O atoms is an ionic bond via the transfer of electrons. Mg atoms have 12 electrons. Its electronic configuration is 2, 8, 2. Hence, Mg has 2 electrons in its valence shell which it wants to donate to achieve the noble gas configuration of Neon. O Atom has 8 electrons. Its electronic configuration is 2, 6. Hence, Oxygen has 6 electrons in its valence shell and it wants 2 more electrons to complete its octet to achieve the noble gas configuration of Neon. Now,

Mg will transfer its 2 valence electrons to O and will form Mg2+ cation and O after getting 2 electrons will form O2− anion and both atoms will complete their octet by forming an ionic bond between them.
$Mg \rightarrow M2+ + 2e^-$ $O + 2e^- \rightarrow O2-$

Mg is a metal and O is a non-metal. The bond between a metal and non-metal is always formed by the transfer of electrons. The nature of the bond is electrovalent or ionic. While forming the bond one must always take care of the electronic configuration of atoms in the excited state as sometimes incorrect configuration leads to the formation of the wrong molecule.

Electrovalent bonding in $CaCl_2$

In the formation of calcium chloride ($CaCl_2$), two electrons from calcium atom (2,8,8,2) are transferred to two chlorine atoms. Calcium atom becomes divalent positive ion, Ca^{2+} and chlorine atoms become monovalent negative ions, Cl-.

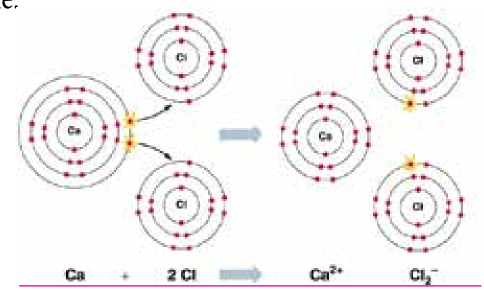


Fig. 14.19

Covalent bonding in HCl

A chlorine atom has 17 electrons, and an electron configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$. A hydrogen atom has only 1 electron, and an electron configuration of $1s^1$.

Chlorine has 7 valence electrons. One of these electrons is unpaired. Hydrogen has 1 valence electron and it is unpaired. The hydrogen atom needs one more electron to complete its valence shell. The chlorine atom also needs one more electron to complete its shell. Therefore one pair of electrons must be shared between the two atoms.

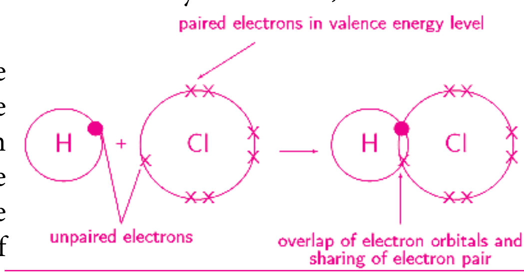


Fig. 14.20

In other words, one electron from the chlorine atom will spend some of its time orbiting the hydrogen atom so that hydrogen's valence shell is full. The hydrogen electron will spend some of its time orbiting the chlorine atom so that chlorine's valence shell is also full. A molecule of hydrogen chloride is formed . Notice the shared electron pair in the overlapping orbitals.

Covalent bonding in CH_4

Methane (CH_4) is a covalent compound containing covalent bonds. Carbon atom has atomic number 6. Its electronic configuration is 2,4. It has four electrons in its valence shell and needs 4 more electrons to get the stable noble gas configuration. Hydrogen atom has one electron and needs one more electron to get stable electronic configuration of nearest noble gas, helium. Therefore, one atom of carbon shares its four electrons with four atoms of hydrogen to form four covalent bonds.

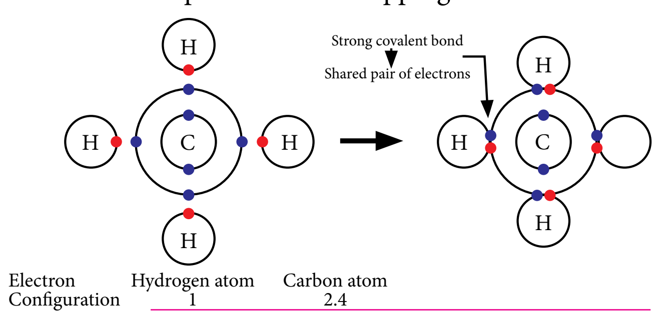


Fig. 14.21

Covalent bond formed in NH_3

In ammonia (NH_3) molecule, three covalent bonds are present. Hydrogen atom has 1 valence electron.Nitrogen atom has 5 valence electrons. Thus it need 3 more electrons in order to achieve stability. So, now these atoms will share their electrons. Each hydrogen atom will share it's electron with nitrogen atom. Thus the octet of nitrogen is complete now. And the hydrogen atom also has become stable by sharing it's three electrons with three(out of 5) electrons of nitrogen. Thus 3 covalent bonds have been formed between these atoms forming stable molecule of NH3.

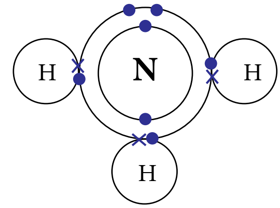


Fig. 14.22

14.5 Molecular Formula

Combining two or more than two atoms forms molecules. Some molecule are formed by combining atoms of same element. For example : Hydrogen molecule (H_2) is formed by combining two atoms of hydrogen element. Water molecule (H_2O) is formed by combining two hydrogen atoms and one oxygen atom.

A symbol is used to represent a molecule.

The symbolic representation of a molecule of a compound or an element which shows the actual number of atoms in a molecule is called molecular formula.

For example, the molecular formula of ammonia is NH_3. Here, NH_3 represents a molecule of ammonia which consists of four atoms. Among four atoms, one is nitrogen and three are hydrogen atoms.

While writing molecule formula, symbol of element and radical should be known well.

Method of writing molecular formula of compounds

Molecular formula of any compound can be written by valency criss cross method. Let's discuss about this method.

i. At first write the name of molecule.
   For example : water molecule.

ii. Confirm the name of elements or radicals and then write their symbols side by side. Write metal first and then after non-metal.
   H O

iii. Write the valency of each element or radical at the top of symbol.
   1 2 ← valency
   H O

iv. Interchange the valency of the elements or radicals.
   1 2
   H O = H_2O_1 = H_2O

Some more examples

Sodium carbonate

1 2

Na_2 $(CO_3)_1$

$Na_2\,(CO_3)_1$

$Na_2(CO_3)_1$

Calcium sulphate

2 2

Ca_2 $(SO_4)_2$

$Ca_2\,(SO_4)_2$

$CaSo_4$

[If exchanged valencies are same, remove it, Here 2 is common]

Sodium carbonate	Calcium sulphate	
1 2 Na_2 $(CO_3)_1$ $Na_2\ (CO_3)_1$ $Na_2(CO_3)_1$	2 2 Ca_2 $(SO_4)_2$ $Ca_2\ (SO_4)_2$ $CaSo_4$	[If exchanged valencies are same, remove it, Here 2 is common]

Some compounds and their molecular formula

S. N.	Compounds name	Molecular formula
1.	Ammonia	NH_3
2.	Hydrochloric acid	HCl
3.	Potassium carbonate	K_2CO_3
4.	Ammonium sulphate	$(NH_4)_2SO_4$
5.	Ferric oxide	Fe_2O_3
6.	Sliver nitrate	$AgNO_3$
7.	Calcium carbonate	$CaCO_3$
8.	Magnesium chloride	$MgCl_2$
9.	Calcium hydroxide	$Ca(OH)_2$
10.	Sulphuric acid	H_2SO_4

Table 14.8

Following information are gained from molecular formula

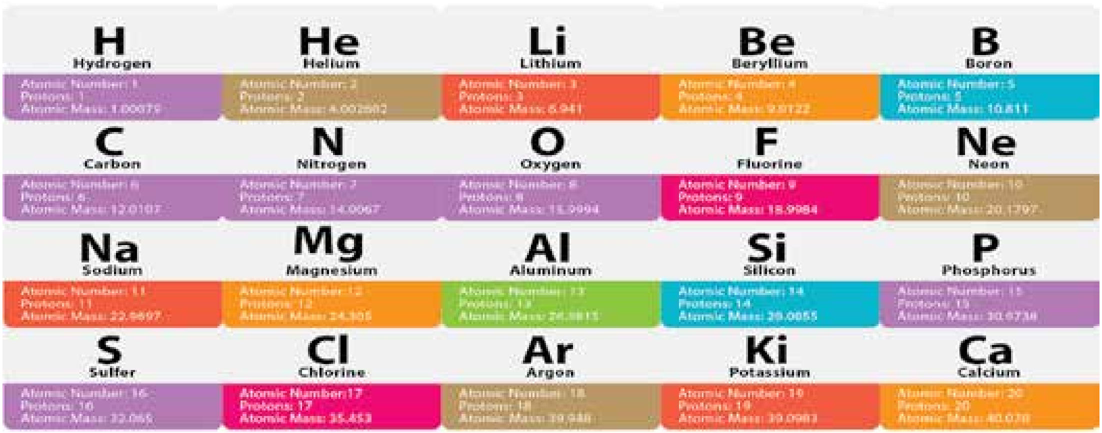
1. The name and symbol of atoms or radicals in a molecule can be known.
2. The number of atoms present in a molecule can be known.
3. Valency of elements or radicals can be known.
4. Molecular weight of a molecule of compound can be determined.

Step		Step	
I II III	K^{1+} Cl^{1-} $\overset{1+}{K}$ $\overset{1-}{Cl}$ K_1 Cl_1 **Formula = KCL [ignore 1]**	I II III	K^{1+} OH^{1-} $\overset{1+}{K}$ $\overset{1-}{OH}$ K_1 OH_1 **Formula = KOH [ignore 1]**
I II III	Ca^{2+} Cl^{1-} $\overset{2+}{Ca}$ $\overset{1-}{Cl}$ Ca_1 Cl_2 **Formula = KCL [ignore 1]**	I II III	Ca^{2+} OH^{1-} $\overset{2+}{Ca}$ $\overset{1-}{OH}$ Ca_1 OH_2 **Formula = KOH [ignore 1]**

I	Al^{3+} Cl^{1-}	I	Al^{3+} OH^{1-}
II	$\overset{3+}{\underset{1}{Al}}$ $\overset{1-}{\underset{3}{Cl}}$	II	$\overset{3+}{\underset{1}{Al}}$ $\overset{1-}{\underset{3}{OH}}$
III	Al_1 Cl_3	III	Al_1 OH_3
	Formula = KCL [ignore 1]		**Formula = KOH [ignore 1]**

Fig. 14.8

14.7 Atomic Weight and Molecular weight



Atomic number (Z)

The number of protons or the number of electrons in a electrically neutral atom of an element is called atomic number. It is denoted by Z. Atomic number always determines the chemical characteristics of the elements. Each element has its own atomic number.

Mathematically,

Atomic number = No. of protons = No. of electrons

i.e. $Z = P^+ = e^-$

Atomic weight (A)

The sum of protons and the neutrons in nucleus of an atom is called its atomic weight. It is also called atomic mass. It is represented by A.

Mathematically,

Atomic weight (A) = No. of protons + No. of neutrons (i.e. $A = p^+ + n^\circ$).

[Since weight of electron is small, it is neglected while calculating the atomic weight.]

The First 20 Elements of the Periodic Table

Atomic weight of some atoms

(i) Atomic weight of carbon

Number of Proton = 6

Number of Neutron = 6

Atomic weight = $p^+ + n^0$

$6+6=12u$

(ii) Atomic weight of Oxygen

Number of Proton=8

Number of Neutron =8

Atomic weight = $p^{+}+n^{0}$

8+8=16 u (amu or Da)

> **1 u = 1 Da = 1 amu (in modern usage) = 1 g/mol**
>
> **Also Known As:** unified atomic mass unit (u), Dalton (Da), universal mass unit, either amu or AMU is an acceptable acronym for atomic mass unit.

Molecular weight

A molecular weight is the sum of the atomic weight of the atoms in a molecule. It is also called molecular mass. It is calculated in practice by summing the atomic weights of the atoms making up the substance's molecular formula. The molecular weight of a hydrogen molecule (chemical formula H_2) is 2 (after rounding off); for many complex organic molecules (e.g., proteins, polymers) it may be in the millions.

Calculating Molecular Weight (method 1)

Count how many atoms of each element exist in the molecule. First, list each element present in the molecule. You may use the chemical symbol or write out the name of the element. Then, count the atoms according to the molecular formula and write them next to the element's name or symbol. For example, carbon dioxide or CO_2, list that there is 1 carbon (C) and 2 oxygens (O) present in the molecule.

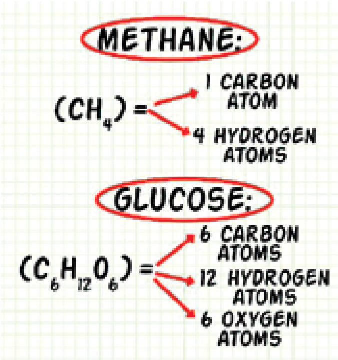


Fig. 14.23

For methane, CH_4, list carbon (C) and hydrogen (H). Methane comprises 1 atom of carbon and 4 atoms of hydrogen.

For glucose, $C_6H_{12}O_6$, list carbon (C), hydrogen (H), and oxygen (O). Glucose comprises 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen.

Find the relative atomic mass of each element in the molecule. Use a copy of the Periodic Table of Elements. The Periodic Table lists the atomic mass of each element below the chemical symbol. For example, oxygen has a relative atomic mass of 15.9994 amu.

- For carbon dioxide (CO_2), the relative atomic mass is 12.011 amu for carbon and 15.999 for oxygen.
- The atomic mass of an element is roughly equal to the summed mass of the protons and neutrons that it contains. Note that the relative atomic mass you find in the periodic table is scaled: it accounts for all of the isotopes of the element in the proportions that they naturally occur.

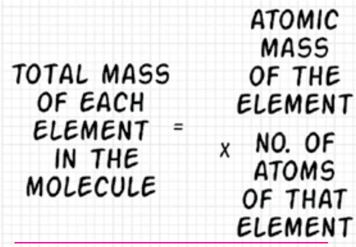


Fig. 14.24

Calculate the total mass for each element in the molecule. Multiply the atomic mass of each element by the number of atoms of that element: (Atomic Mass of Element) x (# of atoms of that element). Do this for each element in the molecule.

- In our carbon dioxide example, the mass of the single oxygen atom is 15.999 amu. Since there are 2 oxygen atoms, you would write 15.999x2 =31.998u.

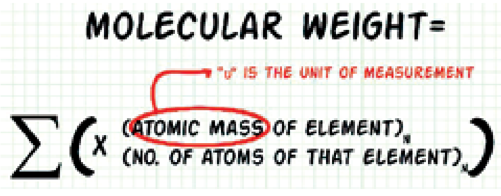


Fig. 14.25

Add up the mass of all the atoms to find the molecular weight.

Molecular weight = Σ((Atomic Mass of Element)n x (# of atoms of that element)n.

- Round the answer as necessary, using significant digits.
- Remember to use the proper units. amu is the old abbreviation for atomic mass units, but the "most correct" modern unit is a lower-case u.
- For carbon dioxide, the molecular weight can be found like so: 12.011+31.998=44.009u

The molecular mass/weight is the mass of a given molecule: it is measured in daltons (Da or u).

Molecular weight of some molecules

(i) Molecular weight of methane (CH4). The atomic mass of hydrogen is 1.008 u. The atomic mass of carbon is 12.011 u. There are 4 hydrogen atoms in methane. Add together the weight of all the atoms in methane to find the molecular weight.

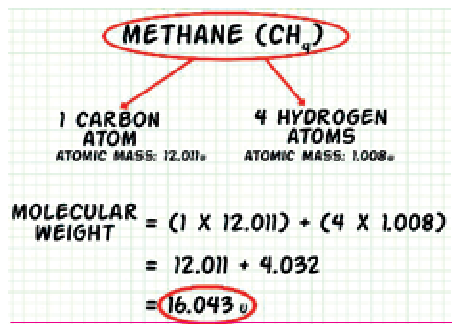


Fig. 14.26

Carbon

Atom =1

Atomic mass =12.011u

Total atomic mass=1x12.011=12.011u

Hydrogen

Atom =4

Atomic mass =1.008u

Total atomic mass=4x1.008= 4.032u

Molecular weight of CH_4=12.011+4.032 =16.032u

II) molecular weight of glucose ($C_6H_{12}O_6$). The atomic mass of carbon is 12.011 u. The atomic mass of hydrogen is 1.008 u. The atomic mass of oxygen is 15.999.There are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms. Add up the mass of all of the atoms in glucose to calculate the molecular weight.

12.011x6=72.066u

1.008x12=12.096u

15.999x6=95.994u

72.066+12.096+95.994=180.156u

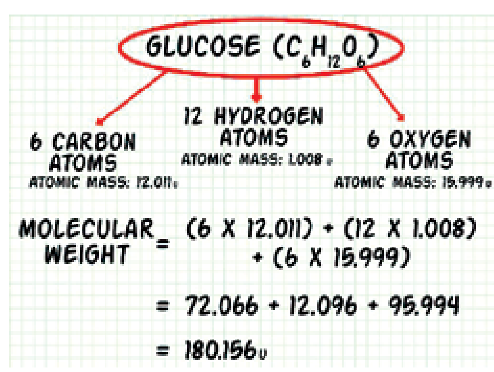


Fig. 14.27

Distribution of electrons in carbon and sodium

Name of the element	Symbol	Atomic Number	Number of Protons	Number of Neutrons	Number of Electron	Distribution				Valency
						K	L	M	N	
Carbon	C	6	6	6	6	2	4	-	-	4
Sodium	Na	11	11	12	11	2	8	1	-	-1

Project Work

i. Prepare a bore atomic model of elements up to atomic number 20 by using locally available materials and present it in the classroom.

ii. Prepare a model of an electrovalent compound (Sodium chloride) by using cardboard or solid materials.

iii. Prepare a model of a covalent compound (water) by using cardboard or solid materials.

Exercise

A. Choose the correct one and put the tick mark(√)

i. What is an electron?

a. A wave   b. A particle

c. Either of two, depending on how it is observed

d. Neither of these

ii. The cathode ray experiment was done for the first time by:

a. J.J. Thomson   b. John Dalton

c. Goldstein   d. Rutherford

iii. The nucleus of an atom contains:

a. Protons   b. Electrons

c. Protons and neutrons   d. Neutrons

iv. By whom was neutron discovered?

a. Bohr   b. Chadwick

c. Rutherford   d. Dalton

v. In an atom valence electron are present in:

a. Outermost orbit   b. Next to outermost orbit

c. First orbit   d. Any one of its orbit

vi. The maximum number of electrons that can be accommodated in third shell (n = 3) is:

a. 2   b. 8

c. 18   d. 10

vii. In an atom, the constituent electrons:

a. Do not move

b. Are uniformly distributed

c. Move around the nucleus in fixed energy levels.

d. Move around the nucleus in a random way.

viii. What is the number of valence electrons of AI?

a. 1 b. 2

c. 3 d. 4

iX. Which of the following statements is not correct for Bohr's model of an atom?

a. The nucleus of an atom is situated at ts centre

b. The electrons move in circular orbits

c. Electrons jumps from one orbit to another

d. An electron neither loses nor gains energy it jumps from one orbit to another.

X. The number of electrons in an element with atomic number X and atomic mass Y will be:

a. (X - Y) b. (Y - X)

c. (X + Y) d. X

Xi.Which of the following has a charge of +1 and a mass of 1 amu?

a. A neutron b. A proton

c. An electron d. A helium nucleus

xii. Which of the following electronic configurations is wrong?

a. Be (3) = 2, 1 b. S (16) = 2, 6, 8

c. P (15) = 2, 8, 5

Xiii.When a beta-particle is emitted from a nucleus, the neutron-proton ratio

a. is decreased b. is increased

c. remains the same d. may increase or decrease

Xiv. A gamma – ray photon is emitted

a. after ionization of an atom

b. due to conversion of a neutron into a proton in the nucleus

c. after de-excitation of a nucleus

d. due to conversion of a proton into a neutron in the nucleus

B. Differentiate with examples

i. Atom and Molecule ii. Valence shell and Valence electron

iii. Octet and Duplet iv. Electrovalent bond and covalent bond

v. Alpha particle and Beta particle

C. Give the reason :

i. The valency of chlorine is one .

ii. An atom is electrically neutral.

iii. Nuclear energy is both beneficial and harmful.

iv. Methane is a covalent compound.

v. NaCl is an ionic compound.

vi. Helium, Neon and Argon have a zero valency .

