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पाठ्यक्रम विकास केन्द्र
सानोठिमी, भक्तपुर
(मान्यता, समकक्षता निर्धारण र मूल्याङ्कन शाखा)

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विषय : पाठ्यसामग्री स्वीकृति सम्बन्धमा ।

श्री नोभा पब्लिकेसन प्रा.लि,
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, माध्यमिक शिक्षा पाठ्यक्रम (कक्षा ९-१०), २०७८, पाठ्यसामग्री विकाससम्बन्धी विद्यमान प्रावधान, ऐन, कानुन, निर्देशिका, कार्यविधि, प्रकाशन शैलीका प्रावधान, पाठ्यकम 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 ।

तारा पाण्डे तिवारी
पाठ्यक्रम अधिकृत

तपसिल

(क)पाठ्यसामग्रीको नाम

१	**Science and Technology**	माध्यमिक तह/ कक्षा : ९

(ख) निर्देशन

१.पाठ्यसामग्री विकाससम्बन्धी विद्यमान प्रावधान तथा पाठ्यसामग्री सुधार र परिमार्जनका लागि यस अघि दिइएका निर्देशनको पूर्ण परिपालना गर्ने ।

२.पाठ्यकमको मूल मर्म र भावनाअनुरूप पाठ्यकमका 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 तथ्यांक तथा नक्सा आधिकारिक र प्रामाणिक हुनुपर्ने ।

४.स्वीकृति पत्र स्क्यान गरी पाठ्यसामग्रीको शीर्षक पृष्ठभन्दा पछि दायाँ (Recto) पृष्ठमा समावेश गर्ने । पाठ्यसामग्रीको प्रत्येक पृष्ठको पुच्छर (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 पुर्‍याउने, 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 थप 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, बिकी वितरण र प्रयोग गर्नु गराउनहुन सम्बन्धित सरोकारवाला सबैमा अनुरोध छ ।

Modern Concept Science AND TECHNOLOGY 9

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PREFACE

Modern Concept Science and Technology for grade 9 is written to meet the objectives of the curriculum of class 9 science and technology developed by CDC (Curriculum Development Center), Sanothimi, Bhaktapur. This edition of our textbook meets the criteria of basic knowledge in science and technology for students who study in class 9. It will help students to achieve the goals of life by gaining of knowledge,skills and values in Science and technology.

Logical placing of key points and well organized matter are given high priority throughout the textbook. Appropriate pictures, matter in simplified language and organization of the content with new features are our high expectation values about popularity of this textbook among the readers.

Features of Modern Concept Science and Technology

A notable concern of many teachers is to follow a well-organized textbook with step by step learningsin a continuous flow. The organization of this textbook is logically designed to make the book's information more accessible.

1. Top of the first page of each unit consists of syllabus issued by CDC (Curriculum Development Center), Sanothimi, Bhaktapur for class 9.
2. Learning outcomes of each unit are given just below the syllabus issued by CDC to focus the teaching learning goals.
3. The most important idea of writing terms and terminologies on the first page of each unit is devoted to screen out the main content to be covered.
4. Highlighted definitions, catchy memory tips and bubble box on pages inside of a chapter for a quick look on important points to be remembered are provided in the first page of each unit.
5. Activities and solved numerical problems are given in each unit of the same page with corresponding to the topic to develop the scientific skill in the readers.
6. Sample questions of Knowledge, Understanding, Application, and Higher Ability with their answer are given at the end of each unit under the title answer writing skill to get idea to solve the questions given in the four steps exercise.
7. This text book focuses primarily on all three level questions to test students' skill under the title four steps exercise.

With these all features in a well-organized content, the central focus of this book is to encourage students and make the text user-friendly for all. The answer writing skill and four levels grid based exercise will help teachers to set test papers for assessments. Students' interest will be peaked when they will find the screen out terms and terminologies, the appropriate pictures and key points throughout the textbook. We hope that this book will help teaching in learner-centered way.

We wish to express our sincere gratitude to Mr. Megh Raj Poudel, Managing director of Nova Publication Pvt. Ltd. for publishing this book. Similarly, thanks are due to Mr. Deepak Bahadur Bista, Ashim (Indra) Rijal, Deepak Banjade, Dilip Belbase and Srijan Adhikari for their valuable help during the preparation and content editing of the book. Likewise, thanks are due to Mr. Jagadish Pokhrel for his praiseworthy language editing.