D. Correct the following molecular formula if wong:

i. Ca_2Cl_2 ii. $NaCl_2$

iv. NH_4Cl v. Cu_2SO_4

v. $K(NO_3)_2$ vi. $CaCO_3$

vii. $NaSO_4$

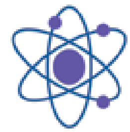
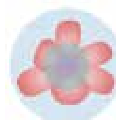
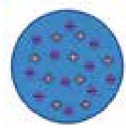
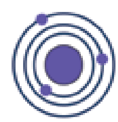
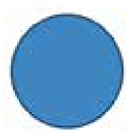
E. Write the molecular formula of following compound

i. Methane ii. Sodium Chloride

iii. Hydrogen Nitrate iv. Calcium bicarbonate

v. Magnesium sulphate
vi. Ferric oxide
vii. Potassium chlorate
viii. Marble
iX. Silica
X. Magnesium oxide
Xi. Cabon dioxide

F. Match the the discovering part of an atom

Soild sphere model (Dalton, 1803)		Discovered the nucleus and that it had a positive charge
Plum pudding model (Thomson, 1897)		Electrons from an electron cloud
Nuclear Model (Rutherford, 1911)		Discovered the electron
Planetary Model (Bohr, 1913)		Discovered that electrons move around the nucleus in specific orbits.
Quantum Model (Schrödinger,1926)		said that atoms are tiny solid sheres. Atoms of different elements are of different sizes.

G. Answer the following questions :

i. Write the charge and mass of an electron?
ii. How many electrons at the maximum can be present in the first shell of an atom?
iii. List three subatomic particles of an atom?
iv. Name two any two noble gases?
v. Write the value of charge on electron
vi. What is atom ?
vii. Define atomic weight ?
viii. Define molecular weight ?
ix. An atom of element 'X' has 3 orbits around its nucleus. What is its maximum electron holding capacity?
x. The oxide of aluminium has a chemical formula Al_2O_3. State the valency of aluminium?
xi. Diagrammatically show the electronic distribution of Na+ in its orbit ?
xii. What is Radioactivity?
xiii. Which has more number of electrons Na or Na^+ ? Why?
xiv. Name the particles which determine the mass of an atom?
xv. If Z = 5, what would be the valency of the element? Also name the element?

xvi. If an atom contains one electron and one proton, will it carry any charge or not?

xvii. Draw a sketch of Bohr's model of an atom with three shells.

xviii. Helium atom has an atomic mass of 4 u and two protons in its nucleus. How many neutrons does it have?

xix. If K and L shells of an atom are full, then what would be the total number of electrons in the atom?

xx. Why alpha- particle scattering experiment was possible by using gold foil only and not by foil of any other metal?

xxi. Explain the difference between the valence electrons and the valency of an element.

xxii. Complete the table below by filling in the number of valence electrons and the valency for each of the elements shown:

Element	No. of valence electrons	No. of electrons needed to fill outer shell	Valency
F			
Ar			
C			
N			
O			

xxiii. Use your notes and the periodic table to complete the following table.

Element	Symbol	Number of Protons	Atomic Number	Nomber of Electrons	Nomber of Neutrons	Atomic Mass Number
	0	8				16
			11			23
Aluminum				13	14	
	K	19				
Chlorine			17			
Iron						56
		14			14	
			7			14
	C				6	

H. Write short note :

i. Valency

ii. Molecular weight

iii. Atomic wight

iv. Ion

v. Sub-atomic particle

vi. Radioactive emmisiom

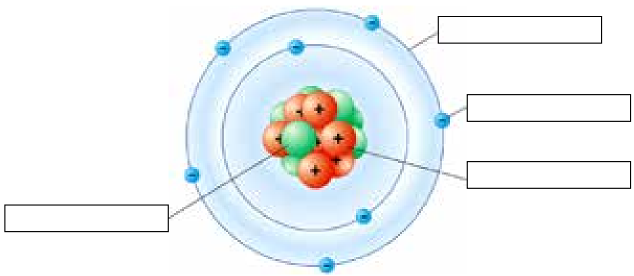
vii. Atomic energy

I. Calculate the molecular weight

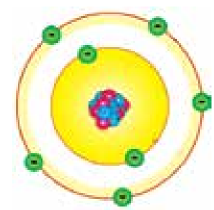
i. Water
ii. Methane
iii. Ammonia
iv. Carbon dioxide
v. Sodium Chloride
vi. Potassium Chlorate
vii. Magnesium sulphate
viii. Calcium carbonate
ix. Glucose

J. Diagrammatic questions

Label the part of the atom below. Write the name of this atom.



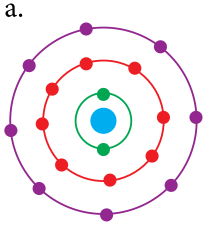
K. Using the diagram below, answer the questions that follow.



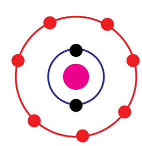
a. How many, electron, proton and neutrons does the atom have ?
b. What is the atomic number and atomic weight ?

L. Observe the given picture and answer the following questions

a.



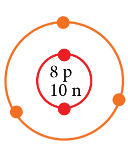
b.



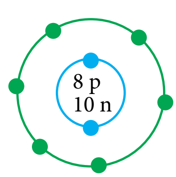
i. Find out the valency of the atoms represented by figure 'a' and 'b'
ii. Write the name of element'a' and 'b' .
iii. Find the atomic weight of both elements .

M. What information do you get from the given figure about the atomic number, mass number and valency of X, Y and Z ?Give your answer in a tabular form.

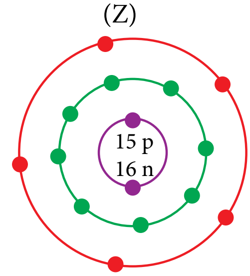
(X)



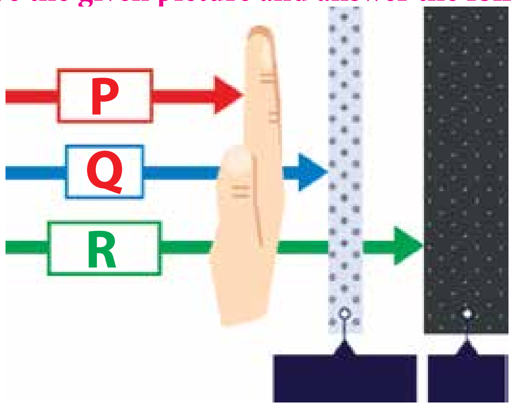
(Y)



(Z)

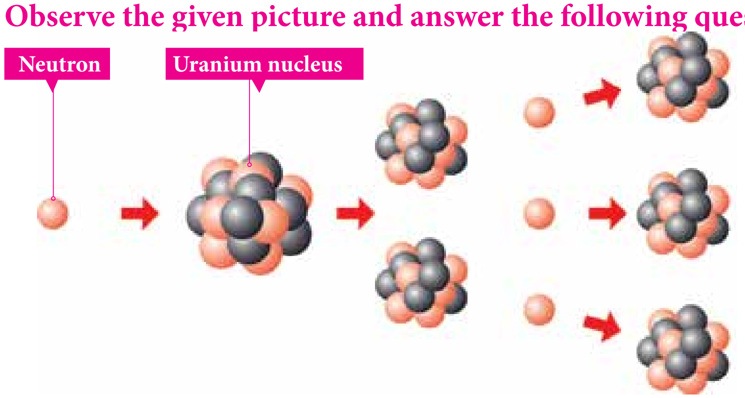


N. Observe the given picture and answer the following questions



i. What did you see in the picture?
ii. What are the radioactive particles P, Q and R?
iii. Write any two differences between P and Q.
iv. Write down the disadvantages of each of these particles.

O. Observe the given picture and answer the following questions



i. What happens when neutron hits uranium nucleus ?
ii. What happens last step ?
iii. Is it fusion or fission ? Give the reason ?

Unit 15 Chemical Reaction

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- introduce chemical reactions and chemical equations
- write and balance simple chemical equations
- introduce with examples of exothermic and endothermic reactions
- describe the importance of chemical reactions in daily life

Pierre-Eugène-Marcellin Berthelot, (1827-1907), French organic and physical chemist, science historian, and government official. His creative thought and work significantly influenced the development of chemistry in the latter part of the 19th century. The fundamental conception that underlay all Berthelot's chemical work was that all chemical phenomena depend on the action of physical forces which can be determined and measured.

Fig. 15.1

No doubt you've seen changes like those pictured in figure above. Discuss about these pictures with your classmates :

i. What do all these changes have in common?
ii. Describe how chemical reactions occur.
iii. List signs that a chemical reaction has occurred.
iv. Make a list of other examples as shown in the picture.

15.1 Chemical Reaction

Burning of Magnesium ribbon in air is a chemical change: Magnesium ribbon burns with a dazzling white flame to give a white powder known as Magnesium oxide (a new substance).

In above picture, they are all chemical changes in matter. In a chemical change, matter changes into a different substance with different properties. The process of displacement, association or dissociation between the atoms and molecules of substances during the chemical change is called chemical reaction. The chemical change is expressed through equation. The method of representing substances involved in chemical reaction in symbol and molecular formula is called chemical equation.

Substances that start a chemical reaction are called **reactants**. Substances that are produced in the reaction are called **products**. Reactants and products can be elements or compounds. A chemical reaction can be represented by this general equation :

Reactants→Products

The arrow (→)shows the direction in which the reaction occurs. The reaction may occur quickly or slowly. For example, foam shoots out of a fire extinguisher as soon as the lever is pressed. But it might take years for metal to rust .

$$\underbrace{\text{Hydrogen + Oxygen}}_{\text{Reactants}} \rightarrow \underbrace{\text{water}}_{\text{Products}}$$

$$\underbrace{\text{Acetylene + oxygen}}_{\text{Reactants}} \rightarrow \underbrace{\text{carbon dioxide + water}}_{\text{Products}}$$

Fig. 15.2

In chemical reactions, bonds break in the reactants and new bonds form in the products. The reactants and products contain the same atoms, but they are rearranged during the reaction. As a result, the atoms are in different combinations in the products than they were in the reactants.

Look at the example in figure given below. It shows how water forms. Bonds break in molecules of hydrogen and oxygen. Then new bonds form in molecules of water. In both reactants and products, there are four hydrogen atoms and two oxygen atoms. But the atoms are combined differently in water.

Hydrogen (H_2) + Oxygen (O_2) → Water (H_2O)

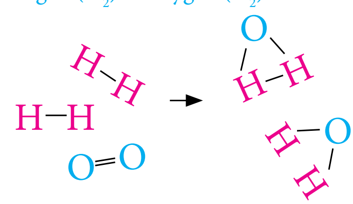


Fig. 15.3

The arrow in figure above shows that the reaction goes from left to right, from hydrogen and oxygen to water. The reaction can also go in the reverse direction. If an electric current passes through water, water molecules break down into molecules of hydrogen and oxygen. This reaction would be represented by a right-to-left arrow (←) in figure above .

Many other reactions can also go in both forward and reverse directions. Often, a point is reached at which the forward and reverse reactions occur at the same rate. When this happens, there is no overall change in the amount of reactants and products. This point is called **equilibrium**, which refers to a balance between any opposing changes.

Not all changes in matter involve chemical reactions. For example, there are no chemical reactions involved in changes of state. When liquid water freezes or evaporates, it is still water. No bonds are broken and no new products are formed.

How can you tell whether a change in matter involves a chemical reaction? Often, there is evidence. Four common signs that a chemical reaction has occurred are:

Change in color: the products are a different color than the reactants.
Change in temperature: heat is released or absorbed during the reaction.
Production of a gas: gas bubbles are released during the reaction.
Production of a solid: a solid settles out of a liquid solution. The solid is called a precipitate.

You can see examples of each type of evidence in given figure.

Production of a solid
adding acid to milk produces solid curds of cottage cheese.

Production of a gas
Dissolving an antacid tablet in water produces gass bubbles.

Change in temperature
Burning wood produces heat.

Change in color Bleaching
hair changes its color

Fig. 15.4

Some examples of Chemical reactions

i. Carbon + Oxygen ⟶ Carbon dioxide
(Association between Carbon and Oxygen)

ii. Potassium chlorate ⟶ Potassium chloride +Oxygen
(Dissociation of Potassium chlorate)

iii. Zinc + Hydrochloric acid ⟶ Hydrogen + Zinc chloride
(Displacement between zinc and hydrochloric acid)

Activity 15.1

Take a 2 cm long magnesium ribbon. Clean it with a piece of sand paper. Hold it firmly with a pair of tongs. Heat it over a spirit lamp or a burner until it burns. Keep the ribbon as far as possible from your eyes. What do you observe? The magnesium ribbon burns with a dazzling light and liberates a lot of heat. It is soon converted into a white powdery substance.

Activity 15.2

Take a few zinc granules in a conical flask or in a test tube. Add dilute sulphuric or hydrochloric acid to it. What do you observe? There is evolution of gas from the test tube. If you touch the bottom of the test tube, you will find that it has become quite warm. You can perform many more such activities in the laboratory or in the activity room.

The two reactions mentioned above can be written in words as follows :

Magnesium + Oxygen → Magnesium oxide ...(1)

Zinc + dil Sulphuric acid → Zinc sulphate + Hydrogen ...(2)

A substance which undergoes a chemical change is called the reactant and the substance which is formed as a result of a chemical change is called the product. In reaction (1) magnesium and oxygen undergo chemical change and they are the reactants. In reaction (2) zinc and dilute sulphuric acid are the reactants. Similarly in reaction (1) magnesium oxide is a new substance formed. It is the product. Can you now say what is the product in reaction (2)? Yes, it is zinc sulphate and hydrogen. In chemical reaction, the reactant (s) is (are) written on the left hand side and the product(s) is (are) written on the right hand side. The change of the reactant into the product is shown through an arrow. Use of + sign is made when there are more than one reactant or there are more than one product. Let us see if you can complete the reaction given below:

Calcium+Chlorine → Calcium chloride $Ca+cl_2 \rightarrow CaCl_2$

Study the equation carefully and write the number of atoms of different elements in the imbalanced equation: $Fe + H_2O \longrightarrow Fe_3O_4 + H_2$

Table - Comparing number of atoms of different elements in reactants and products

Element	Number of atoms on reactants side	Number of atoms on products side
Fe	1	3
H	2	2
O	1	4

Table 15.1

15.2 Chemical Equation

The chemical reaction which is expressed by using molecular formulae of reactants and products is called a chemical equation.

For example,

$$2H_2 + O_2 \longrightarrow 2H_2O$$

In a chemical equation, the reactants and the products are separated by an arrow (→). The reactants are written on the left hand side of the arrow and the products are written on the right side of the arrow.

In order to write a chemical equation, we have to write formula equation. Any formula equation may hold an unequal number of atoms of one or more elements on its react and product sides.

Types of Chemical Equation

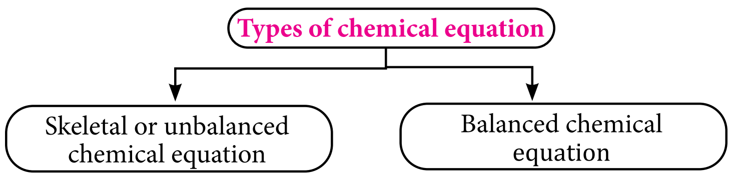


Fig. 15.5

Skeletal or unbalanced chemical equation

The chemical equation which has on equal number of atoms in reactant and product side is called unbalanced chemical equation.

Examples

i. Sodium + Chlorine → Sodium chloride [Word equation]
   $Na + Cl_2 \rightarrow NaCl$ [Skeleton equation]

ii. Nitrogen + Hydrogen → ammonia
   $N_2 + H_2 \rightarrow NH_3$

iii. Zinc + Hydrochloric acid →Zinc chloride + Hydrogen
   $Zn + HCl \rightarrow ZnCl_2 + H_2$ [Skeleton equation)

Word equation

A word equation is an expression of a chemical reaction, equation using words rather than letters, numbers, and operators.In chemistry, a word equation indicates the order of events of a chemical reaction. The number of moles and types of reactants yield the number of moles and types of products.

Word equations help in learning chemistry because they reinforce the thought process involved in writing a chemical reaction or equation.

The chemical reaction $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$ would be expressed as:

hydrogen gas + oxygen gas → steam (Word equation)

As a word equation or as "Hydrogen and oxygen react to form water" or "Water is made by reacting hydrogen and oxygen."

While a word equation doesn't ordinarily include numbers or symbols (Example: You wouldn't say "Two H two and one O two makes two H two O", sometimes it is necessary to use a number to indicate the oxidation state of a reactant so that a person writing a chemical equation can do it correctly. This is mostly for the transition metals, which can have multiple oxidation states.

For example, in the reaction between copper and oxygen to form copper oxide, the chemical formula of copper oxide and the number of copper and oxygen atoms involved depends on whether copper(I) or copper(II) participates in the reaction. In this case, it would be fine to say:

copper + oxygen → copper(II) oxide (Word equation)
or
Copper reacts with oxygen to produce copper two oxide.

Formula equation

Formula equation is a representation of a chemical reaction using symbols of the elements to indicate the amount of substance, usually in moles, of each reactant and product. Formula equation is a visual representation of a reaction using chemical formulas. A chemical formula is an expression that states the number and types of atoms that make up any given molecule using the symbols for the elements and sub-scripted numbers.A chemical formula is a notation used by scientists to show the number and type of atoms present in a molecule, using the atomic symbols and numerical subscripts. A chemical formula is a simple representation, in writing, of a three dimensional molecule that exists. A chemical formula describes a substance, down to the exact atoms which make it up.

Examples

i. $4Na\ (s) + O_2\ (g) \longrightarrow 2Na_2O\ (s)$

ii. $MnO_2\ (s) + 4HCl\ (aq) \longrightarrow MnCl_2\ (aq) + 2H_2O\ (l) + Cl_2\ (g)$

iii. $2Al\ (s) + 6HCl\ (aq) \longrightarrow 2AlCl_3\ (aq) + 3H_2\ (g)$

Unbalanced chemical equation

The chemical equation in which the total number of atoms of each element in reactants and products are not equal.

Example

i. $Na + Cl_2 \longrightarrow NaCl$

Element	Number of atoms in the product	Number of atoms in the reactant
Sodium	1	1
chlorine	2	1

Table 15.2

In this equation, the number of sodium on the right and left is equal. But the number of chlorine is not equal.

ii. $Al+HCl \rightarrow H_2+AlCl_3$

Element	Number of atoms in the product	Number of atoms in the reactant
Aluminium	1	1
chlorine	1	3
Hydrogen	1	2

Table 15.3

In this equation, the number of aluminium on the right and left is equal. But the number of hydrogen and chlorine is not equal.

iii. $Zn+HCl \rightarrow ZnCl_2+H_2$

Element	Number of atoms in the product	Number of atoms in the reactant
Zinc	1	1
Hydrogen	1	2
chlorine	1	2

Table 15.4

In this equation, the number of zinc on the right and left is equal. But the number of hydrogen and chlorine is not equal.

Examples of balanced chemical equation

(i) $2Na + Cl_2 \longrightarrow 2NaCl$

Element	Number of atoms in the product	Number of atoms in the reactant
Sodium	2	2
chlorine	2	2

Table 15.5

In this equation, the number of sodium and chlorine on the right and left is equal..

ii. $2Al+6HCl \rightarrow 3H_2+2AlCl_3$

Element	Number of atoms in the product	Number of atoms in the reactant
Aluminium	2	2
chlorine	6	6
Hydrogen	6	6

Table 15.6

In this equation, the number of alminium , chlorine and hydrogen on the right and left is equal.

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

Element	Number of atoms in the product	Number of atoms in the reactant
Zinc	1	1
Hydrogen	2	2
chlorine	2	2

Table 15.7

In this equation, the number of zinc, hydrogen and chlorine on the right and left is equal.

Balanced chemical equation

The chemical equation which has equal number of atoms in reactant and product side is called balanced chemical equation.

i. Sodium + Chlorine → Sodium chloride [Word equation]
$2Na + Cl_2 \rightarrow 2NaCl$ [Balanced chemical equation]

ii. Nitrogen + Hydrogen → ammonia

$N_2 + 3H_2 \rightarrow 2NH_3$ [balanced chemical equation]

iii. Zinc + Hydrochloric acid →Zinc chloride + Hydrogen

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$ [balanced chemical equation]

Methods of writing balanced chemical equation

Mass is neither created nor destroyed on the basis of this principle, chemical equation can be balanced. The sum of mass of reactants is equal to sum of mass of products.

The following points should be remembered for writing balanced chemical equation.

a. At first write the chemical reaction in word.
b. The symbols of elements or molecules and molecular formula should be written correctly.
c. The subscript of molecular formula in chemical equation should not be changed.
d. The suitable multipliers are selected to multiply the molecular formula so that the total number of atoms on either side of the equation should be equal.

This method is called 'Hit' and 'Trial' method.

Example

Aluminium + Hydrochloric acid ⟶ Aluminium chloride + Hydrogen

$Al + HCl \longrightarrow AlCl_3 + H_2$

First, find each number of the atoms on either side of equation and find unbalanced number of atoms.