Finally, we owe full responsibility of misprints and other technical errors, if any, found in this textbook in spite of our best effort to make this book error-free. Constructive criticism and suggestions for improvement of this book will be highly appreciated.

Authors

Kathmandu, Nepal

Contents

UNIT 1

SCIENTIFIC LEARNING

ESTIMATED TEACHING PERIODS	TH	PR
	5	2

Galileo Galilei
(1564 -1642)

Curriculum issued by CDC

- Introduction to scientific learning
- Area of science (physics, chemistry, biology, environment science, astronomy and geology)
- Professional opportunities in different areas of science
- Achievement and challenges in science and technology
- Precautions while doing laboratories activities in the science laboratory
- Introduction and use of scientific notations in scientific measurement
- Introduction and use of metric prefixes in scientific measurement
- Use of least count in scientific measurement
- Use of average reading in scientific measurement

Learning outcomes

After completion of this unit, students will be able to:

- introduce scientific learning and area of science along with identification of professional opportunities.
- study achievement and challenges which are brought by science and technology.
- adapt the precautions while doing laboratories activities.
- use scientific notations, metric prefixes, least count and average reading in scientific measurement.

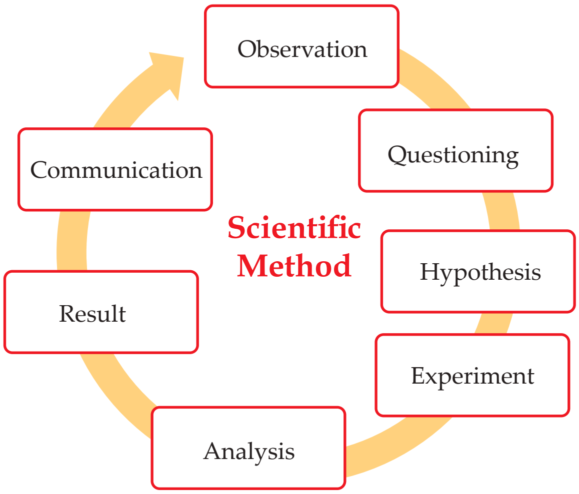
Terms and terminologies

1. Science:	Science process skills are the steps that scientists take when they study and investigate a phenomenon.
2. Experiment:	Experiment is a process used to verify knowledge.
3. Science process skills:	Science process skills are the steps that scientists take when they study and investigate a phenomenon.
4. Scientific method:	The method of systematic study which includes observation, questioning, formulation of hypothesis, experiment and testing, analysis of data, result, and communication is called the scientific method.
5. Scientific learning:	The process of learning that uses steps of the scientific method is called scientific learning.
6. Biology:	Biology is the scientific study of living things.
7. Biologists:	Biologists are experts in biology.
8. Zoology:	Zoology is the study of animals.
9. Botany:	Botany is the study of plants.
10. Physics:	Physics is the branch of science which deals with the study of matter and energy.
11. Chemistry:	Chemistry is the scientific study of the properties and behaviour of matter.
12. Scientific notation:	Scientific notation is a useful way to represent very large numbers or very small numbers conveniently in decimal forms.
13. Metric prefixes:	Prefixes are preceding factors used to represent very small or very large physical quantities in SI units.
14. Least count:	The smallest measurement value that we can take by using a measuring instrument is called its least count.
15. Average measurement:	An average is the sum of all values of measurement divided by the number of attempts made to measure a particular quantity.

Introduction

We have some experience in observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena. Any systematic study of a natural phenomenon is called science. Science is systematic knowledge developed through the exploration of various natural phenomena. Experiment is a process used to verify knowledge. During experiments, we collect data through measurement. We need to follow some basic safety rules while performing experiments and collecting data in the laboratory. Generally, in experiments, we collect data through measurement that involves numbers with small values. When scientists study various natural phenomena, they come across measurements involving very big and very small numbers. Such numbers can be written simply in the power of ten. In measurements, the average of the data reduces the error during the data analysis.

Science and scientific learning



Several natural events occur around us. These events are about living and non-living things. They raise a number of questions and curiosities in our minds. These questions help us to explain and understand the real world. On observing events, we wonder what is going on. How do different events take place? Why is it like that? Such questions run in the minds of billions of people every second. Science offers the most reliable answers to such questions.