Atoms	Reactant side	Product side
Al	1	1
H	1	2
Cl	1	3

Here, the number of aluminium atoms on both sides are equal but the number of atoms of hydrogen and chlorine are not equal on either side of equation.

To make equal number Al is multiplied 2, HCl by 6, $AlCl_3$ by 2 and H_2 by 3. Then equation can be written as:

$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

Now, in above equation the number of atoms became :

Atoms	Reactant side	Product side
Al	2	2
H	6	6
Cl	6	6

So, above chemical equation is called balanced equation.
Some examples of balanced chemical equations are given below.

- Potassium + Chloride ⟶ Potassium chloride
  $2K + Cl_2 \longrightarrow 2KCl$
- Sodium + Oxygen ⟶ Sodium oxide
  $4Na + O_2 \longrightarrow 2Na_2O$

- Aluminium + Nitrogen $\longrightarrow$ Aluminium nitride
  $2Al + N_2 \longrightarrow 2AlN$
- Sodium + Chloride $\longrightarrow$ Sodium chloride
  $2Na + Cl_2 \longrightarrow 2NaCl$
- Hydrogen Peroxide $\longrightarrow$ Water + Oxygen
  $2H_2O_2 \longrightarrow 2H_2O + O_2$
- Calcium carbonate $\xrightarrow{heat}$ Calcium oxide + Carbon dioxide
  $CaCO_3 \longrightarrow CaO + CO_2$
- Potassium chlorate $\xrightarrow{heat}$ Potassium chloride + Hydrogen
  $2KClO_3 \longrightarrow 2KCl + 3O_2$
- Zinc + Hydrochloric acid $\longrightarrow$ Zinc chloride + Hydrogen
  $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$
- Potassium + Hydrochloric acid $\longrightarrow$ Potassium chloride + Hydrogen
  $2K + 2HCl \longrightarrow 2KCl + H_2$
- Calcium + Sulphuric acid $\longrightarrow$ Calcium sulphate + Hydrogen
  $Ca + H_2SO_4 \longrightarrow Ca\ SO_4 + H_2$
- Sodium chloride + Sliver nitrate $\longrightarrow$ Sodium nitrate + silver chloride
  $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$
- Sodium hydroxide + Hydrochloric acid $\longrightarrow$ Sodium chloride + Water
  $NaOH + HCl \longrightarrow NaCl + H_2O$
- Potasium hydroxide + Nitric acid $\longrightarrow$ Potassium nitrate + Water
  $KOH + HNO_3 \longrightarrow KNO_3 + H_2O$

Information obtained from balanced chemical reaction

i. Name and molecular formula of reactants and products.
ii. The number of molecules in reactant and product.
iii. The ratio of weight of molecules in reactant and products.
iv. Type of chemical reaction.

Demerits of skeleton chemical equation

i. An unbalanced chemical equation does not follow the law of conservation of mass.
ii. It does not tell us about the ratio of reactant and product molecules.
iii. It does not give information about the number of each element in reactants and products.

It is essential to balance the chemical equation because a balanced chemical equation satisfies the law of conservation of mass in chemical reactions.
Sodium hydroxide and potassium hydroxide are called caustic soda and caustic potash respectively. It is so because they produce burning effect.

Exothermic and Endothermic Reaction

Chemical reactions are due to a absorption or production of heat. So, during chemical reaction on basis of heat evolved or absorbed, they are divided into two types.

A chemical reaction which needs heat is called endothermic reaction.

Some examples of endothermic reaction are:

$N2 + O_2 + Heat \longrightarrow 2NO$
$2NaCl + Heat \longrightarrow 2Na + Cl_2$

A chemical reaction in which heat is produced is called exothermic reaction.

Some examples of exothermic reaction

$$C + O_2 \longrightarrow CO_2 + \text{Heat}$$
$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2 + \text{Heat}$$

Importance of chemical reaction in our daily life

Chemical reactions are at the heart of literally every biological process in the universe. Stars form because of chemical reactions; our sun ignited because of chemical reactions in its core. Life developed on Earth as a result of chemical reactions.

The 'circle of life' is, at its heart, a series of chemical reactions. Even our ability to think and move is a result of chemical reactions that occur in our bodies.

Chemical reactions help us understand the properties of matter. By studying the way a sample interacts with other matter, we can learn its chemical properties. These properties can be used to identify an unknown specimen or to predict how different types of matter might react with each other.

By observing chemical reactions, we are able to understand and explain how the natural world works. Chemical reactions turn food into fuel for your body, make fireworks explode, cause food to change when it is cooked, make soap remove grime, and much more.

Exciting and entertaining chemical reactions pique interest in science. These types of demonstrations encourage people to ask questions and may lead them into science-related careers.

Chemical reactions help us to solve crimes and explain mysteries. By analyzing blood and tissue samples, for example, police are able to identify the perpetrators of crimes. Chemical reactions are also the tools we use to date fossils, analyze ancient materials, and better understand how our ancestors lived. By observing chemical reactions in outer space, we are able to identify and describe other planets. We can even determine which planets and moons are likely to be able to sustain life.

Fire, the most important discovery made by human beings, is simply a chemical reaction.

Without chemical reactions, nothing would ever change. Atoms would stay atoms. New molecules wouldn't form. No organisms could live. If matter didn't react with other matter, the universe would be extremely boring.

Project Work

Make a list of the importance of chemical reactions in our daily lifes and present it in your classroom.

Exercise

A. Choose the correct one and put the tick mark(√)

i. Carbon dioxide is formed through a chemical reaction between carbon and .....

a. hydrogen b. nitrogen
c. water d. oxygen

ii. **In chemical reactions, atoms are :**

a. created b. destroyed

c. rearranged d. neutralized

iii. **Which of the following conditions cannot take place during a chemical reaction?**

a. Formation of new atoms b. Bonds breaking between atoms

c. Formation of new molecules d. Bonds forming between atoms

iv. **Which of the following is a balanced equation?**

a. $3N_2+3H_2 \rightarrow 2NH_3$ b. $4Al+6HCl \rightarrow 3H_2+2AlCl_3$

c. $2O_2+3H_2 \rightarrow 2H_2O$ d. $2K+Cl_2 \rightarrow 2KCl$

v. **What are the elements or compounds formed by chemical reactions?**

a. The products b. The reactants

c. The solids d. The gases

vi. **What number is needed in front of the NaF in order for this equation to be balanced? ____$NaF+Br_2 \rightarrow 2NaBr+F_2$**

a. 1 b. 2

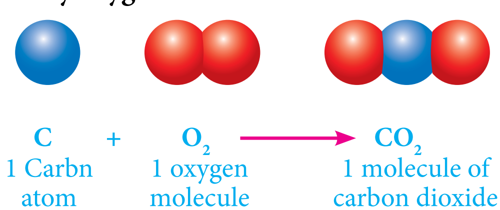
c. 3 d. 4

vii. **Idendify the reactant(s) in the chemical reaction $CO_2+H_2O \rightarrow H_2CO_3$**

a. CO_2 b. CO_2 and H_2O

c. CO_2,H_2O and H_2CO_3 d. H2CO_3

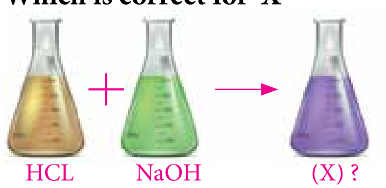
viii. **If a lump of coal contains 200 billion carbon atoms and it burns completely, how many oxygen molecules will it consume?**



a. 50billion b. 100 billion

c. 200 billion d. 400 billion

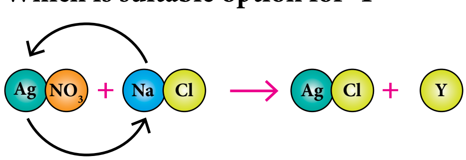
ix. **Which is correct for 'X'**



a. H_2O b. Nacl

c. H_2O+Nacl d. NaH+ H_2O

x. **Which is suitable option for 'Y'**



a. $NaNO_2$ b. $NaNO_3$

c. $NaNO_4$ d. NaNO

B. Balance the following chemical equations:

i. $Mg+O_2 \rightarrow 2MgO+Heat$
ii. $4Na (s) + O_2 (g) \longrightarrow Na_2O (s)$
iii. $MnO_2 (s) + HCl (aq) \longrightarrow MnCl_2 (aq) + 2H_2O (l) + Cl_2 (g)$
iv. $Al (s) + HCl (aq) \longrightarrow AlCl_3 (aq) + H_2 (g)$
v. $H_2SO_4 (aq) + NaOH (aq) \longrightarrow Na_2SO_4 (aq) + H_2O (l)$
vi. $2Na(s)+Cl_2(g) \rightarrow NaCl(s)$
vii. $Fe +H_2O \rightarrow Fe_3O_4 +H_2$
viii. $CaO(s)+H_2O(l) \rightarrow Ca(OH)_2(aq)$
ix. $H_2 (g) + Cl_2 (g) \longrightarrow HCl (g)$
x. $Zn (s) + 2AgNO_3 (aq) \longrightarrow Zn(NO_3)_2 (aq) + Ag (s)$

C. Write formula equations of the following and balance them:

i. Carbon + Oxygen ⟶ Carbon dioxide
ii. Hydrogen + Chlorine ⟶ Hydrogen chloride
iii. Hydrogen + Oxygen ⟶ Water
ix. Potassium chlorate ⟶ Potassium chloride + Oxygen
v. Zinc + Hydrochloric acid ⟶ Hydrogen + zinc chloride

D. Complete the equation with words.

i. Aluminum + hydrochloric acid →
ii. Sodium + chlorine →
iii. Magnesium + zinc nitrate →
iv. Mercury + oxygen →
v. Calcium hydroxide (heated) →
vi. Zinc chloride + hydrogen sulfide →
vii. Sodium sulfate + barium chloride →
viii. Water (electrolyzed) →
ix. Potassium chlorate (heated) →
x. Mercury + nitric acid →
xi. Fluorine + potassium bromide →
xii. Calcium chloride + ammonium hydroxide →

E Differentiate with examples

i. Reactants and Products
ii. Chemical equation and Chemical reaction
iii. Word equation and formula equation
iv. Balanced and unbalanced equation
v. Exothermic reaction and Endothermic reaction

F. Answer the following questions :

i. What is meant by a chemical reaction?
ii. What is meant by word equation and formula equation ? Give example .
iii. Define reactant and product.
iv. Define balanced chemical equation.
v. What does (s), (l) and (aq) represent in a chemical equation.
vi. What information can we get by balanced chemical equation ?
vii. Write the balanced equation for the reaction between calcium carbonate and dilute hydrochloric acid .

G. Write the product of following chemical reactions.

i. When carbon burns in air.
ii. Limestone is heated.

iii. Burning magnesium ribbon is inserted into gas jar containing oxygen.
iv. Decomposing the Hydrogen peroxide in presence of manganese dioxide.
v. When potassium and Hydrochloric acid reacts.
vi. When calcium and hydrochloric acid reacts.
vii. Calcium hydroxide is passed into gas jar containing carbon dioxide.
viii. The burning magnesium inserted into the gas jar containing nitrogen gas.
ix. When sodium metal piece is kept in water.

H. Diagrammatic questions

i. Label each of these parts of an equation. Use the word bank provided :

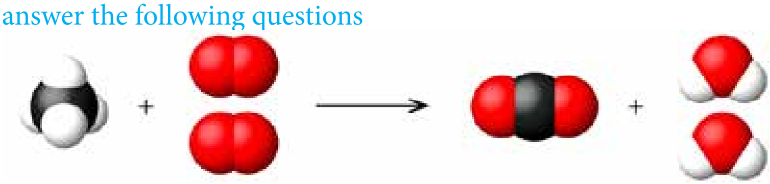
Yield or Prdoce	Product	Reactant Solid	Coefficient	Gas
Dissolved in water	Liquid		Element	

A D E F G H

$$\underbrace{Sr\,(cr) + 2H_2O\,(I)}_{A} \longrightarrow \underbrace{Sr\,(OH)_2(aq) + H_2(g)}_{B}$$

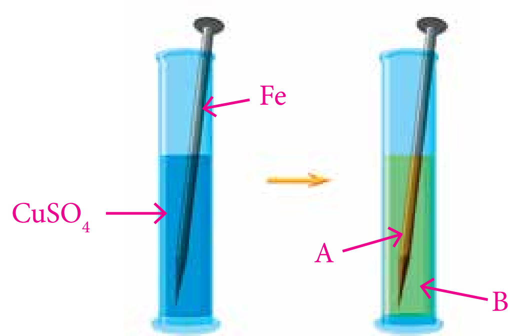
a. In the chemical equation shown, the substances in part A are called______________
b. Part F is read as ____________________
c. The substances in part B are called ____________________
d. Part G means that the material, $Sr(OH)_2$, is ____________________
e. Prad D is called a(n) ____________________
f. Part E means that the material, H_2, is a(n) ____________________
g. Part H means that the material, H_2, is a(n) ____________________
h. Part C is a(n) ____________________

ii. A model of the compounds involved in a chemical reaction is give below. Based on this, answer the following questions



a. What are A and B ?
b. Putting methane and oxygen in place of A then what happens in B.
c. Write its words, formula and balanced equations.
d. How do combine red, black and white on both sides?

iii. Study the given diagram and answer the following questions:



a. What are A and B ?
b. Write the name of reactant.
c. Write the word and balanced equations
.

Unit 16 Gases

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- prepare hydrogen, oxygen and nitrogen gases in the laboratory and describe their properties
- describe the usefulness of hydrogen, oxygen and nitrogen gases
- introduce the ozone layer and explain its formation and depletion process and explore its importance

Henry Cavendish, (1731 -1810), natural philosopher, the greatest experimental and theoretical English chemist and physicist of his age. Cavendish was distinguished for great accuracy and precision in research into the composition of atmospheric air, the properties of different gases, the synthesis of water, the law governing electrical attraction and repulsion, a mechanical theory of heat, and calculations of the density (and hence the weight) of Earth. His experiment to weigh Earth has come to be known as the Cavendish experiment.

16. Introduction

Natural or man-made substance like plants, animals, food, petrol, steel etc. all are impossible to make without gases. Gases have great role directly or indirectly in our daily life. 96.2 % of our weight is composed of only four elements, oxygen, hydrogen, nitrogen and carbon. Among these substances oxygen, hydrogen and nitrogen are gases. These elements can form different useful substances. These elements are directly related to human life. All required gases are obtained directly from atmosphere or industrial manufacturing. Hydrogen, oxygen and nitrogen can be prepared in laboratory to study their properties. In this lesson we study about these three gases.

In atmosphere, gases are found in mixture form. The gases contain in atmosphere are given in the table below.

S.N.	Gases in air	Percentage by volume
1	Nitrogen (N_2)	78.08%
2	Oxygen (O_2)	10.95%
3	Carbon dioxide (CO_2)	0.03%
4	Argon (Ar)	0.93%
5	Hydrogen (H_2)	0.00005%
6	Ozone (O_3)	0.000004%
7	Other gases	0.003945%

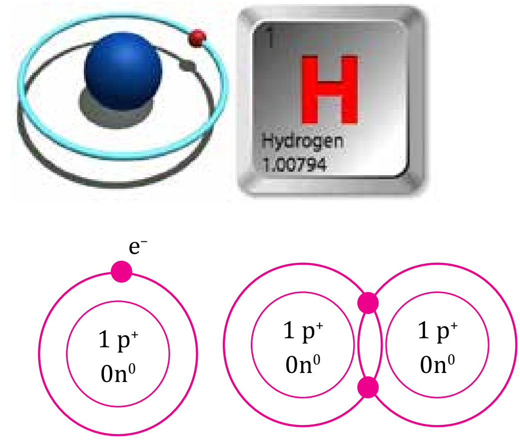
Table 16.1

16.1 Hydrogen Gas

Some information about hydrogen

Symbol	H
Atomic number	1
Atomic weight :	1.008 amu
Molecular formula :	H_2
Molecular weight :	2.016 amu
Group in periodic table	IA
Period in periodic table	1
Valency	1
Electronic configuration :	$1s^1$
Boiling Point :	-253°C
Freezing Point :	-259°C

Table 16.2



Atomic model of Hydrogen

Molecular structure of Hydrogen

Fig. 16.1

Occurrence of Hydrogen

Hydrogen is a reactive element and does not occur much in the free state. It is found in volcanic gases and natural gases in trace amount. However, it occurs abundantly in a combined state.

In the combined state, hydrogen is an important constituent of water, acid, alkali and many organic compounds of vegetables, and animal products. The chief source of hydrogen is water in which its amount is double in comparison to oxygen.

The lightest but largest amount of element in universe is hydrogen. It is found in sun, and the stars. But it is found only 0.00005% (by volume) in the earth. Hydrogen is very active element. It readily reacts with other elements and forms compound such as acid, hydrocarbon, etc.

Henry Cavendish, a British Scientist, discovered hydrogen gas in 1766 AD. He named it "inflammable gas". Later in 1783, Antony Lavoisier proposed the name hydrogen because it produced water on burning with oxygen.

Methods of preparation

Main sources of hydrogen are acid, base and water. Now, we discuss the laboratory preparation method and electrolysis process.

Hydrogen gas can be prepared by the action of metals with acids, alkalis and water.

i. From Acids

Metals such as zinc, iron, magnesium etc. are more electro-positive than hydrogen and react with acid forming hydrogen gas i.e.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$

However, metals like silver, copper etc. are less electropositive than hydrogen. So, these metals do not produce hydrogen gas from acids.

ii. From Alkalis

Hydrogen gas can be obtained from the action of metals such as zinc, almunium, etc. with boiling caustic soda.

i.e. $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2\uparrow$

Sodium zincate

iii. From Water

At ordinary temperature, highly reactive metals like sodium, potassium, calcium etc. react with water to release hydrogen gas.

i.e. $2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$

Note : When electricity is passed into a voltameter containing acidified water, it decomposes into hydrogen and oxygen in the ratio of 2:1.]

i.e. $2H_2O \xrightarrow[\text{dil } H_2SO_4]{\text{Electrolysis}} 2H_2 + O_2\uparrow$

Laboratory preparation of hydrogen gas

Active elements like zinc, magnesium, etc. displace the hydrogen contained in acid to evolve hydrogen gas. In laboratory hydrogen gas can be prepared by reaction of zinc granules with dilute hydrochloric acid or dilute sulphuric acid.

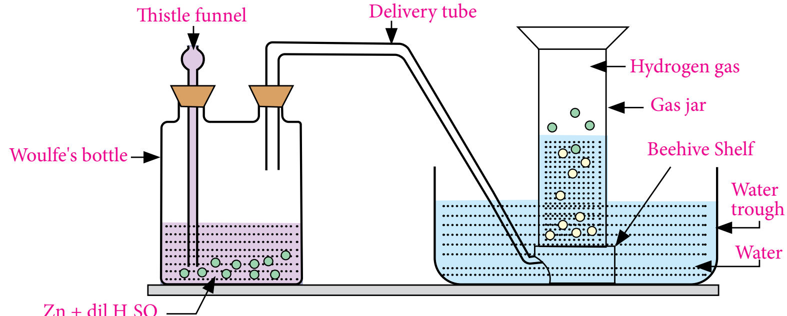
zinc + dil. hydrochloric acid $\longrightarrow$ zinc chloride (aq) + hydrogen (g)

$Zn(s) + 2\text{ dil }HCl(aq) \longrightarrow ZnCl_2(aq) + H_2\uparrow$

We use impure zinc for laboratory preparation. Pure zinc reacts slowly, impurity increases the rate of reaction.

Procedure :

Keep some granules of zinc in the woulfe's bottle and arrange the apparatus as shown in figure. Pour dilute hydrochloric acid or dilute sulphuric acid through the thistle funnel until the lower end of funnel in solution is completely dipped.



Laboratory prepartion of hydrogen gas

Fig. 16.2

When zinc comes in contact with dilute acid, it reacts with acid and gives off hydrogen gas. This gas passes through delivery tube. The gas is collected in the gas jar by downward displacement of water as shown in the figure.

Precautions :

i. The apparatus should be air tight.
ii. We should use granulated impure zinc.
iii. We should not use concentrated H_2SO_4/HCl.
iv. The experiment must be done away from the fire.
v. The lower end of the thistle funnel must be dipped in the acid solution.

Test of hydrogen gas

When a burning match stick is intruded into the gas jar containing the gas produced, the gas burns with pale-blue flame and the match stick gets extinguished with "pop" sound. It proves that gas is hydrogen.