Introduction to science

The word 'science' has been derived from the Latin word *'Scientia'* which means knowledge. Science is systematic knowledge that is developed through the exploration of various natural phenomena. It is an organised and experimentally verified knowledge. Such knowledge is developed due to the inventive attitude of human thinking. The process of learning that uses the steps of the scientific method is called scientific learning. Science has become an integral part of our life. In science, concepts and theories take shape on the basis of the scientific method. The method of systematic study which includes observation, questioning, formulation of hypothesis, experiment and testing, analysis of data, result, and communication is called the scientific method. Science depends on some basic skills related to identifying and solving problems. These are known as science process skills. Science process skills are the steps that scientists take when they study and investigate a phenomenon. Classifying, observing, measuring and inferring, communicating, etc. are some of those basic skills.

Activity 1.1

Collect different types of balls, table tennis, basketball, cricket, etc. What steps will you follow to find out which type of ball bounces the highest?

Memory Note

Albert Einstein, Isaac Newton, Marie Curie, Charles Darwin, Nikola Tesla and Galileo Galilei are popular scientists.

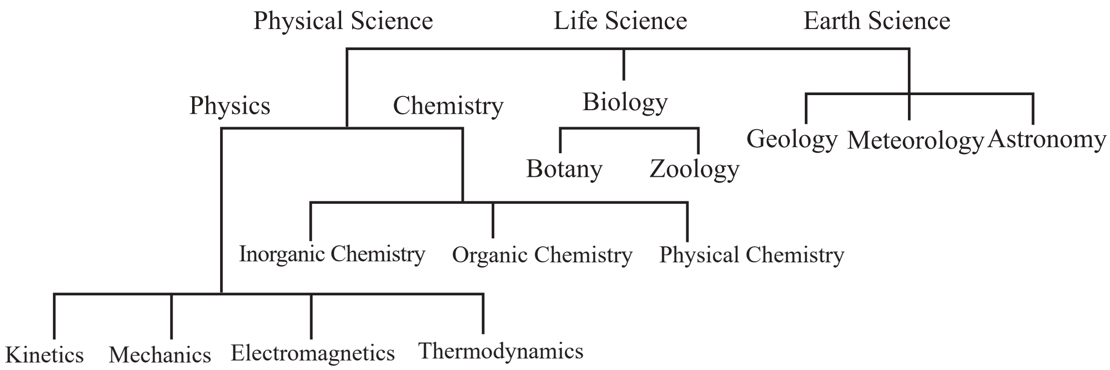
Fact and Reason

Why should we practise scientific learning?

We should practise scientific learning because it helps us to discard superstition, discover new knowledge, understand the universe, develop new technology and make life easier.

Branches of Science

There are different fields of science. Most of them belong to one of the three main groups. They are biology, physics, and chemistry. Some of the branches are interlinked with one another, too. For our understanding, we can classify the branches as in the chart below:



Biology

Biology is the scientific study of living things, from the tiniest cells to the largest whales. Experts in biology are called biologists. Biology has different branches. Zoology is the study of animals. Similarly, botany is the study of plants. Biologists who study how living things interact with one another and with the natural world are called ecologists. Their corresponding branch of study is ecology. Microbiologists study micro-organisms. Thus, biology has several branches such as botany, ecology, evolution, genetics, marine biology, medicine, microbiology, molecular biology, physiology, zoology, etc.

Physics

Why does water flow from a higher to a lower point? The answer is found in physics. Physics tells us how things work. It helps us to understand the concepts of nature and the universe. From the galaxy to the small atom, we understand a variety of objects thanks to physics. Thus, physics is the branch of science which deals with the study of 'matter' and 'energy'.

Memory Note

Physics is derived from the Greek word 'Physikos' which means nature. Albert Einstein is also known as the father of physics.

The use of waves for human benefits like that in communication is one of the gifts of physics. Physics is applied in the field of engineering. Rockets are launched in space. They return to the earth. These journeys were made possible by physics.

Chemistry

Activity

Observe the activity that is shown in the given diagram. What are the properties of substances used in this activity? What happens after mixing these two substances?