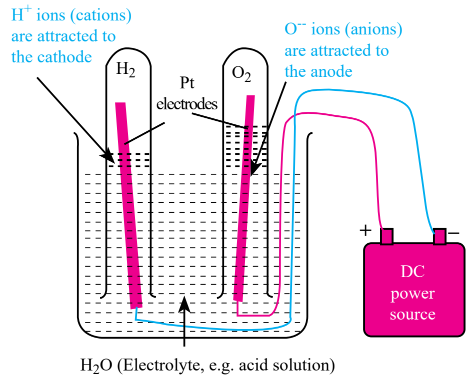
Other methods of production of hydrogen gas

i. By the electrolysis of water :

When an electricity is passed into water, hydrogen is formed at the cathode and the oxygen at anode.

$$2H_2O \xrightarrow{\text{Electrolysis}} 2H_2 + O_2$$

Manufacture of hydrogen gas is done from water. Water is abundantly available in the earth. Hydrogen is manufactured from water because water molecule is made up of hydrogen and oxygen.



electrolysis of water

Fig. 16.3

Put some sulphuric acid in water containing in electrolytic cell and pass electricity through it. Due to this, water molecule is dissociated into hydrogen ion and oxygen ion. Hydrogen ion moves towards cathode and oxygen moves towards anode and collected in the form of hydrogen and oxygen. Collected gas is passed into cylinder through the tube.

$$2H_2O \rightleftharpoons 2H_2\uparrow + O_2$$

From this method, 100% pure hydrogen gas is prepared. This method is cheap.

ii. From methane steam method :

When a mixture of steam and methane is passed over a heated nickel catalyst at 700°C – 1000°C, and compressed to 3 – 25 atmospheric pressure in reactor, hydrogen gas is manufactured. CO_2 is obtained as a by-product.

$$CH_4 + H_2O \xrightarrow[\text{3 - 25 atm/Ni}]{700°C} CO + 3H_2\uparrow$$

$$CO + H_2O \rightarrow CO_2 + H2\uparrow$$

This is the safest and cheapest method of manufacturing of hydrogen gas.

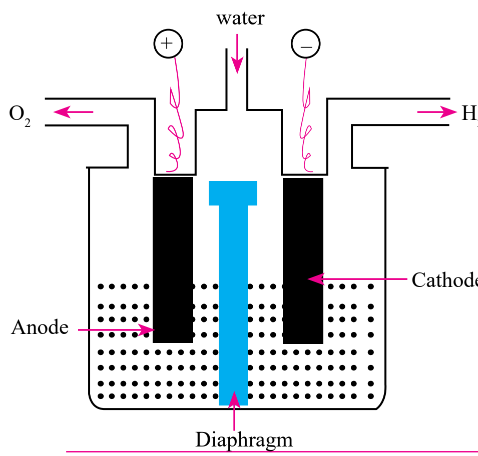


Fig. 16.4

Nascent hydrogen

The atomic form of hydrogen produced at the time of chemical reaction is known as nascent hydrogen. The name nascent means newly formed. The nascent chemical species are highly unstable because they have high reactivity, they are under high pressure, and they have high internal energy. Hence, produced nascent species immediately combine themselves to produce the molecular form of hydrogen which is less reactive than the nascent species.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + Zn + H \text{ [Nascent hydrogen]}$$

$$H + H \rightarrow H_2\uparrow \text{[Molecular Hydrogen]}$$

Properties of Hydrogen gas

i. It is colourless, odourless and tasteless gas.
ii. It is lighter than air.

iii. It is neutral to litmus paper.
iv. It is slightly soluble in water.
v. It becomes liquid at -253°C and becomes solid at -259°C.

Chemical properties of hydrogen gas

i. When hydrogen gas burns with air or oxygen it forms water.

$$2H_2 + O_2 \xrightarrow{\text{burns}} H_2O \text{ (water)}$$

ii. At high temperature generally hydrogen gas reacts with non-metal easily.

$$C + 2H_2 \xrightarrow[\Delta]{} CH_4 \text{ (metane)}$$

$$S + H_2 \xrightarrow[\Delta]{} H_2S$$

iii. Metal like sodium, potassium, calcium etc. reacts with hydrogen gas to give corresponding metallic hydrides.

$$2Na + H_2 \xrightarrow[\Delta]{} 2NaH \text{ (sodium hydride)}$$

$$2K + H_2 \xrightarrow[\Delta]{} 2KH \text{ (potassium hydride)}$$

$$Ca + H_2 \xrightarrow[\Delta]{} CaH_2 \text{ (calcium hydride)}$$

iv. When dry hydrogen reacts with hot metallic oxides, metal and water is produced.

$$Fe_2O_3 + 3H_2 \xrightarrow[\Delta]{} 2Fe + 3H_2O$$

$$CuO + H_2 \xrightarrow[\Delta]{} Cu + H_2O$$

$$PbO + H_2 \xrightarrow[\Delta]{} Pb + H_2O$$

Uses of hydrogen gases

i. It is used to produce ammonia gas.
ii. It is used to produce metal from metal oxide.
iii. It is used in manufacturing of vegetable ghee by the process of hydrogenation.
When hydrogen gas is passed into vegetable oil in presence of (8 to 10) atmospheric pressure, 250°C temperature and Nickel crystal, the vegetable oil converts into vegetable ghee.

$$\text{Vegetable oil} + H_2 \xrightarrow[\text{Ni}]{8 \text{ to } 10 \text{ atm}/250^0C} \text{vegetable ghee}$$

iv. It is used as a fuel in rockets.
v. It is used for making oxyhydrogen flame for cutting and welding of metals.

16.2 Oxygen Gas

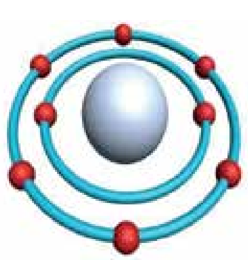


Fig. 16.5

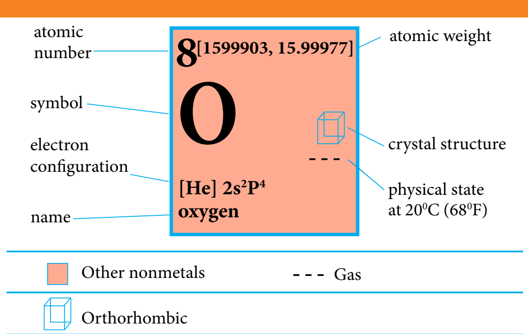


Fig. 16.6

Fact About Oxygen

- Animals and plants require oxygen for respiration. Plant photosynthesis drives the oxygen cycle, maintaining it around 21% in air. While the gas is essential for life, too much of it can be toxic or lethal. Symptoms of oxygen poisoning include vision loss, coughing, muscle twitching, and seizures. At normal pressure, oxygen poisoning occurs when the gas exceeds 50%.

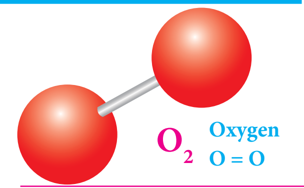


Fig. 16.7

  Liquid and solid oxygen is pale blue. At lower temperatures and higher pressures, oxygen changes its appearance from blue monoclinic crystals to orange, red, black, and even a metallic appearance.

  Oxygen is a nonmetal. It has low thermal and electrical conductivity, but high electronegativity and ionization energy. The solid form is brittle rather than malleable or ductile. The atoms readily gain electrons and form covalent chemical bonds.

  Oxygen gas normally is the divalent molecule O_2. Ozone, O_3, is another form of pure oxygen. Atomic oxygen, which is also called "singlet oxygen" does occur in nature, although the ion readily bonds to other elements. Singlet oxygen may be found in the upper atmosphere. A single atom of oxygen usually has an oxidation number of -2.

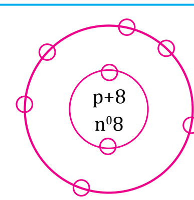
  Oxygen supports combustion. However, it is not truly flammable! It is considered an oxidizer. Bubbles of pure oxygen don't burn.

- Oxygen is paramagnetic, which means it is weakly attracted to a magnet but doesn't retain permanent magnetism.

  Approximately 2/3 of the mass of the human body is oxygen. This makes it the most abundant element, by mass, in the body. Much of that oxygen is part of water, H_2O. Although there are more hydrogen atoms in the body than oxygen atoms, they account for significantly less mass. Oxygen is also the most abundant element in the Earth's crust (about 47% by mass) and the third most common element in the Universe. As stars burn hydrogen and helium, oxygen becomes more abundant.

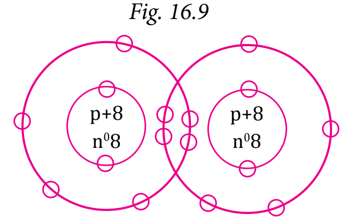
Some information about oxygen

Symbol	O
Molecular formula	O_2 (O = O)
Valency	2
Position in periodic table	Group VI Period : 2
Electronic configuration	2, 6 ($1s^2$, $2s^2$, $2p^4$)
Atomic number	8
Atomic weight	16 amu
molecular wight	32 amu
Boiling point	−183°C
Melting point	−219°C



Atomic model of oxygen

Fig. 16.9



Molecular structure of oxygen molecule

Fig. 16.10

Occurrence

Oxygen is an abundantly occurring element on the earth. Air consists about 21% oxygen gas.

Oxygen gas is needed for animals and plants to stay alived. Oxygen destroys the harmful bacteria inside our body. Oxygen is found in water, carbon dioxide, calcium carbonate, silica, wood, etc. in compound. More than 49% of the materials found on the earth surface are the compounds of oxygen.

Oxygen was discovered by a Swedish Chemist Scheele in 1773 AD. and named as fire air or vital air. In 1776 AD. French Scientist Antony Lavoisier gave the name "Oxygen".

Laboratory preparation of oxygen gas

By using heat

When potassium chlorate is heated in presence of manganese dioxide, oxygen gas is produced. Manganese dioxide acts as a catalyst which increases rate of reaction.

$$\text{Potasium chlorate} \xrightarrow[\text{Heat } 250^0\text{c}]{MnO_2} \text{Potasium chloride + oxygen}$$

$$2KClO_3 \xrightarrow[\triangle]{MnO_2} 2KCl + 3O_2$$

Method/Procedure

Four parts of potassium chlorate and one part of manganese dioxide mixture is taken in hard glass test tube and fitted other required apparatus as shown in figure. When the mixture is heated up to 250°C, oxygen gas is produced which is collected in gas jar by downward displacement of water.

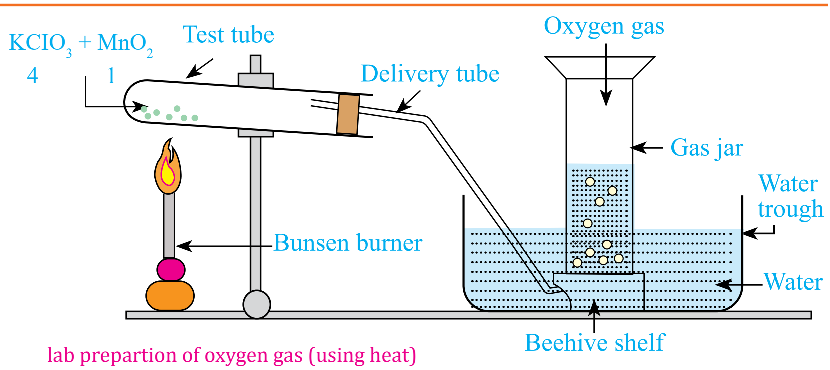


Fig. 16.11

Precautions

i. We should take pure MnO_2.

ii. The hard glass test tube should be made inclined.

iii. The apparatus should be airtight.

Without using heat

Oxygen gas is prepared in laboratory by the decomposition of hydrogen peroxide in the presence of manganese dioxide.

$$\text{Hydrogen peroxide} \xrightarrow{MnO_2} \text{Water + Oxygen}$$

$$2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$$

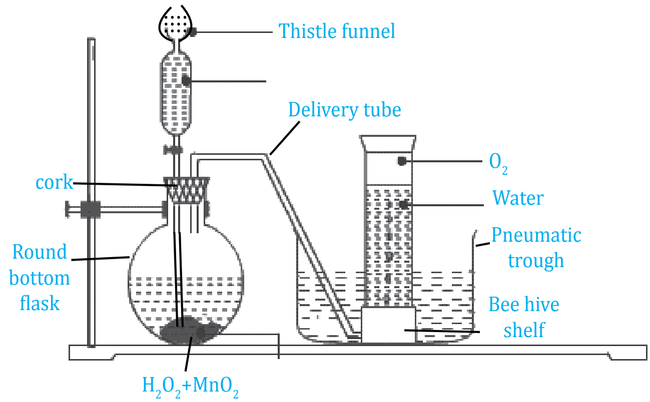
Keep some manganese dioxide in the round bottom flask and arrange the apparatus as shown in the figure. Pour hydrogen peroxide drop by drop with the help of stopper. When hydrogen peroxide decomposes in the presence of MnO2, it gives off oxygen gas. Oxygen gas produced in the round bottom flask is passed through the delivery tube and the gas is collected in the gas jar by downward displacement of water.

Test for oxygen gas

When a burning match stick is inserted in the gas jar containing oxygen, the flame becomes brighter indicating that the gas jar is filled with oxygen gas. Oxygen helps to burn the substance.

Manufacturing of oxygen gas

The oxygen gas is available abundantly in water and air. From these two sources, oxygen gas is manufactured for commercial purpose.



Laboratory preparation of O_2 without heating

Fig. 16.12

From Electrolysis of water

Oxygen gas can be prepared by electrolysis of water.

$$2H_2O \xrightarrow{\text{Electrolysis}} 2H_2 + O_2$$

(This is same like hydrogen. So, look at the manufacturing of hydrogen by electrolysis.)

From air

The mixture of different types of gases is collected and compressed into low volume with a high pressure. This mixture of gases now changes into liquid state. In this liquid mixture, there are only nitrogen and oxygen gases. The boiling point of nitrogen (-196°C) is lower than that of oxygen (-183°C). So, nitrogen gas escapes out leaving only oxygen gas. When they are subjected to fractional distillation, then oxygen gas is collected in cylinders.

Physical properties of oxygen

i. Oxygen is colourless, odourless and tasteless.
ii. It is slightly soluble in water.
iii. It is neutral gas.
iv. It is non-combustible but helps in combustion.
v. It becomes liquid at -183°C and solid at -219°C temperature.

Chemical properties of oxygen

i. When metal burns in the presence of air or oxygen, they form their oxides. But gold and platinum do not form their oxides.

$$4\,Na + O_2 \xrightarrow[\Delta]{} 2\,Na_2O$$

$$4K + O_2 \xrightarrow{\text{burns}} 2K_2O \text{ (potassium oxide)}$$

$$2Mg + O_2 \xrightarrow{\text{burns}} 2\,MgO \text{ (magnesium oxide)}$$

ii. When non-metal burns in presence of oxygen, they can also form their oxides.

$$2\,H_2 + O_2 \xrightarrow{\text{burns}} 2H_2O$$

$$C + O_2 \xrightarrow{\text{burns}} CO_2 \text{ (carbon dioxide)}$$

iii. When hydrocarbon compounds burn in presence of oxygen, it produces carbon dioxide, water and energy.

$$CH_4 + 2O_2 \xrightarrow{\text{burns}} CO_2 + 2H_2O + \text{energy (methane)}$$

$$C_2H_4 + 3O_2 \xrightarrow{\text{burns}} 2CO_2 + 2H_2O + \text{energy}$$

iv. When glucose present, in cell of our body burns with oxygen in the presence of biological catalyst, it produces carbon dioxide, water vapour and energy.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{biocatalyst}} 6CO_2 + 6H_2O + \text{energy (glucose)}$$

This reaction occurs during respiration in our body.

Uses of oxygen gas

i. Oxygen is used by all living things for respiration. It helps to produce energy by oxidation of digested food (glucose).

ii. It is used to produce artificial respiration for patients in hospital.

iii. The burning of oxygen with acetylene gas produces large amount of energy. So, it is used for welding and cutting metals. The so produced flame is called oxyacetylene flame.

iv. Liquefied oxygen is used in rocket as a part of fuel.

v. Mine workers, sea drivers and mountaineers carry oxygen cylinder for respiration.

16.3 Nitrogen Gas

Some information about nitrogen

Nitrogen is comparatively inert gas. Generally, nitrogen gas does not react with other elements or compounds. But it has vital role in plants, animal and industrial field. Proteins, enzymes, RNA, DNA etc. found in animals and plants contain nitrogen. It is present in atmosphere about 78.08% (by volume). In some rocks and minerals, it is found in compound state.

Nitrogen gas was discovered by a Scottish Scientist Daniel Rutherford in 1772 AD. and named as mephitic air air (poisonous gas). The name nitrogen was given by J.A Chaptal in 1790 AD.

Symbol	N
Molecular formula	N_2 ($N \equiv N$)
Valency	3, 5
Group in periodic table	VA
Period in periodic table	2
Electronic configuration	2, 5 ($1s^2$, $2s^2$, $2p^3$)
Atomic number	7
Atomic weight	14 amu
Molecular weight	28 amu
Boiling point	– 196°C
Melting point	– 210°C

Table 16.3

General methods of preparation of nitrogen gas

Nitrogen gas can be prepared by different methods. It can be prepared by fractional distillation of air and from the reaction between ammonium chloride and sodium nitrite. Here, only laboratory preparation method and manufacturing methods are studied.

By action with chlorine in excess of ammonia :

When excess amount of ammonia is treated with chorine, the oxidation of ammonia occurs and nitrogen gas is produced i.e.

$$8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2\uparrow$$

Nitrogen gas can be prepared by heating ammonium nitrite only, however, it is an unstable compound. Being an unstable compound, it is very different to keep safe.

Laboratory preparation of nitrogen gas

Nitrogen gas is prepared in laboratory by heating a mixture of ammonium chloride and sodium nitrite in solution state.

$$\text{Ammonium chloride + sodium nitrite} \xrightarrow{\text{Heat}} \text{sodium chloride + water + Nitrogen}$$

$$NH_4Cl + NaNO_2 \xrightarrow{\triangle} NaCl + 2H_2O + N_2\uparrow$$

Procedure

A mixture of 5 g of sodium nitrite and 4 g of ammonium chloride are taken in round bottom flask and put 50 ml of water in it to make solution. Arrange all apparatus as shown in figure.

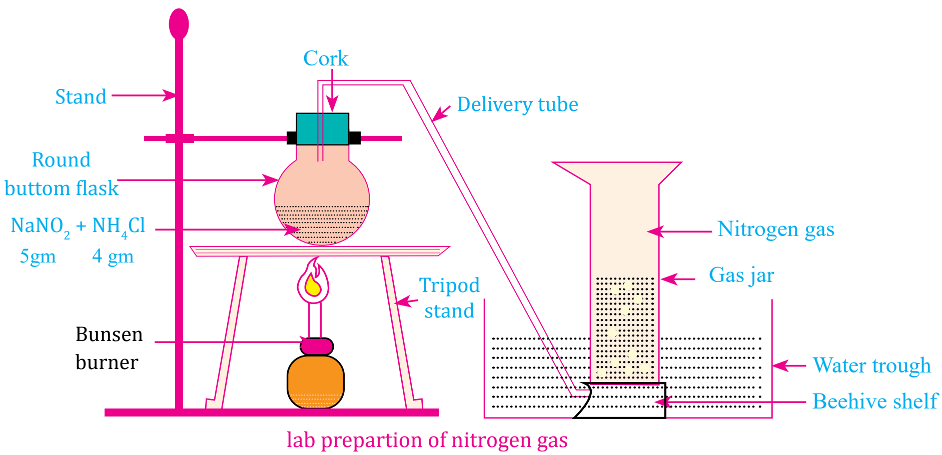


Fig. 16.13

Heat the solution slowly. Nitrogen gas is produced and is collected in gas jar by downward displacement of water.

Precautions

i. The apparatus should be air-tight.

ii. The solution of ammonium chloride should be made before heating as solid ammonium chloride is highly volatile.

iii. Heat the mixture slowly.

Test of nitrogen gas

When magnesium burns in air, it forms yellow powder. If we put some drop of water in yellow powder, ammonium smell is felt. This confirms the jar contains nitrogen gas.

Manufacturing of nitrogen gas

From liquid gas

Air from atmosphere is collected and liquefied at very low temperature and high pressure. Then it is subjected to fractional distillation. Nitrogen vapourizes faster than that of oxygen because the boiling point of oxygen and nitrogen are -183°C and -196°C respectively. The escaped nitrogen gas is collected in the cylinder.

Properties of nitrogen gas

A. Physical properties

i. It is a colourless, odourless and tasteless gas.
ii. It is lighter than air.
iii. It is neutral to the indicators.
iv. It is insoluble in water.
v. It liquefies at -196°C and solidifies at -210°C.
vi. Neiter burns itself, nor helps other to burn.

B. Chemical properties

Nitrogen is a diatomic molecule having triple covalent bonds (N≡N). Due to the presence of three bonds, it is very less reactive at ordinary temperature. But at high temperature the bond between nitrogen atoms break and induce certain chemical reactions.

i. Active metals such as magnesium and aluminium burn in the atmosphere to form nitrides.

$$3Mg + N_2 \xrightarrow{\triangle} Mg_3N_2 \text{ (Magnesium nitride)}$$

$$2\,Al + N_2 \xrightarrow{\triangle} 2\,AlN \text{ (Aluminium nitride)}$$

ii. When a mixture of hydrogen and nitrogen is heated about 450°c under a pressure of (200-600) atmp in presence of catalyst ammonia gas is produced. This method is called Haber's process.

$$N_2 + 3H_2 \xrightarrow[\text{Fe(catalyst) Mo(promoter)}]{450^0\text{c, (200 - 600) atm}} 2\,NH_3$$

iii. Nitrogen forms nitric oxide when it reacts with oxygen at very high temperature of about 3000°c. This reaction also occurs during lightening.

$$N_2 + O_2 \xrightarrow[3000°\text{c}]{\text{electric arc}} 2\,NO \text{ (Nitric oxide)}$$

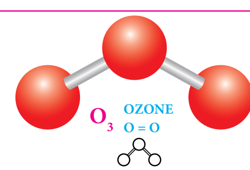
Uses of nitrogen

1. Nitrogen gas is used in production of ammonia, nitric acid etc.
2. It is used to manufacture fertilizers.
3. It is used in electric bulb to provide inert atmosphere.
4. Liquid nitrogen is used as refrigerator to preserve food, fruits etc.
5. It is used for making high temperature thermometers.

16.4 Ozone

Some pictures are given below, which was made public by the United Nations Environment Program.

All of these are related to ozone depletion. Study the pictures and discuss the questions given below.



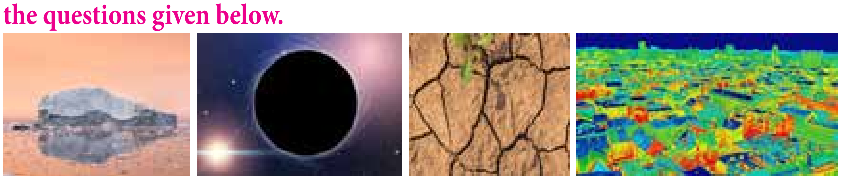


Fig. 16.14

Intoduction

Almost always the ozone has only been correlated with the hole in the ozone layer and the damages it has caused to the environment. The richness of the ozone layer that makes the hole so significant and the science behind the hole is far less popular. Schonbein in the year 1840 confirmed its existence and Jacques-Louis Soret rooted the chemical formula of ozone as O_3 and proved that ozone is an allotropic form of Oxygen.

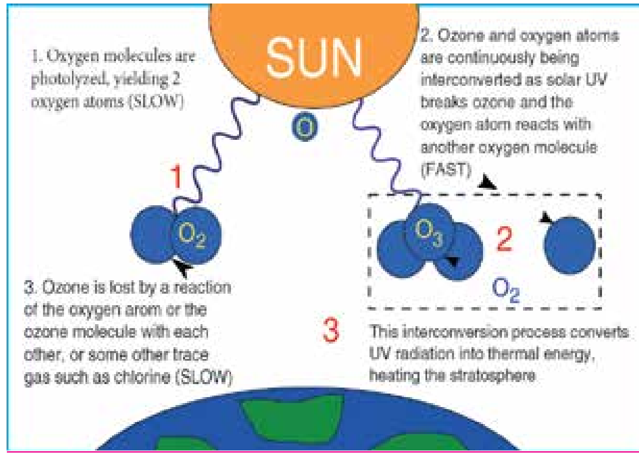


Fig. 16.15

The importance of ozone is defined by the fact that it protects the earth from harmful ultraviolet rays from the sun. The ozone layer is found in the upper regions of the stratosphere where it protects the earth from the harmful ultraviolet rays of the sun. These radiations can cause skin cancer in humans. The ultraviolet rays split the oxygen molecule into free oxygen atoms, these free oxygen atoms combine with the oxygen molecule to form ozone. This salient layer lies at a distance of 12-15 miles beyond the earth surface.

According to United Nations Environment Program, significant depletion of the Arctic ozone layer now occurs in most years in the late winter and early spring period (January–March). However, Arctic ozone depletion is less severe than that observed in the Antarctic and exhibits larger year-to-year differences as a consequence of the highly variable meteorological conditions found in the Arctic polar stratosphere. Even the most severe Arctic ozone depletion does not lead to total ozone amounts as low as those seen in the Antarctic, because Arctic ozone abundances during early winter before the onset of ozone depletion are much larger than those in the Antarctic. Consequently, an extensive and recurrent "ozone hole", as found in the Antarctic stratosphere, does not occur in the Arctic.

The abundance of globally averaged total ozone is now about 2–3% below the amount present during 1964–1980. The abundance of global total ozone declined steadily throughout the 1980s due to the increase in reactive halogen gases in the stratosphere resulting from human activities. In the early 1990s, global total ozone was depleted by 5% relative to the 1964–1980 average, the maximum depletion observed during the modern instrument era. In both hemispheres, total ozone depletion is small near the equator and increases toward the poles. The larger depletion at higher latitudes is due, in part, to the late winter/early spring destruction of ozone that occurs in polar regions, particularly in Antarctica.

Ozone depletion is not the principal cause of global climate change. Ozone depletion and global climate change are linked because both ozone-depleting substances and their substitutes are greenhouse gases. Ozone is also a greenhouse gas, so stratospheric ozone depletion leads to surface cooling. Conversely, increase in tropospheric ozone and other greenhouse gases lead to surface warming. The cooling from ozone depletion is small compared to the warming from the greenhouse gases responsible for observed global climate change. The Antarctic ozone hole has contributed to changes in Southern Hemisphere surface climate through effects on the atmospheric circulation.

Antarctic ozone hole

The 2021 Antarctic ozone hole reached its maximum area on October 7 and ranks 13th largest since 1979, scientists from NOAA and NASA reported 27th october 2021. This year's ozone hole developed similarly to last year's: A colder than usual Southern Hemisphere winter lead to a deep and larger-than-average hole that will likely persist into November or early December.

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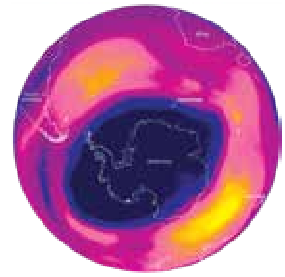
Southern Hemisphere ozone levels (oct. 7, 2021)



The 2021 Antarctic ozone hole reached its maximum area on October 7 and ranks 13th largest since 1979, scientists from NOAA and NASA reported

Fig. 16.16

This is a large ozone hole because of the colder than average 2021 stratospheric conditions, and without a Montreal Protocol offsite link, it would have been much larger. What we call the ozone hole is a thinning of the protective ozone layer in the stratosphere (the upper layer of Earth's atmosphere) above Antarctica that begins every September. Chlorine and bromine derived from human-produced compounds are released from reactions on high-altitude polar clouds.

The chemical reactions then begin to destroy the ozone layer as the sun rises in the Antarctic at the end of winter.

Ozone Layer

Certain industrial processes and consumer products result in the emission of ozone-depleting substances (ODSs) to the atmosphere. ODSs are manufactured halogen source gases that are controlled worldwide by the Montreal Protocol. These gases bring chlorine and bromine atoms to the stratosphere, where they destroy ozone in chemical reactions. Important examples are the chlorofluorocarbons (CFCs), once used in almost all refrigeration and air conditioning systems, and the halons, which were used as fire extinguishing agents. Current ODS abundances in the atmosphere are known directly from air sample measurements.

Ozone is the molecule of three oxygen atoms(O_3). It is found in stratosphere. It is the protective layer that protects by absorbing about 99% harmful ultraviolet radiation. This layer helps to maintain balance in temperature and weather.

Ozone molecules are naturally formed in the atmosphere due to influence of ultraviolet radiation. When ultraviolet rays strike the stratosphere, oxygen molecules break into oxygen atoms and combine with oxygen atoms to form ozone.

$$O_2 \xrightarrow{\text{UV rays}} \underset{\text{atomic oxygen}}{[O] + [O]}$$

$$O_2 + O \longrightarrow O_3$$

Importance of Ozone Layer

i. It protects us from the severe burn due to UV rays, as it absorbs about 99% harmful radiations.
ii. It maintains the balance of temperature and weather.
iii. It protects us from skin disease, cancer and deficiency of immune power.

Depletion of Ozone Layer

The thinning of ozone layer is called depletion of ozone layer. CFCs is the most responsible compound for ozone depletion in atmosphere. Harmful chlorofluorocarbon gas is used in aerosols, foams, refrigerator, air conditions, solvent, fire, extinguisher, etc. The CFCs move slowly upward to the stratosphere and are decomposed by powerful UV rays releasing nascent chlorine. The nascent chlorine atoms react with ozone and atom of oxygen is removed from ozone. A single atom of chlorine can destroy a large number of ozone molecules.

$$CF_2 + Cl_2 \xrightarrow{\text{UV rays}} CF_2Cl + Cl$$

$$CI + O_3 \xrightarrow{\text{UV rays}} ClO + O_2$$

$$CI + O \xrightarrow{\text{UV rays}} Cl + O$$

$$O + O_3 \xrightarrow{\text{UV rays}} O_2 + O_2$$

Thus, Cl and O participate in reaction and cause ozone layer depletion.

In 1985 AD, an English scientist J.C Farmann found out the first time ozone layer depletion over antarctica.

Effects of Ozone layer depletion

i. It causes different diseases like skin cancer, skin irritation, cataract, loss of immunity, etc. in human beings.
ii. It decreases the production of crops.
iii. It affects the fertility of the animals.
iv. It causes global warming.

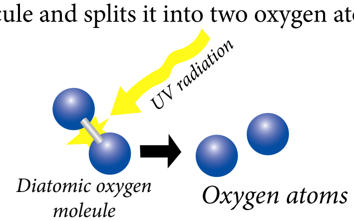
Conservation of Ozone Layer

Ozone is a protective layer. Its depletion causes various diseases. So, its conservation is essential. We can conserve the ozone layer by the following methods.

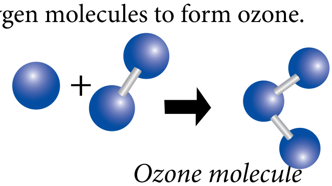
i. We should reduce or avoid the use of appliances that use CFCs and HCFCs.
ii. We should reduce the use of nitrogenous fertilizers.
iii. We should replace the fossil fuels by using alternative source of energy like wind energy, solar energy, hydro- electricity, etc.
iv. We should be aware of adverse effect of ozone layer depletion.
v. We should promote public vehicles rather than private vehicles.

Natural Ozone Production in the Stratosphere

Ultraviolet radiation from the sun strikes a diatomic oxygen molecule and splits it into two oxygen atoms.

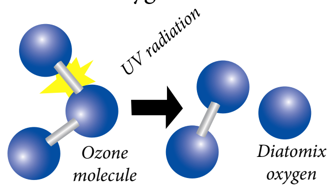


The free oxygen atoms react with diatomic oxygen molecules to form ozone.

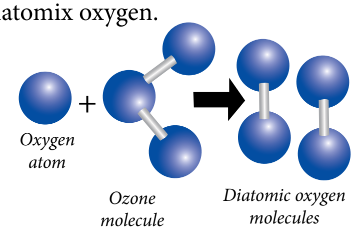


Natural Ozone Destruction in the Stratosphere

Ozone absorbs ultraviolet light in the range of 290-320 nanometers. This solar energy breaks apart the ozone molecules into diatomic oxygen molecules and oxygen atoms.



The free oxygen atom can react with an ozone molecule and form two molecules of diatomix oxygen.



Exercise

A. Choose the correct one and put the tick mark(√)

i. In presence of which catalyst is H_2 atract from water gas and steam?

a. Magnesium oxide   b. copper oxcide

c. Iron oxide   d. Nickel

ii. Which of the following compounds is used for laboratory preparation of H_2 ?

a. HCL   b. HNO_3

c. NaOH   d. $ZnSo_4$

iii. Which of the following compounds is used for laboratory preparation of O_2 ?

a. HCL   b. HNO_3

c. NaOH   d. MnO_2

iv. Which of the following statements are not true for hydrogen?

a. It exists as diatomic molecule.

b. It has one electron in the outermost shell.

c. It can lose an electron to form a cation which can freely exist

d. It forms a large number of ionic compounds by losing an electron.

v. **Which of the following statements about hydrogen are correct?**

a. Hydrogen has three isotopes of which protium is the most common.

b. Hydrogen never acts as cation in ionic salts.

c. Hydrogen ion, H+ , exists freely in solution.

d. Dihydrogen does not act as a reducing agent

vi. Hydrogen peroxide is obtained by the electrolysis of ______.

a. water   b. sulphuric acid

c. hydrochloric acid   d. fused sodium peroxide

vii. Hydrogen peroxide is _________.

a. an oxidising agent

b. a reducing agent

c. both an oxidising and a reducing agent

d. neither oxidising nor reducing agent

viii. The ozone layer prevents ___ from passing through the Earth's atmosphere.

a. Ultraviolet rays   b. Infrared rays

c. x-rays   d. all of the above

ix. **Following form(s) of oxygen is (are) involved in the ozone-oxygen cycle.**
   a. atomic oxygen (O)   b. diatomic oxygen (O_2)
   c. triatomic oxygen (O_3)   d. all of the above

x. **CFCs were used as**
   a. fuel in airplanes   b. refrigerants in cooling units
   c. paint   d. all of the above

B. Match Column I with Column II for the given properties/applications mentioned therein.

Column I	Column II
i. H	a. Steam
ii. H_2	b. Used to prepare O_2
iii. H_2O	c. Nascent
iv. H_2O_2	d. Can be used in cutting and welding.

C. Give the reason :

i. We use impure zinc for laboratory preparation of hydrogen.
ii. We should not use concentrated H_2SO_4 for laboratory preparation of hydrogen.
iii. In laboratory preparation method of O_2,the hard glass test tube should be made inclined.
iv. We should conserve ozone layer .
v. Ozone is useful as well as harmful.

D. Answer the following questions :

i. How will you prepare hydrogen gas in laboratory? Explain its properties and test ?
ii. Draw the diagram of laboratory method to produce hydrogen gas with labeled diagram.
iii. What are physical properties of hydrogen gas? Write its 4 important properties,
iv. What is hydrogenation? Write its importance in our daily life.
v. Write four uses of hydrogen ges.
vi. Write the products of compounds with balanced equation when hydrogen gas reacts with following substances.
   a. Sodium   b. Oxygen   c. Nitrogen   d. Ferric oxide
vi. Draw the clears picture and explain the laboratory method of preparation of oxygen gas without heating.
vii. Write methods of manufacturing of oxygen gas from liquid air.
ix. Write any four physical properties of oxygen gas.
x. You are given gas in a gas jar. How would you make sure the gas is ‘oxygen or not?
xi. What happens when metals or non-metal burns in presence of oxygen? Explain with example.
xii. Write any four uses of oxygen gas.
xiii. Draw a picture of laboratory method of preparation of nitrogen gas.
xiv. Write a balanced chemical equation of reaction between nitrogen gas and oxygen gas.
xv. Write any four physical properties of nitrogen gas.
xvi. Write three uses of nitrogen gas.
xvii. What is ozone layer ? How do CFCs cause ozone layer depletion?
xviii. List the name of the compounds along with their source, which cause ozone layer depletion.
xix. How does ozone layer depletion affect the earth?
xx. Ozone layer depletion raises the temperature of the earth. How ?
xxi. How can we conserve ozone layer? Give three points.

E. Complete the following chemical equations and balance.

i. $H_2 + \ldots\ldots\ldots\ldots \longrightarrow H_2O$

ii. $Na + H_2 \xrightarrow{\text{burns}} \ldots\ldots\ldots\ldots$

iii. $\ldots\ldots\ldots\ldots \xrightarrow{\text{burns}} KCl + O_2$

iv. $\ldots\ldots\ldots + O_2 \longrightarrow CO_2 + 2H_2O + \text{energy}$

v. $\ldots\ldots\ldots\ldots \xrightarrow{\text{electrolysis}} H_2 + O_2$

vi. $P + 5O_2 \longrightarrow \ldots\ldots\ldots\ldots$

vii. $Mg + N_2 \xrightarrow{\text{Heat}} \ldots\ldots\ldots\ldots$

viii. $Mg_3N_2 + \ldots\ldots\ldots\ldots \longrightarrow Mg(OH)_2 + NH_3$

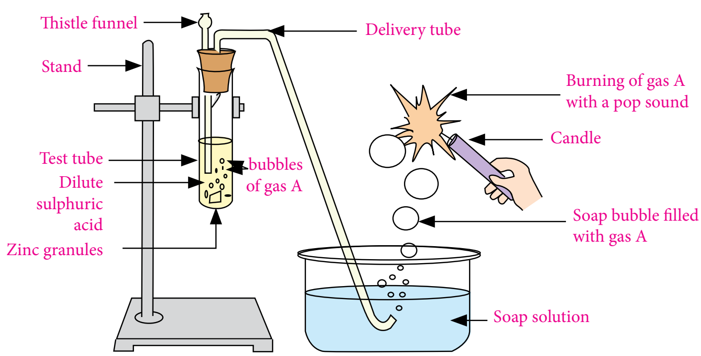
ix. $NH_4cl + \ldots\ldots\ldots\ldots \xrightarrow{\text{Heat}} N_2 + H_2O + Nacl$

x. $CF_2 + Cl_2 \xrightarrow{\text{UV rays}} \ldots\ldots\ldots\ldots + \ldots\ldots\ldots\ldots$

xi. $Cl + O \xrightarrow{\text{UV rays}} Cl + \ldots\ldots\ldots\ldots$

F. Diagrammatic questions

i. Study the diagram below and answer the following questions.



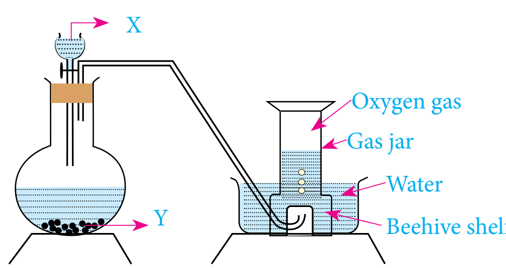
a. Identify gas 'A' .

b. Write any four precuations for 'A' while preparing in laboratory.

c. What happens when the gas 'A' reacts with carbon and sodium ? Write with balanced equation .

d. Write any four uses of 'A'.

ii. The set up below was used to prepare dry hydrogen gas. Study it and answer the questions that follow.



a. Identify one mistake in the set-up above

b. What is the role of Liquid Z?

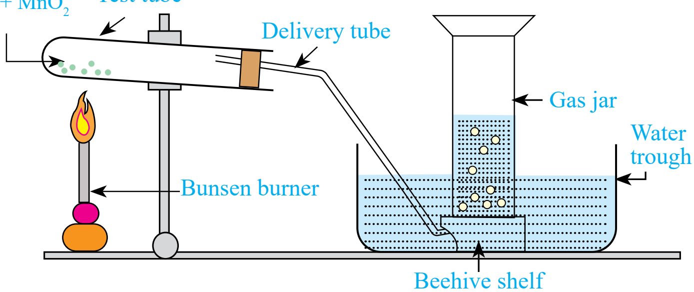
c. Using an equation give one chemical property of hydrogen gas

iii. **The set up below can be used to prepare oxygen gas. Study it and answer the questions that follow.**

a. Identify substance X and Y

b. What property of oxygen makes it possible for it to be collected as shown in the above set up?

iv. **Study the given diagram and answer the following questions :**



a. Which gas is collected in the gas jar ?

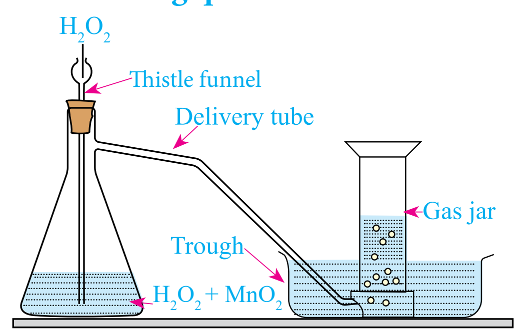
b. Write chemical equation for the preparation of this gas.

v. **Study the given diagram and answer the following questions :**

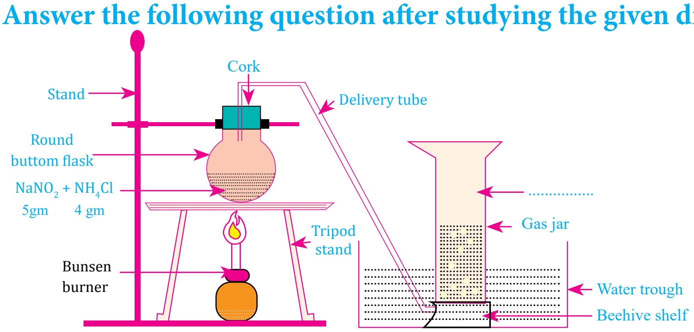
a. Which gas is collected in the gas jar ?

b. Write chemical equation for the preparation of this gas.

c. Write the chemical equation for the reaction for the reaction between this gas and carbon.



v. **Answer the following question after studying the given diagram.**



a. Which gas is being collected in the gas jar?

b. What are the chemicals used in the preparation of given gas?

c. Show two steps of balanced chemical reaction in the preparation of the given gas.