Chemistry is the branch of science in which we study the properties and behaviour of matter. We can test the properties of the mixing substances using indicators. The mixing of acids and bases results in the formation of a new substance with different properties. This phenomenon is called a chemical reaction. An expert in chemistry is called a chemist. Thus, chemistry deals with reactions between two or more types of matter that give rise to a new type or types of matter. For example, when hydrogen and oxygen are mixed in appropriate ratio and conditions, they give rise to water (H_2O).

Interconnected fields of science

The study of the structure of the earth (i.e., geology) and the study of more distant planets and stars (i.e., astronomy) overlap with many areas of physics, chemistry, and biology. Geologists study rocks and minerals. Astronomers study the celestial bodies. Similarly, meteorology is the branch of science concerned with the processes and phenomena of the atmosphere.

Scope of branches of science

Activity 1.3

Look at the pictures of the people involved in different works. Identify their major field of study and the corresponding profession. Search for five more fields of science and the corresponding profession that people can take up after completing their studies.

Picture			
Field of study	Engineering	....	....
Profession	Civil engineer	....	....

The wide scope of science can be seen in scanning the fields of engineering, medicine, computer, agriculture, etc. Civil engineers plan, design and oversee construction and maintenance of building structures and infrastructure, such as roads, railways, airports, bridges, dams, irrigation projects, power plants, water and sewerage systems, etc. Mechanical engineers are involved in the design, development, construction, and testing of mechanical devices, including tools, engines, and machines. Study of agriculture science, aqua science, astronomy, biochemistry, biomedical science, earth science, electronics, environmental science, forensic science, horticulture, home science, geology, etc. provide career opportunities in respective fields.

Memory Note

Engineering is applied physics.

Achievements of science and technology and corresponding challenges

Science and technology have generated new knowledge, such as discoveries of new principles. They have dramatically contributed to the development and progress of people's lives, the economy, and society. Following are some of the achievements and challenges associated with inventions in the field of science and technology.

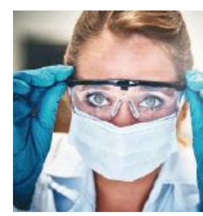
Inventions	Achievements	Challenges
Medicine	Treatment of many diseases possible.	Over dose, multiple medicines, etc. may be fatal for life.
Vaccine	Improvement of the immune system. Eradication of different diseases such as polio.	Several vaccines may no suit the genetic makeup of human beings.
Hydroelectricity	Power generation on a huge scale for the advancement of the industrial sector and transportation system.	Dams may burst and cause floods. High tension electricity lines, carrying high voltage, pose risks to people.
Nuclear energy	Generation of electricity from nuclear power plants, treatment of cancer through radiotherapy.	Management of nuclear waste is difficult. Nuclear power plants pose risks to life in the surroundings.
Engine	Easy transportation, improved human civilisation.	Environmental pollution is due to the release of smoke from the combustion of fuel.
Wireless communication	Worldwide communication possible through the use of satellite technology.	If not secured, it may lead to security threat and data exploitation.

Computer, internet	High-speed data processing, rapid calculation, functions with accuracy.	Virus attack, data attack, etc. may pose risks to computer security.
Robot	Working in a challenging environment with accuracy possible with the invention of the robot.	It threatens human role, jobs, and opportunities.

Safety in the laboratory

Activity 1.4

Look at the given pictures showing safety rules in the laboratory. What safety rules do you notice from these pictures? Discuss them with your friends in the classroom.



We need to perform experiments in the science laboratory in a safe way. Following are the safety rules that will help in avoiding unnecessary accidents while working in the science laboratory.

1. Students should not perform unauthorised experiments.
2. Aprons or laboratory coats are required for students in laboratories.
3. Wear safety glasses when you are heating or pouring any substance or mixing chemicals.
4. Never mix chemicals for the fun of it. Mixing may produce a dangerous and possibly explosive substance.
5. Never taste any chemical or transfer chemicals by mouth pipette.
6. Never try to smell or inhale chemicals.
7. Keep combustible materials away from open flames.
8. Always wear heat-resistant gloves while handling hot materials.
9. On leaving the lab, wash hands with a disinfectant soap.
10. Learn the location and operation of laboratory emergency safety equipment such as fire extinguishers, fire blankets, fire alarms, etc.

Scientific notation

Activity

Look at some of the very big and very small measurements. What other such measurements do you know?