Unit 17
Metals and Non-metals

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- distinguish between metals and non-metals
- mention the sources and importance of essential minerals for the human body
- write down the names of the sources of mercury and lead that can enter the human body and to find out their negative effects

Marie Curie, née **Maria Salomea Skłodowska,** (1867- 1934), Polish-born French physicist and chemist, famous for her work on radioactivity and twice a winner of the Nobel Prize. With Henri Becquerel and her husband, Pierre Curie, she was awarded the 1903 Nobel Prize for Physics. She was the sole winner of the 1911 Nobel Prize for Chemistry. She was the first woman to win a Nobel Prize, and she is the only woman to win the award in two different fields.

Fig. 17.1

Look at the pictures above and discuss:

i. What did you see in the picture?
ii. Are these all objects interconnected?
iii. Distinguish metals and non-metals ?
iv. Which metals / non-metals are these items made of ? Identify and write the name ?
v. Mention the names of any five metals which you have seen and write down their uses.

17. Introduction

The objects around us are made up of different matters, like wood, plastic, glass, copper, iron, gold, silver etc. These matters may be elements or compounds. Pure matters can be divided into three groups metal, non-metal and metalloid. Metals are used in motors, aeroplane, train etc. Without these objects our life can't be easier. If iron metal found in our blood and magnesium found in chlorophyll are absent, no one can exists in the earth. What will happen if zinc element is absent in our body. Due to zinc metal, our nose can feel smell. What are the important properties of these elements? What is the difference between metal and non-metal? What are the role of metals? We study about this in this lesson.

Metals possess metallic luster when they are freshly cut or line is drawn on them except alkali metals. Alkali metals such as sodium (Na) and potassium (K) are highly reactive metals. So, they are stored in kerosene because they can easily catch fire even when they come in contact in air.

a. Physical properties of metals

The physical properties given in the chart can be studied through different activities.

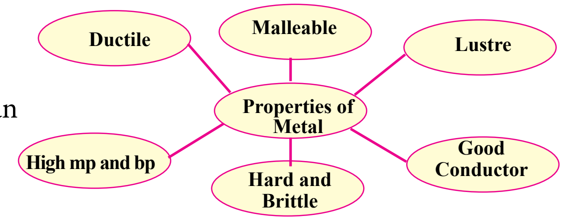


Fig. 17.2

Activity 17.1

Hardness of metal

Test the hardness and softness of piece of wood, piece of copper, iron nail, aluminium pot, sulphur coal, etc, separately by touching. Try to break down and copy the results in following table.

Bodies	Softness or hardness	break down easily or not	Result
Iron nail	hard	can't break down easily	
Coal			
Copper piece			
Aluminium pot			
Sulphur			

From the above activity, it is clear that metals are hard. They can't be made pieces easily. But all metals are not hard such as lithium, sodium and potassium. These metals are not hard and can be easily made into pieces. At normal temperature mercury is found in liquid state.

Activity 17.2

Lustre property of metal

Take zinc plate, copper pot, gold foil, paper, phosphorus etc. Which one has more lustre? Which one does not have lustre? Observe them. These bodies are scratched separately by iron nail and observe it. Make the following table and copy it.

Bodies	Shine or not	Result
Coal		
Copper		
Sulphur		
Zinc plate		
Gold		
Paper		

Metals shine, which is called metallic lustre. Due to presence of free electrons they have shining property. Non-metal does not shine.

Activity 17.3

Malleability

Beat the above bodies with a hammer slowly. What changes occur in that bodies? Observe it and fill the following table according to that change.

Objects that can be changed into plate form	Objects that can't be changed into plate form

Even though metals are hard, when metals are beaten by hammer or heated, they change into sheet form. Because of this properties, different bodies can be made from metals. This property of metal is called malleability.

Activity 17.4

Ductility

From which metals wires can be made? Fill in the table with correct information by taking help of your classmates.

Objects that can be changed into wire form	Objects that can not be changed into wire form

Wire can be made by stretching (drawing) the metals slowly. Due to this property metal do not change. This property of metal is called ductility.

Activity 17.5

Conducting property for electricity

Take dry cell, wire and a bulb and make a electric circuit as shown in figure.

Put paper, sulphur, copper, iron, aluminium, wood etc. separately between the space AB of the electric circuit. Which bodies do make bulb glow when that are connected in circuit? The body which make the bulb glow is metal and metal allows the flow of current through it.

Conducting bodies	
Non conducting bodies	

Activity 17.6

Conductor of heat

Take a candle light and match box. Heat the steel spoon, iron nail, pencil, wooden piece etc. separately and hold it at another end by your hand. Do you feel hot when they are heated at another end ?

Fill in the following table and make results in your own way.

Bodies	Conductor of heat or not	Result

Metals are good conductor of heat. Generally, non-metals are bad conductor of heat.

The attraction force between molecules of metal is strong. So, they are strong and hard. The melting point and boiling point of metals are very high. The boiling point and melting point of some metals are given below.

Metals	Melting points	Boiling points
Mg	650°C	1107°C
Al	660°C	2467°C
Fe	1535°C	2750°C
Cu	1083°C	2567°C
Na	97.79°C	882.94°C
K	63.5°C	759°C

Table 17.1

Melting and boiling points of sodium and potassium are very low than that of the other metals.

When metals are mixed at molten state without chemical reaction, homogeneous mixture of metals are formed that is called alloy. Bronze is the example of this kind.

Activity 17.7

It can produce sound

Take rod and metal utensil. Hit the utensil with rod. What kind of sound can you hear? What is the similarity between this sound and cycle bell or classroom bell of your school? Discuss in classroom. When metal is hit, it produces "Ting" sound called sonorous.

b. Chemical properties of metals

Metals are electropositive in nature. They generally have 1, 2 or 3 electrons in their valence shells and readily lose these electrons to form positively charged ions (cations). These cations are stable as they acquire noble gas configuration after losing the valence shell electrons.

e.g. $Na(g) \longrightarrow Na^{+}(gas) + e^{-}$

2,8,1 2,8

During electrolysis of their aqueous solutions they are discharged at the cathode. On the other hand non-metals are electronegative in nature. They generally have 5,6 or 7 electrons in their valence shells.

They have tendency to form anion by gaining electrons.

$Cl(g) + e^{-} \longrightarrow Cl^{-}(g)$

2,8,7 2,8,8

Let us now understand some common chemical reactions of metals.

Reaction of metals with Oxygen

Most of the metals react with oxygen and form oxides. The reaction may take place without heating as in sodium, calcium or potassium, while some metals react with oxygen on heating to form oxides.

$4Na(s) + O_2(g) \longrightarrow 2Na_2O(s)$ $\quad$ $Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$

Oxides of metals are basic in nature as they react with water and form bases

e.g. Na_2O, CaO, MgO, K_2O etc.

$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$ $\quad$ $CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq)$

Oxides of aluminium (Al_2O_3), zinc (ZnO), tin (SnO) and iron (Fe_2O_3) are amphoteric in nature as they react with acids as well as with bases.

$Al_2O_3(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2O(l)$

$Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(l)$

Reaction of metals with acids

Metals react with common acids like dilute HCl and dilute H_2SO_4 with evolution of H_2. The reaction of Mg ribbon with dil. HCl is represented in figure below.

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$

$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2$

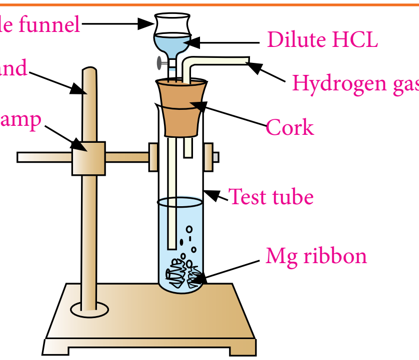


Fig. 17.3

Reaction of Metals with Water

Many metals react with water to form hydroxides. Hydroxides are basic in nature. Sodium and potassium react with cold water.

$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$

$2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$

Magnesium reacts with hot water

$Mg(s) + H_2O(l) \longrightarrow Mg(OH)_2(aq) + H_2(g)$

Metals like Al or Fe react on heating with water or with steam. In these conditions metals form metal oxides.

$2Al(s) + 3H_2O(g) \longrightarrow Al_2O_3(s) + 3H_2(g)$ (steam)

$Fe(s) + 4H_2O(g) \longrightarrow Fe_3O_4(s) + 4H_2(g)$ (steam)

Reaction of metals with Common bases

Some metals like aluminum and zinc react with common bases.

$Sn(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2SnO_3$ (sodium stannate)
$Zn(s) + 2NaOH(aq) \longrightarrow Na_2ZnO_2$ (Sodium zincate)

Differences between metal and non-metals

S. N.	Property	Metal	Non-metal
1.	Hardness	Hard and can't be made piece easily.	Soft and can be made piece easily.
2.	Malleability	Malleable	Not malleable
3.	Ductile	Can be drawn into wire.	They are brittle
4.	Lustre	Possess metallic lustre.	Do not possess metallic lustre.
5.	Conduction of electricity and heat	Good conductor of heat and electricity.	Poor conductor of heat and electricity.
6.	Melting and boiling point	Generally, melting and boiling point is high.	Generally, melting and boiling point is low.

Table 17.2

Some metals needed for the human body

Zinc

Zinc is found in organism in a very small amount. But it has great importance. About 300 enzymes of human body contain zinc. An adult human body contains about 2 g to 3 g of zinc. Almost all organs of our body's cell, bone, juice etc contain zinc. About 90% of zinc is found in muscles and bones.

High concentration of zinc is found in prostate gland and semen. Similarly, our retina contains more zinc. With increasing age, amount of zinc decreases. Zinc is found in compound and ion state not in element state.

Importance of zinc in human life

i. It is essential for the development of embryo in mother's womb.
ii. It is needed for the sense of smell and taste.
iii. It is needed to increase the fertility of men and to regulate menstrual cycle of women.
iv. It helps to maintain immune system of the body against diarrhoea, pneumonia and common cold.
v. It is essential to treat anorexia (loss of appetite) in people.
vi. It plays a role in cell division, cell growth and wound healing.
vii. It is also essential to treat sporiasis and neurodermatitis.

Sodium and potassium ions

Sodium and potassium metals are present in the form of ions in human body. They are present inside and outside the cell. These ions play very important role in the functioning of nervous system. There is an interesting mechanism for the exchange of ions in cells. The sodium ions present outside the cell when enter into it, the potassium ions leave the cell. This process occurs at the same time.

The process in which the sodium ions enter the cell and potassium ions leave it at the same time is called sodium-potassium pump.

Importance of sodium and potassium ions

The sodium-potassium pump is essential for several processes in the human body.

i. It is essential to exchange information between neurons and brain.
ii. To maintain the pH of electrolyte in the cell.
iii. To keep the muscles healthy.
iv. To regulate the heartbeat and body temperature, etc.

Proper quantity of sodium and potassium ions and their optimum regulation is essential for the body. Poor functioning of sodium-potassium pump may result in muscular spasm, paralysis, migraine, abnormal blood pressure etc.

Harmful effect of Mercury and Lead

Although some metals are crucial for growth, development and functioning of the human body, some metal ions have adverse effects in human health. Mercury and lead are extremely harmful for the human health.

Mercury

Poisoning effect of mercury is called hydrogyria or mercurialism. Even a single drop of mercury may block blood vessels and cause death. The compound of mercury has the following adverse effects in human health.

i. The compounds of mercury damage the brain.
ii. They also weaken the ability to speak, hear and see things.
iii. They easily pass through placenta and adversely affect the growth and development of foetus.
iv. They also damage kidneys and lungs.
v. They adversely affect the development of brain of a child.

Lead

Lead is also a poisonous metal. It harms almost all organs of the body. The compounds of lead have the following adverse effects in the human health.

i. Lead mainly damages the human brain.
ii. It can cause headache, abdominal pain, change in behaviour, anaemia etc. in children.
iii. It also hampers the development of brain in children.
iv. Blood can not combine with oxygen in presence of lead which causes anaemia.
v. It also affects the calcium absorption by bone which causes weakening of bones.

Metalloids

Elements like silicon (Si), Arsenic (As), antimony (Sb), germanium (Ge) etc. show the properties of both metals and non-metals. Such elements are called metalloids.

Characteristics of Metalliods

i. They are semi conductor of heat and electricity.
ii. They have metallic luster.
iii. They can form alloys.
iv. They are neither malleable nor ductile.

Exercise

A. Choose the correct one and put the tick mark(√).

i. The ability of metals to be drawn into thin wire is known as:

a. ductility b. malleability
c. sonorousity d. conductivity

ii. **Which of the following property is generally not shown by metals?**
   a. Electrical conduction b. Sonorous in nature
   c. Dullness d. Ductility

iii. **Which one of the following metals do not react with cold as well as hot water?**
   a. Na b. Ca
   c. Mg d. Fe

iv. **Which of the following oxide(s) of iron would be obtained on prolonged reaction of iron with steam?**
   a. FeO b. Fe_2O_3
   c. Fe_3O_4 d. Fe_2O_3 and Fe_3O_4

v. **Generally metals react with acids to give salt and hydrogen gas. Which of the following acids does not give hydrogen gas on reacting with metals (except Mn and Mg)?**
   a. H_2SO_4 b. HCI
   c. HNO_3 d. All of these

vi. **Stainless steel is very useful material, for our life. In stainless steel, iron is mixed with**
   a. Ni and Cr b. Cu and Cr
   c. Ni and Cu d. Cu and Au

vii. **Generally metals are solid in nature. Which one of the following metals is found in liquid state at room temperature?**
   a. Na b. Fe
   c. Cr d. Hg

viii. **Generally non-metals are not lustrous. Which of the following non-metals is lustrous?**
   a. Sulphur b. Oxygen
   c. Nitrogen d. Iodine

ix. **An element A is soft and can be cut with a knife. This is very reactive to air and cannot be kept open in air. It reacts vigorously with water. Identify the element from the following.**
   a. Mg b. Na
   c. P d. Ca

x. **Which of the following methods is suitable for preventing an iron frying pan from rusting?**
   a. Applying grease b. Applying paint
   c. Applying a coating of zinc d. All of the above

B. Give the reason :

i. Sodium is kept immersed in kerosene oil.
ii. Gold and platinum are the two metals found in free state in nature.
iii. Platinum, gold and silver are used to make jewellery.
iv. Sodium, potassium and lithium are stored under oil.
v. Aluminium is a highly reactive metal, yet it is used to make utensils for cooking.
vi. Copper is used to make hot water tanks and not steel (an alloy of iron).

C. Differentiate with examples

i. Metals and Non-metals
ii. Good conductor and Bad conductor

iii. Melting point of metals and non-metals
iv. Malleability and Ductility

D. Answer the following questions :

i. What are the physical properties of metal? Explain with two examples.
ii. Write any five differences between metal and non metal.
iii. Iodine shines like metal but it is not metal. What is the reason behind it?
iv. How can you verify that metal can conduct electricity? Explain.
v. Metal has high melting and boiling point. What is the reason behind it?
vi. Write any three chemical properties of metal and explain each with examples.
vii. Iron can be electroplated by copper but not by silver why?
viii. What are the effects of deficiency of zinc in our body? Write four points.
ix. What are the role of sodium and potassium ions in human body?
x. What are the adverse effects of Hg and Pb in human life? Write two negative effects for each.
xi. You must have seen tarnished copper vessels being cleaned with lemon or tamarind juice. Explain why these sour substances are effective in cleaning the vessels.
xii. Differentiate between metal and non-metal on the basis of their chemical properties.
xiii. A man went door to door posing as a goldsmith. He promised to bring back the glitter of old and dull gold ornaments. An unsuspecting lady gave a set of gold bangles to him which he dipped in a particular solution. The bangles sparkled like new but their weight was reduced drastically. The lady was upset but after a futile argument the man beat a hasty retreat. Can you play the detective to find out the nature of the solution he had used?
xiv. Make a list of the following metal sources needed by the human body

Metal	**Iron (Fe)**	**Zinc (Zn)**	**Sodium (Na)**	**Potassium(k)**
Sources				

xv. Complete the following table :

Element	**Mercury**	**Lead**
Harmful effect	(a)................................ (b)................................ (c)................................	(a)................................ (b)................................ (c)................................

E. Give an example of a metal which

i. Is a liquid at room temperature?
ii. Can be easily cut with a knife?
iii. Is the best conductor of heat?
iv. Is a poor conductor of heat?

F. Write equations for the reactions of

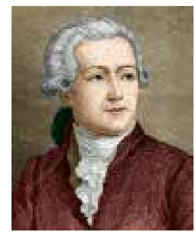
i. iron with steam
ii. calcium and potassium with water

Unit 18
Carbon and its Compounds

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- point out the presence of carbon in common substances like wood, sugar, fats etc.
- describe physical and chemical properties of carbon
- distinguish between organic and inorganic compound
- illustrate the usefulness of organic compounds in daily life



Antoine Lavoisier, in full **Antoine-Laurent Lavoisier**, (1743-1794), prominent French chemist and leading figure in the 18th-century chemical revolution who developed an experiment based theory of the chemical reactivity of oxygen and coauthored the modern system for naming chemical substances. Lavoisier named the elements carbon, hydrogen and oxygen; discovered oxygen's role in combustion and respiration; established that water is a compound of hydrogen and oxygen; discovered that sulfur is an element, and helped continue the transformation of chemistry from a qualitative science into a quantitative one.

Look at the pictures below and discuss:

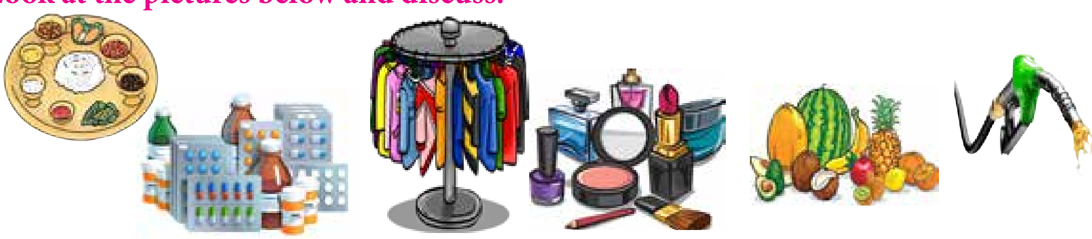


Fig. 18.1

i. What did you see in the pictures ?

ii. How do you use these items in your daily life?

iii. Is your daily life possible without these items?

iv. Identify a common factors between these items .

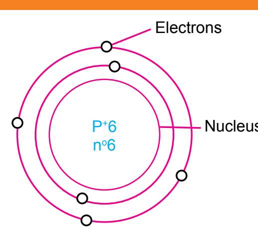
v. What could be its sources?

18.1 Carbon

Some information about carbon

Atomic number	6
Atomic weight	12 amu
Group in periodic table	IV A
Period in periodic table	2
Valency	4
electronic configuration	2,4 ($1s^2$, $2s^2$, $2p^2$)

Table 18.1



Atomic model of carbon

Fig. 18.2

The word 'Carbon' word came from Latin word, Charcoal. From the ancient time people identified it as charcoal. Many substances are of the type of carbon. Similarly, man knew it very early before about coal and coke. Then man found diamond and graphite that are made up from carbon. Carbon is present in all living things.

Carbon is abnormal non-metal which has four covalent bond with other carbons atom and it can make covalent bond easily with other elements. Due to this property of carbon till now, more than 10 millions carbon compounds are found in the world. So, what are the properties of carbon? How is the carbon compound? In this lesson we study about this in detail.

The electronic configuration of carbon shows that carbon has four valence electrons. It indicates that carbon can attain a stable electronic configuration like that of inert gases in the following ways.

i. It can lose four valence electrons
ii. It can gain four electrons in its valence shell.
iii. It can share its four valence electrons with other atoms.

The energy consideration, however, suggests that loss or gain or four electrons by a carbon atom is not possible. Hence, carbon cannot form electrovalent bonds with other atoms. The only possibility to attain stable electronic configuration is that a carbon atom should share its four valence electrons with other atoms. So, it forms covalent bond and its compounds are covalent in nature.

Carbon in common materials

Carbon is the component of all living organisms. Our all body parts from the head to the leg contain different compounds of carbon. Is there carbon compounds in our wearing cloth, bench, table, etc? Think about it. All substance which are made from animals and plants contain carbon.

Generally, colour of carbon is black and easily burnt with air. When carbon burns, it produces sooty flame with heat and light. If any substance burns with sooty flame, heat and light remains of burnt is black solid because that substance contains carbon.

Activity 18.1

Collect some materials like piece of wood, sugar, oil, ghee, kerosene, tong, spatula, burner, match box and do the following activities.

i. At first hold piece of wood by spatula and burn it. Then observe it.
ii. Put oil, ghee, kerosene etc. separately in spatula and burn it. Observe it.
iii. Put some sugar in spatula and heat it slowly and observe what happens to sugar and its colour? In which colour of sugar makes good smell? In this state sugar changes into caramel. What happens at last? The remain of burnt sugar is black substance which has bad smell is called sugar charcoal.

After doing above activity discuss in the class. What happens when carbon compounds burn? Make conclusion about this.

If so in which substances, are carbon found?

Sources of carbon

Carbon in elements form	Carbon in organic form	Carbonic compound founding nature	Carbon in gas form
Coal	carbonates	carbohydrate	CO_2
Coke	bicarbonates	protein, fats	CO
Charcoal	carbides	petrol, urine, vitamin	hydrocarbon gases
Diamond	(CaC_2, sic)	silk, paper, soap etc.	methane
Graphite	mineral		ethane
Graphene	stones		LPG

Table 18.2

How is it possible to form this great number of carbon compound?

Nature of carbon

Carbon atom is a non-metal with atomic number six. Its valency shell has four valence electrons. So, valency of carbon atom is 4. To make octet state, it shares all four elements and forms four covalent bond. Carbon atoms form covalent bond from one carbon to another carbon or other elements. Carbon has strange property that it can form covalent bond from one carbon to another carbon. Generally, other elements when form covalent bond they share their electrons with one or two of its other atoms like O2 and O3. But, carbon can make four covalent bond with other for carbon atoms. In this way, from one carbon atom to another carbon atoms produces long chain of carbon. This property of carbon is called catenation.

Catenation

Carbon has unique ability of forming covalent bonds with other atoms by giving rise to long chain molecules of compounds.

The catenation is a unique property of a carbon atom to link with other carbon atoms forming a long chain or branch chain with the help of covalent bonds.

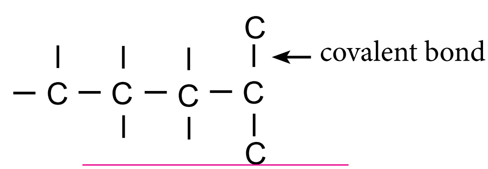


Fig. 18.3

Catenation is the main reason for the presence of a large number of organic compounds in nature. Polythene and polyvinyl chloride (PVC), etc. have a long chain of carbon attached to one another forming a large number of compounds.

The property of carbon atom due to which its atoms form a long chain by combining with one another is called catenation.

Tetravalency

Carbon has four valence electrons having valency four. This valency of carbon is responsible for making it capable for bonding with four other carbon atoms or atoms of other elements. Carbon also forms compounds with oxygen, nitrogen, chlorine, sulphur and many other elements. This gives some specific properties to carbon compounds.

Note : The properties of carbon such as catenation and tetravelency can form hundreds of thousands of carbon compounds. Therefore, carbon is the only element whose compounds constitute a separate branch of chemistry, that is called organic chemistry.

The organic chemistry is the branch of chemistry that deals with the study of carbon and its compounds i.e. substance derived or found in living organisms.

Due to four valency of carbon and its catenation property, carbon can produce number of compounds. In chemistry it has separate branch to study about carbon compound called organic chemistry.

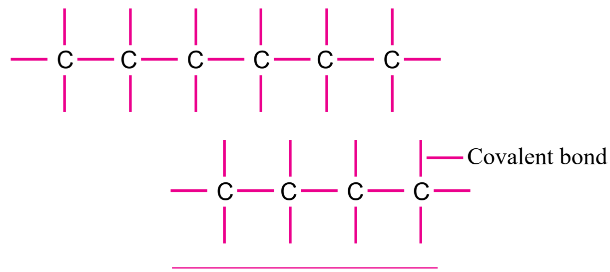


Fig. 18.4

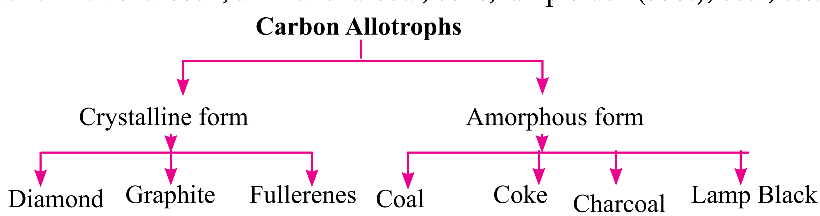
Allotropes of carbon

Carbon exists in different states. These forms differ in physical properties such as melting point, boiling point, colour, density conductivity. However, they are chemically same. These compounds exhibit similar chemical properties. These different forms of carbon are called allotropes. The property of an element by virtue of which it can show many physical forms and have similar chemical properties is called allotrophy.

Carbon is known to exist in two distinct allotropic forms. They are :

Crystalline forms : diamond, graphite and fullerene

Amorphous forms : charcoal , animal charcoal, coke, lamp black (soot), coal, etc.



In above table, there are some sources which have only carbon elements such as coal, diamond, graphite etc. These are the forms of carbon. The different forms of carbon element are called allotropes and the process is called allotropy.

The property of an elements to exist in different physical forms with slightly different chemical properties is called allotropy.

Differences between Diamond and Graphite

Diamond	Graphite
i. It is the hardest known substance.	i. Graphite is soft and slippery.
ii. It is a transparent and colourless substance with bright appearance.	ii. It is an opaque, dark gray and shiny substance.
iii. Its specific gravity is 3.5.	iii. Its specific gravity is 2.2.
iv. It is a bad conductor of heat and electricity.	iv. It is a good conductor of heat and electricity.

Table 18.3

18.2 Physical and Chemical Properties of Carbon

Physical properties of carbon

Allotropes of carbon may have different physical properties, but there are some common properties which are given below.

i. It is found in solid state, such as diamond, graphite, etc.
ii. It is not soluble in water.
iii. At high temperature, it directly converts into gaseous state.
iv. It is black in colour but diamond is colourless.
v. It is bad conductor of electricity and heat. But graphite is good conductor for electricity.
vi. Its density lies between 1.5 to 3.5.

Chemical properties of carbon atom

Reaction with steam : When carbon is heated with steam (water vapour) at above 900°c – 1000°c, a mixture of carbon monoxide and hydrogen is produced.

i.e. $$\underset{\text{(Steam)}}{C + H_2} \xrightarrow{900°c - 1000°c} \underset{\text{Water gas}}{CO + H_2}$$

The mixture of carbon monoxide and hydrogen gas is called water gas. Water gas is used as the source of heat in different industries as it produces large amount of heat on burning.

i. Combustion

In the presence of oxygen carbon burns and produces carbon dioxide but insufficient of oxygen gas which gives carbon monooxide.

$C + O_2 \xrightarrow{\text{burns}} CO_2 + \text{Heat}$ $\qquad$ $2C + O_2 \xrightarrow{\text{burns}} 2\,CO + \text{Heat}$

ii. Reducing property

a. It produces metal from less reactive metal oxide.

$ZnO + C \longrightarrow Zn + CO$ $\qquad$ $PbO + C \longrightarrow Pb + CO$

b. When carbon reacts with calcium oxide and silicon oxide, it produces carbides

$SiO_2 + 3C \longrightarrow SiO + 2CO$ $\qquad$ $2CaO + 6C \longrightarrow 2CaC_2 + 2CO$

c. When water steam at 1000°C is passed into carbon, it produces carbon monoxide and hydrogen gas called water gas.

$C + H_2O \xrightarrow{1000^0c} CO + H_2$ (water gas)

18.3 Organic and Inorganic Compounds

Before the synthesis of organic compounds in laboratory, it was believed that organic compounds were produced only by natural process conducted in different organs of plants and animals. In the past time, it was believed that the formation of organic compounds in living organisms took place under the effect of vital force (a mysterious force) and they could not be synthesized in the laboratory.

It was in 1828 AD that the German chemist Friedrich Wohler prepared an organic substance i.e. he synthesized urea in laboratory by heating an organic compound ammonium cyanate and proved the concept of the vital force of life. i.e.

$$\underset{\substack{\text{Ammonium cyanate}\\ \text{(Inorganic compound)}}}{NH_4CNO} \xrightarrow{\text{Heat}} \underset{\substack{\text{urea}\\ \text{(Organic compound)}}}{NH_2 - CO - NH_2}$$

Thereafter, numerous organic compounds were synthesized in laboratory. Therefore, the term organic is now used in a broad sense to describe all compounds of carbon, whether they are natural or artificial. Methane, ethane, alcohol, ether, wax, sugar, kerosene, fatty acids, glycerol, esters, etc. are some of the examples of organic compounds. The organic compounds are studied under the branch of chemistry called organic chemistry.

Organic compound

The compounds which contain carbon and hydrogen combined together with other elements are called organic compounds.

The organic compounds which contain hydrogen and carbon only are called hydrocarbons. Methane. ethane, propane, etc. are some examples of organic compounds.

The branch of chemistry concerned with the compounds of carbon is called organic chemistry.

Inorganic compound

The compounds which are obtained from minerals are called inorganic compounds. They do not contain hydrogen and carbon bond together. Water, common salt, sulphuric acid, etc. are some examples of inorganic compounds.

Generally, inorganic substances do not contain carbon, but it is not always the case. Sodium chloride, sulphuric acid, magnesium sulphate, potassium chloride, hydrochloric acid, sodium hydroxide, calcium hydroxide etc. are some examples of inorganic compounds.

The branch of chemistry which deals with the study of inorganic compounds or compounds of elements other than carbon is called inorganic chemistry.

Note : Some carbon compounds like carbondioxide, carbon monoxide (CO), carbonates and bicarbonates of metals (eg - K_2CO_3, $CaCO_3$, $Mg(HCO_3)_2$ etc) contain carbon but they are traditionally considered to be the inorganic compounds.

Difference between Organic and Inorganic Compounds

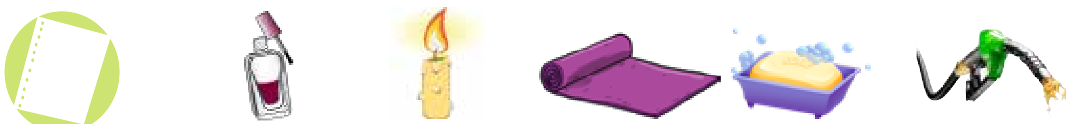
Organic Compounds	Inorganic Compounds
i. Generally, organic compounds are insoluble in water. For example, oil, ghee, wax, kerosene etc.	i. Generally, inorganic compounds are soluble in water. For example. NaCl, $CuSO_4$, HCl etc.
ii. They are soluble in organic solvent e.g. wax, kerosene, oil, petrol etc. get dissolved in ether.	ii. They are insoluble in organic solvent e.g. NaCl is insoluble in kerosene.
iii. They have generally low melting and boiling point.	iii. They have generally high melting and boiling point.
iv. They are more combustible e.g. wood, L.P.G., kerosene.	iv. They are less combustible e.g. NaCl, $CuSO_4$, etc.
v. They are covalent compounds.	v. Generally they are ionic compounds (electrovalent) and sometimes covalent as well.
vi. Generally, they do not form ions easily in water but some organic acids (e.g. carbonic acids) may form very less ions which act as weak electrolytes.	vi. Generally, they form ions in water, and act as strong electrolytes.

vii. The composition of organic compound is complex.	vii. The composition of inorganic compound is simple.
viii. There are more than 50,000 such compounds. e.g. alcohol, ether, ester, glycerol, petrol, etc.	viii. There are about 50,000 such compounds, e.g. $CuSO_4$, NaCl, $MgSO_4$, KCl, H_2SO_4 etc.

Table 18.4

18.4 Uses of Organic Compounds in Our Daily Life.

Organic compounds are inseparable in human life. They are used by mankind or associated at all stages of life right from one's birth to death. Various classes of organic compounds and their uses in our daily life as follows:



Paper (Cellulose) | Nail Polish (Nitrocellulose, butyl acetate) | Candle (wx, tallow) | Fabric (Cellulose, nylon, ryon) | Soap (Fatty acid salt) | Gasoline (Mixed hydrocarbons)

Fig. 18.5

- Polymers consist of long chains and branches of molecules. Common polymers you encounter every day are organic molecules. Examples include nylon, acrylic, PVC, polycarbonate, cellulose, and polyethylene.
- Petrochemicals are chemicals derived from crude oil or petroleum. Fractional distillation separates the raw material into organic compounds according to their different boiling points. Examples include gasoline, plastics, detergents, dyes, food additives, natural gas, and medicines.

Although both are used for cleaning, soap and detergent are two different examples of organic compound. Soap is made by the saponification reaction, which reacts to hydroxide with an organic molecule (e.g., an animal fat) to produce glycerol and crude soap. While soap is an emulsifier, detergents tackle oily, greasy (organic) soiling mainly because they are surfactants, which lower the surface tension of the water and increase the solubility of organic compounds.

- Whether a perfume fragrance comes from a flower or a lab, the molecules you smell and enjoy are an example of organic compound .
- The cosmetics industry is a lucrative sector of organic compound . Chemists examine changes in the skin in response to metabolic and environmental factors, formulate products to address skin problems and enhance beauty, and analyze how cosmetics interact with the skin and other products.

These common products make use of organic compound :

Shampoo, Gasoline, Perfume, Lotion, Drugsm Food and food additives, Plastics, Paper, Insect repellent, Synthetic fabrics (nylon, polyester, rayon), Paint, Mothballs (naphthalene),Enzymes, Nail polish remover, Wood, Coal, Natural gas, Solvents, Fertilizers, Vitamins, Dyes, Soap, Candles etc .

Most products you use involve organic compound. Your computer, furniture, home, vehicle, food, and body contain organic compounds. Every living thing you encounter is organic. Inorganic items, such as rocks, air, metals, and water, often contain organic matter, too.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Which gas is produced when zinc oxide reacts with carbon?

a. Carbon dioxide　　b. Carbon monoxide

c. Nitrogen oxide　　d. Methane

ii. Colourless and transparent carbon allotrops is :

a. Diamond　　b. Charcoal

c. Graphite　　d. Coal

iii. Water gas is the mixture of...........

a. $CO_2 + H_2$　　b. $CO_2 + O_2$

c. $C0 + 0_2$　　d. $CO + H_2$

iv. Which is the inorganic compound?

a. Ethyl alcohol　　b. Acetic acid

c. Methane gas　　d. Carbon dioxide

v. What is meant by carbon?

a. a basic metal elementa　　b. a basic non-metal element

c. generally it is found in all non-living things

d. very high melting and boiling point

vi. Which is not correct for organic compound :

a. they are coloured and have odour　　b. the composition is complex

c. burn easily　　d. form ions in water

vii. Carbon and its reactions are mainly important to the study of:

a. Physical chemistry　　b. Analytical chemistry

c. Organic chemistry　　d. Inorganic chemistry

viii. Which is the group of organic compounds?

a. Glycerin, phenol, alcohol, carbon dioxide

b. Methane, Methanol, Cloform, Urea

c. Protein, carbohydrates, ammonia, methane

d. Ether, Amania, Methane, Insulin

B. Give the reason :

i. Wearing cloth contains carbon .

ii. Carbon always forms co-valent bond .

iii. Water gas used in industries .

iv. Carbon form large number of compound in comparison to other element .

v. Graphite dust can be used as a dry lubricant .

vii. When burning wood in the Chulo, sometimes black smoke comes and sometimes less smoke comes and burns well.

viii. Carbon is a reducing agent

C. Differentiate with examples :

i. Amorphous and Crystalline　　ii. Allotropes and allotrophy

iii. Water gas and water vapour　　iv. Organic and inorganic compound

v. Organic chemistry and inorganic chemistry

D. Answer the following questions :

i. What are the sources of carbon in nature?
ii. Sketch the atomic model of carbon.
iii. Which property of carbon has differentiated it from other non-metal.
iv. What are allotrops ?Write two allotrops of carbon.
v. How can we prove that sugar contains carbon?
vi. How can we prove that Ghee contains carbon?
vii. Difine organic and inorganic compound.
viii. Write two differences between organic and inorganic compound.
ix. Name four sources of carbon found in nature.
x. Write down any two properties of carbon.

E. Write short note

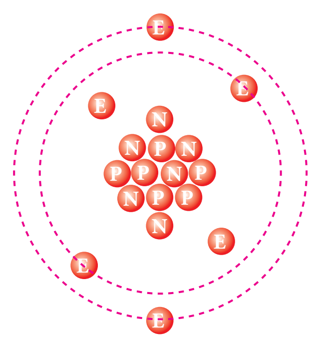
i. Sources of carbon
ii. Nature of carbon
iii. Catenation
iv. Allotropes of carbon
v. Water gas
vi. Organic Compound

F. Write the chemical formula :

i. Water gas
ii. Urea
iii. Water vapour
iv. Coal
v. Carbon monoxide

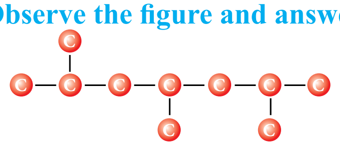
G. Diagrammatic questions

i. Observe the figure and answer the following questions :

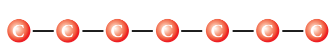


a. Which element model is shown in the figure ?
b. Which element is represented in the picture?
c. What kind of bond does that element form?
d. Write the valency and atomic number of that element.
e. Write the names of any four allotropes of that element.
f. What compound does this element form with water vapor? Write with a balanced chemical equation.

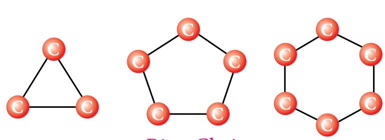
(ii) Observe the figure and answer the following questions :



Branched Chain



Linear Chain



Ring Chain

a. Which properties of carbon is shown in the picture?
b. What causes carbon to show this ability ?
c. Write down any two characteristics of carbon.
d. Which bond is shown in the picture?

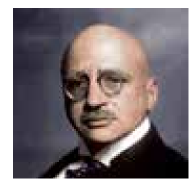
Unit 19 Materials Used in Daily Life

STUDENT'S LEARNING OUTCOMES

After studying this unit, the students will be able to :

- introduce chemical fertilizers and pesticides
- identify the symptoms of plants deficient in nitrogen, phosphorus and potassium by experiment
- explain the importance, effects and biological alternatives of chemical fertilizers and pesticides

Fritz Haber, (1868-1934), German physical chemist and winner of the 1918 Nobel Prize for Chemistry for his successful work on nitrogen fixation. The Haber-Bosch process combined nitrogen and hydrogen to form ammonia in industrial quantities for production of fertilizer and munitions. One of the most important plant fertilizers is nitrogen.



Look at the pictures above and discuss:

Fig. 19.1

a. What did you see in there pictures?
b. Have you ever seen at agricultural activity as shown in the picture ?
c. What are the farmers doing?
d. Are these activities mandatory in the agricultural sector ?
e. There are also some separate items in the picture. What could they be?

19. Introduction

To be able to grow, develop, and produce at their best, plants must have specific elements or compounds called plant essential nutrients (necessary nutrients for plant).

A plant that lacks an essential nutrient cannot complete its life cycle—the seed may not germinate; the plant may not be able to develop roots, stems, leaves, or flowers properly; or it may not be able to produce seeds to create new plants. Often the plant itself will die.

However, having too much of a nutrient can harm and even kill plants. For example, having too much nitrogen can cause a plant to grow more leaves but less or no fruit. Too much manganese can make the leaves turn yellow and eventually die. And excess boron can kill a plant.

You can save money and effort—and even your plants— if you know what and how much to give your plants. The plants will be healthier and more productive if you give them what they need—no more and no less.

Plant essential nutrients

Scientists have identified 17 essential nutrients and grouped them according to the relative amount of each that plants need:

i. Primary nutrients, also known as macronutrients, are those usually required in the largest amounts. They are carbon, hydrogen, nitrogen, oxygen, phosphorus, and potassium.

ii. Secondary nutrients are those usually needed in moderate amounts compared to the primary essential nutrients. The secondary nutrients are calcium, magnesium, and sulfur.

iii. Micro- or trace nutrients are required in tiny amounts compared to primary or secondary nutrients. Micronutrients are boron, chlorine, copper, iron, manganese, molybdenum, and zinc.

Very few plants need five other nutrients: cobalt, nickel, silicon, sodium, and vanadium.

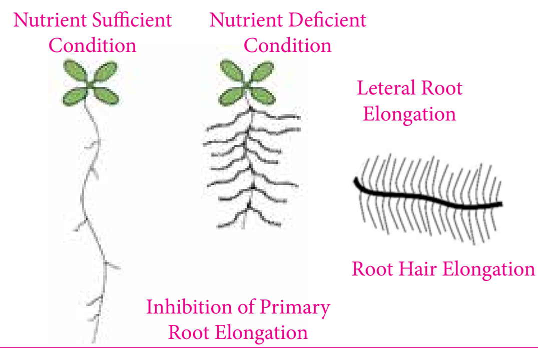
Plant growth and development largely depend on the combination and concentration of mineral nutrients available in the soil. Plants often face significant challenges in obtaining an adequate supply of these nutrients to meet the demands of basic cellular processes due to their relative immobility. A deficiency of any one of them may result in decreased plant productivity and/or fertility. Symptoms of nutrient deficiency may include stunted growth, death of plant tissue, or yellowing of the leaves caused by a reduced production of chlorophyll, a pigment needed for photosynthesis. Nutrient deficiency can have a significant impact on agriculture, resulting in reduced crop yield or reduced plant quality. Nutrient deficiency can also lead to reduced overall biodiversity since plants serve as the producers that support most food webs.

Changes in the climate and atmosphere can have serious effects on plants, including changes in the availability of certain nutrients. In a world of continual global climate change, it is important to understand the strategies that plants have evolved to allow them to cope with some of these obstacles.

Classification of Essential plant nutrients

Essential plant nutrients (17)

- Frame work elements (Taken from air and water: 3)
  - Carbon
  - Hydrogen
  - Oxygen
- Mineral elements (Taken mainly from soil in Ionic forms: 14
  - Macronutrients (6)
    - Primary nutrients (3)
      - Nitrogen
      - Phosphorus
      - Potassium
    - Secondary nutrients (3)
      - Calsium
      - Magnesium
      - Sulphur
  - Macronutrients (8)
    - Zinc
    - Copper
    - Manganese
    - Iron
    - Boron
    - Molybdenum
    - Chlorine
    - Nickel



Nutrient deficiency in plants

Nutrient deficiency is evident in the symptoms these plants show.

This (a) grape tomato suffers from blossom end rot caused by calcium deficiency. The yellowing in this (b) Frangula alnus results from magnesium deficiency. Inadequate magnesium also leads to (c) intervenal chlorosis, seen here in a sweetgum leaf. This (d) palm is affected by potassium deficiency.

a. **b.** **c.** **d.**

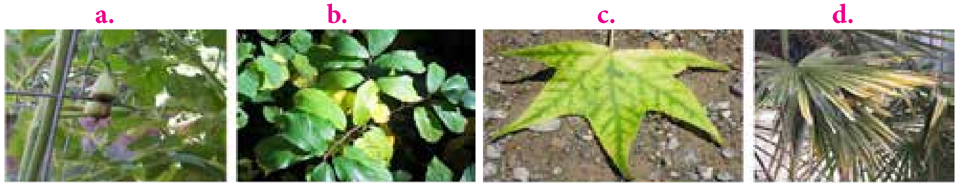


Fig. 19.2

19.1 Fertilizers

Population of the world is increasing but crops production from farming is not increased in the same ratio. So, the demands of food of increased population is not fulfilled by recent food production. This indicates that we have to increase crops production. For that, we have to know about state of soil and essential nutrients for crops. Two kinds of nutrients are required for crops. The main macronutrients are, Nitrogen (N), Phosphorus (P) and Potassium (K) Three macronutrients viz : calcium (Ca), Magnesium (Mg) and Sulphur (S) and micronutrients like Cupper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Zinc (Zn), Boron (B), etc. These macro nutrients and micro nutrients are found in soil which are absorbed by roots of green plants. These nutrients when mixed with soil that increases productivity of crops. We can restore the fertility of soil by adding suitable amount of fertilizer.

The fertilizers are the substances which are added to the soil to increase the crop production by supplying essential nutrients.

Types of fertilizers

A. Organic fertilizers

The fertilizers which are derived from the decomposition of excreta of animals, plant residue, dead bodies of organism, litter, straw, vegetable waste, poultry droppings etc. are called organic fertilizers.

When the animal remaining and plant residues get decomposed in the limited amount of oxygen, they release a large amount of methane gas (CH_4) with a pungent smell. Since CH_4 is a green house gas which can cause green house effect if released in a large amount into the atmosphere. Therefore, in order to reduce the production of CH_4 gas, plant residues and animal remains are cut into smaller pieces and moved up and down in a regular time interval during the preparation of compost manures. This process increases the rate of decaying and does not pollute the environment. This method increases the rate of decaying of organic matter and also increases the fertility of soil.

The method of preparation of compost manure in the presence of oxygen is called aerobic method. Similarly, the process in which the organic fertilizers can also be derived from organic matter without the supply of oxygen is called an anaerobic method. Organic fertilizers can be prepared by using mechanical method.

The organic fertilizers are of two types :

i. Green manures

Green manures are derived by growing most of the leguminous plants and some non leguminous plants, cutting them down and burying into the soil to decay. After few days, they degrade and add many nutrients such as nitrate to the soil. The dead green plants add organic matter to the soil which increases soil's fertility called humus.

Barseem, soybean, pigeon pea, dhaincha, etc. can be used as green manures. Green manures are the cheapest and easily available sources of fertilizers. They add all the essential nutrients to the soil and thereby, increase about 30-50% crop yield.

ii. Animal manures

The manures which are made by burying the dead animals, plants and excreta of animals in a pit with an alternating layers of soil is called animal manures. Here, the complex organic matter of dead bodies and organic wastes are decomposed by bacteria and fungi forming simpler compost manures.

Advantage of organic fertilizer

i. They cause less pollution.
ii. They increase water holding capacity of soil as well as increases its fertility.
iii. They are cheaper as they are produced from wastes.
iv. They are useful for all variety of plants.
v. They do not have side effect on human beings as those of inorganic fertilizer.

Disadvantage of organic fertilizer

i. They are required in large quantity. So, it is difficult to recollect and transport them.
ii. They are insoluble in water.
iii. They are poor in inorganic nutrients.

Note

i. Animal manures lacks inorganic nutrient elements such as nitrogen (N), phosphorus (P) and potassium (K). Therefore, chemical fertilizers are used in the crop field to replace the deficiency of these major nutrients.
ii. The chemical elements such as boron, magnesium, iron, zinc, sulphur, etc. required by plants in fewer amount are called micro nutrients. These elements are called micro elements as they are required in a small quantity.

iii. Macronutrients are the chemical elements such as carbon, hydrogen, oxygen, nitrogen, phosphorus, etc which are required by plants in large quantities. These elements are called major or macro nutrients as they are required in a large quantity.

B. Inorganic fertilizer/Chemical fertilizer

The water soluble chemical compounds which are added to soil to increase crop production by supplying essential nutrients are called inorganic or chemical fertilizer.

These fertilizers supply nitrogen, phosphorus, potassium, etc. to the soil. Ammonium sulphate, ammonium phosphate, urea, potassium nitrate, etc. are some examples of chemical fertilizer.

They are needed for the growth and development and seed production.

Advantage of inorganic fertilizer

i. They are easy to collect and transport from one place to another.
ii. They increase the fertility of soil.
iii. They contain most of the nutrients essential for growth and development of plants.
iv. They are water soluble, so they can be absorbed by plants easily.

Disadvantage of inorganic fertilizer

i. They cause environmental pollution.
ii. They increase acidity or alkalinity of soil.
iii. They affect the quality of soil.

Some chemical fertilizers

Nitrogen containing fertilizer	Phosphorus containing fertilizer	Potassium containing fertilizer
Ammonium sulphate $(NH_4)_2 SO_4$	Ammonium phosphate $(NH_4)_3 PO_4$	Potassium chloride (KCl)
Ammonium nitrate (NH_4NO_3)	Calcium super phosphate $[Ca(H_2PO_4)_2CaSO_4]$	Potassium sulphate (K_2SO_4)
Urea $(NH_2 CO NH_2)$	Triple super phosphate $[3Ca(H_2PO_4)_2]$	Potassium nitrate (KNO_3)
	Ammonium biphosphate $[(NH_4(HPO_4)]$	Potassium carbonate (K_2CO_3)
	Bone dust	

Table 19.1

Importance and effects of chemical fertilizers

Importance of nitrogen	Effects of deficiency of nitrogen
It helps in rapid growth of plants.	Reduction of crop yield.
It helps to increase the crops yield.	Produces yellow leaves in plants.
It helps to increase photosynthesis process.	Reduces in size of flower fruit and seeds.
It increases amount of protoplasm protein and chlorophyll.	

Table 19.2

Importance of phosphorus	Effects of deficiency of phosphorus
Needed for growth of leaves, bud and roots.	Poor growth of roots of plants.
Helps in developing seeds.	Reduces rate of cell divisions in plants.
Helps in fast maturity of fruit and seed.	Essential for protein synthesis and cell division.

Table 19.3

Importance of potassium	Effects of deficiency of potassium
Helps in propagating food for plants.	Reduces the amount of protein in cell.
Helps in protein syntheses and cell division.	Slower the rate of cell division.
Increases disease resistant capacity of plants.	Drying or death of leaves of plants.
Promotes the flowering plants.	Small plants may die.

Table 19.4

Precautions while using chemical fertilizer

i. Before using chemical fertilizer acidity or alkalinity of soil should be known.
ii. Mouth and nose are to be covered by masks or cloth while using chemical fertilizer.
iii. Chemical fertilizer should not be allowed to go to sources of water.
iv. Chemical fertilizer should be used in proper amount.
v. Chemical fertilizer should be kept away from the reach of children.

Use of Chemical fertilizers and its impacts on the environment and human health

Though the use of chemical fertilizers to enhance crop field is commercially beneficial, however improper use of these fertilizers can have adverse impacts on environment. Some adverse impacts of chemical fertilizers on environment and human health are as follows :

i. Some chemical fertilizers specially nitrogen containing nitrogen promotes the growth of algae and weeds which reduces dissolved oxygen in water. The lower amount of dissolved oxygen makes the life of aquatic animals difficult and ultimately they die.
ii. The use of chemical fertilizers are responsible for pollution of rivers and lakes which leads to eutrophication and ground water pollution.
iii. Long term use of chemical fertilizers in large scale causes acidification of soil which reduces fertility of soil.
iv. Long term use of chemical fertilizer can change the soil pH, upset beneficial microbial ecosystems, increase pest, and even contribute to the release of green house gases (GHGs).
v. Repeated applications of chemical fertilizers may result in toxic build up of chemicals such as arsenic, cadmium and uranium in the soil. These toxic chemicals can eventually make their way into our crops.

Difference between Organic and Inorganic (Chemical) fertilizers

S.N.	Organic fertilizers	Chemical fertilizers
i.	The fertilizers which are derived from the decomposition of animal remains and plant residues are called organic fertilizers	The fertilizers which is manufactured by using different chemical substances are chemical fertilizers.

ii.	They are comparatively less rich in major nutrients such as nitrogen, phosphorus and potassium.	They are rich in nutrients such as nitrogen, phosphorus and potassium.
iii.	Organic fertilizers are slowly absorbed by plants since they are slightly soluble in water.	They are easily and rapidly absorbed by the plants since they highly soluble in water.
iv.	They are not nutrient specific organic fertilizers.	They are nutrient specific chemical fertilizers.
v.	They maintain the quality of soil such as aeration and retention of moisture.	They deplete the soil's quality causing poor aeration and moisture retention
vi.	In the organic fertilizers, the release of nutrients to the crop is affected by the decomposition rate and timing of the use of the fertilizers	They release their nutrients to crop immediately.
vii.	They provide humus to the soil.	They do not provide humus to the soil.
viii.	They do not have harmful effects on living organisms.	They have harmful effects on living organisms.
ix.	They restore soil texture.	They do not restore soil texture
x.	Examples : green manures, livestock manures, compost manures, household wastes, crop residues etc.	Examples : Ammonium sulphate, Potassium chloride, bone meal, urea, ammonium phosphate etc.

Table 19.5

Activity 19.1

Look at the pictures given below and discuss:

a. What is the picture trying to show?
b. What could be good terminology for X written in the middle?
c. What are the benefits of this type of activity?

Conservation of soil

Did you know ...

...that a spoonful of soil contains more micro-organisms than there are people on earth? And that many of these micro-organisms are key indicators of soil quality?

...that virtually all fresh water falls on soils and travels over them, percolates through them, evaporates from them, is stored in them, or interacts with them to drive several chemical, physical, and biological processes?

...that soil quality is a moving target, depending on soil use? But that in general, soil quality is an assessment of the fitness of a soil to perform certain functions such as supporting plant growth, partitioning and holding water, and acting as an environmental buffer?

...that soil quality directly affects water quality, biodiversity, wildlife habitat, plant growth, and crop production? And that the key determinant of whether soil quality is improved, restored, sustained, or degraded is management?

Soil Quality

Soil quality is the capacity of a soil to function for specific land uses or within ecosystem boundaries. This capacity is an inherent characteristic of a soil and varies from soil to soil. Such indicators as organic-matter content, salinity, tilth, compaction, available nutrients, and rooting depth help measure the health or condition of the soil-its quality-in any given place.

For example, organic-matter content, biological activity, acidity, and salinity are related to the ability of a soil to store and cycle nutrients for plant growth. Soil tilth, compaction, and available water capacity reflect the ability of a soil to regulate and partition the flow of water. Texture, such as loam or clay, is an important soil property in the support of buildings and roads. An enhancement of soil health or quality could be measured by an increase in organic matter content in cultivated soils over the years, which would reflect the soil's ability to cycle nutrients.

If, through human use, the ability of a soil to perform certain functions is maintained or enhanced, its quality contributes to sustain-ability. However, if the ability of a soil to perform beneficial functions has been impaired, the quality or condition of that soil has been degraded and that land use detracts from the sustainability of the soil resource.

Conservation of Soil quality

Crop Rotation: The way you plant your crops can have an impact on the soil. Crop rotation is a process that works to conserve soil. It is accomplished by planting and growing a series of different crops in the same soil. This process prevents overgrowth of pathogens and lack of fertility in the soil, overall.

Terrace Planting : This type of planting is done by maximizing the topography of the land. It benefits from the way the rainwater flows naturally. This is a way to protect the soil from erosion. It is also a proven method to encourage growth from moist soil areas.

Maintain pH: The pH levels in the soil can be affected by a number of things. Pollutants and acids are just two examples in this category. Purchasing a soil tester is a good way to monitor your soil's levels. This also allows you to learn what needs to be added to ensure healthy soil and conservation.

Add Earthworms: There are a variety of things that live in the soil around us. You can add earthworms to your soil to ensure its health. This is a conservation method that encourages the decomposition of organic material. This is what earthworms do on a regular basis. They increase the soil's ability to absorb nutrients.

Mulch: Mulch is one of the great conservation tools that protect the soil, and the majority of these are used simply to beautify lawns. Mulch works to prevent erosion from the wind. It is also a great product to help the soil to retain the water it needs.

Monitor Grazing : Farmers in different industries can play a critical role in conserving soil. These are often farmers with animals that graze. Monitoring the areas that cows and other animals graze is important. This helps to prevent the depletion of the soil. It also addresses the issue of hoof damage, which can occur to the soil.

Monitor Growth: When crops or plants grow normally, they have a healthy appearance. If there is a problem with the growth, often the soil is the issue. Checking the salient composition and fertility is important. This is done through regular monitoring of the soil and overall plant growth.

Contact a Soil Expert: There are professional landscapers and certain ecological restoration non-profit groups which offer soil restoration services and assist in repairing the badly eroded soil around your home voluntarily or for little cost. They assess the severity of the soil damage on your property by performing a detailed examination of your land and come up with solutions for restoring the soil to its natural health. Even if your soil is healthy, you should consult with a professional landscaper at least once a year to inspect your property for potential problems and discuss preventative solutions.

Soil scientists and others are developing tools to measure and monitor soil quality by developing key indicators to assess soil condition or health. While monitoring is important for assessing change, it alone will not improve soil quality. Monitoring does help provide feedback on how prescribed conservation management systems are performing and provides conservationists with data to design needed modifications in these systems.

Insecticide

Insecticide is a type of pesticides. It is a man made poisonous chemical which is used to control or kill the insects. Insects are harmful to crops, domestic animals and human beings. Insecticides are of two types: Organic and inorganic insecticides.

i. Organic insecticides

The synthetic organic compounds made up of carbon, hydrogen and oxygen are called organic insecticides. They are also of three types.

Organ chlorine insecticides: Having chlorine as poisonous substances. Examples- Aldrin, dieldrin, Benzene Hexa Chloride (BHC), Dichloro Diphenyl Trichloroethane (DDT).

Organ phosphorus insecticides: Having phosphorus as poisonous substance

Examples- Malathion, parathion, Falone etc.

Carbamate insecticides: Having amino group (-NH2) as poisonous substance.

Examples- Baygon, Turmeric etc.

ii. Inorganic Insecticides

Insecticides made from mineral are called inorganic insecticides. They are used to protect cotton, fruit and vegetable from insects.

Advantages of insecticides

i. It controls and kills the harmful insects.
ii. It helps to control the diseases by killing the germs.

Disadvantage of insecticides

i. It kills useful insects too.
ii. It pollutes the environment.
iii. It affects the other plants and animals.
iv. It may cause the cancer to human being.

Exercise

A. Choose the correct one and put the tick mark(√)

i. If the nitrogen is the main element of fertilizers then the fertilizers are classified as
a. structural fertilizers   b. non-structural fertilizers
c. nitrogen fertilizers   d. respiratory fertilizers

ii. The excess of nitrogen fertilizers leads to
a. pest problems   b. growth problems
c. fruiting problems   d. flowering problems

iii. The greenhouse gas which can be emitted from the storage of nitrogen-based fertilizers is
a. nitrous oxide   b. nitric oxide
c. oxygen   d. hydroxide

iv. The organic fertilizers can be derived from
a. animal materials only   b. plant materials only
c. carbon materials   d. animal and plant materials

v. Green manure plants are
a. Poaceae   b. Solanaceae
c. Leguminosae   d. Compositae

vi. This chemical fertilizer is essential for better rhizobial nitrogen fixation
a. calcium   b. potassium
c. sodium   d. phosphorus

vii. Wchich one is not included in organic farming
a. crop rotation   b. chemical fertilizer
c. green manures   d. compost and farmyard manures

viii. Appropriate use of cow dung is made in
a. medicine   b. fuel
c. manure   d. building/construction material

ix. Composted manure is formed from
a. farm and household refuse
b. animal refuse and rotten vegetables
c. organic wastes from where biogas extraction takes place
d. green and farmyard manure

x. Which type of deficiency symtoms is seen in bean?
a. Potassium   b. Nitrogen
c. Magnesium   d. Phosphorus

B. Differentiate with examples

i. Fertilisers and manures
ii. Organic and chemical fertiliser
iii. Compost and green manures
iv. compost and vermicompost.
v. NPK and DAP

C. Give the reason :

i. NPK fertilizers are major nutrients essential for increasing the crop yield.
ii. Organic fertilizer is environment friendly .
iii. The presence of chemical fertilizer in sources of water causes the death of aquatic lives.
iv. Insecticides should not be used more than needed .
v. Insecticides shouldn't use in vegetable and food crops .

D. Answer the following questions :

i. What is fertilizer made of?
ii. What are the main types of fertilizers?
iii. What is the most important part of fertilizer?
iv. Why are fertilizers used?
v. Is fertilizer regulated?
vi. Which gas is used in fertilizer?
vii. What is the color of complete fertilizer?
viii. How do fertilizer differ from each other?
ix. How does fertilizer affect the environment?
x. What is NPK fertilizer?
xi. Does fertilizer evaporate?
xii. What is the full form of DAP fertilizer?
xii. How many nutrients are essential for plants?
xiv. Name a biopesticide.
xv. What is the main benefit of mixed cropping?
xvi. Name a nutrient which is not present in fertilisers.
xvii. What happens due to deficiency of nutrients?
xviii. How is the use of manure beneficial for our environment?
xix. What is green manure?
xx. Why is excess use of fertilisers detrimental for the environment?
xxi. Differentiate between compost and vermicompost.
xxii. What mineral nutrients are supplied to the plants by air, water and soil?
xxiii. Why should pesticides be used judiciously?
xxiv. Enumerate the advantages of mixed farming.
xxv. How is compost manure made ?
xxvi. What are insecticides and explain its effects?

E. Write short note :

i. Fertilisers
ii. Organic fertiliser
iii. Green manures
iv. Bio-insecticides
v. Necessary nutrients for plant
vi. Conservation of soil quality
vii. Insecticide

F. Write the molecular formula :

i. Ammonium phosphate
ii. Potassium chloride
iii. Urea
iv. Calcium super phosphate
v. Potassium carbonate

G. Diagrammatic questions

i. Observe the given picture and answer the following questions :

a. Which fertilizer deficiency makes the leaves yellow?
b. Write the names of any two sources of that fertilizer?
c. Write down any three importances of that fertilizer.

ii. Observe the given picture and answer the following questions :

(Picture X and Picture Y(right)

a. These two wheat plants have different symptoms. In the absence of which fertilizer, these symptoms are seen?
b. Write the names of any two sources of the fertilizer.
c. Write down any three importances of that fertilizer.