Very small measurements	Very big measurements
The diameter of an atom is 0.0000000001 m. The size of a virus is 0.00000002 m to 0.00000025 m	The distance to the moon is approximately 400 000 km. The distance to the sun is approximately 150 000 000 km.

We learn about very big and very small numbers in science. Such numbers can be expressed as a factor of power in ten, which is called scientific notation. Scientific notation is a useful way to represent very large numbers or very small numbers conveniently in decimal forms. It saves time while writing very big and very small numbers.

Way to write very small numbers in scientific notation

Number	**Method**	**Scientific notation**
0.00000002 m	Move the decimal eight spaces to the right. Raise the power ten to the negative eight.	2×10^{-8} m
0.0000000091 kg	Move the decimal nine spaces to the right. Raise the power ten to the negative nine.	9.1×10^{-9} kg

Way to write very large numbers in scientific notation

Number	Method	Scientific notation
6400000 m	Move the decimal in between the first two numbers. Raise the power ten to the positive six.	6.4×10^{6} m

83000000000 W	Move the decimal in between the first two numbers. Raise the power ten to the positive ten.	8.3×10^{10} m

Memory Note

Negative exponents are associated with very small numbers and positive exponents are associated with very large numbers while expressing numbers into scientific notations.

Fact and Reason

Why is scientific notation important?

The scientific notation is important because it makes calculation easier, faster and more convenient.

Metric Prefixes

Prefixes are the preceding factors used to represent very small or very large physical quantities in SI units. For example, if we write 20km, 20 is the magnitude of the quantity, the metre is called the SI unit of length, and 'k' in front of the unit 'm' is called the preceding factor or prefix representing 10^3 (i.e. 1000).

Mathematically, kilo represents 1,000

So, 20km = 20 × 1000m = 20000m

The prefix is used to represent a very small and a very large number. The following table shows some examples of prefixes.

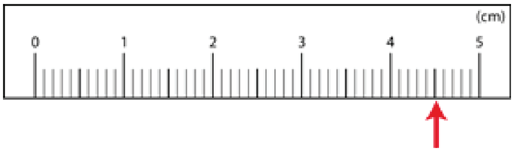
Metric prefixes and symbol of order of magnitude

Order	Prefix	Symbol	Order	Prefix	Symbol
10^{15}	peta	P	10^{-1}	deci	d
10^{12}	tera	T	10^{-2}	centi	c
10^{9}	giga	G	10^{-3}	mili	m
10^{6}	mega	M	10^{-6}	micro	μ
10^{3}	kilo	k	10^{-9}	nano	n
10^{2}	hecto	h	10^{-12}	pico	p
10^{1}	deca	da	10^{-15}	femto	f

Least count

Activity 1.5

Study the calculation of the smallest measurement of scale. Similarly collect other instruments to calculate the smallest measurement of different measuring instruments like measuring cylinder, ammeter, voltmeter, etc.



There are 10 divisions between the 1cm and 2cm marks. Hence the smallest measurement of scale is 1/10 of a centimetre. That is also 0.1 centimetres.

Each measuring instrument such as a measuring scale, measuring cylinder, ammeter, voltmeter, etc. has some numbers and lines printed on their surface. We use these divisions to note down our measurements. The smallest measurement value that we can take by using a measuring instrument is called its least count. The least count of an instrument is one of the very important values to get accurate readings of instruments.

Memory Note

The smallest value that can be measured by an instrument is called the Least Count (L.C.) and the highest is called the precision.

Fact and Reason

Why is the least count of the instrument important?

The least count of the instrument is important because it helps us to get accurate readings.

Average measurement

Activity 1.6

Take a laboratory thermometer and measure the temperature of boiling water. Note the first reading. Now repeat the same procedure to take four more readings of boiling temperature. The average of all readings as

$$\text{Average temperature} = \frac{T_1+T_2+T_3+T_4+T_5}{5}$$

Do you notice any difference in the first reading and the average temperature calculated from the above procedure?

In the step of data collection, we take an average of readings. Mathematically, an average is the sum of all values of measurement divided by the number of attempts made to measure a particular quantity. An average measurement reduces the possible error during data analysis. Error propagates by including the value of single reading during data analysis.

Answer writing skill

1. **What is science?**

   Science is the study of the nature and behaviour of natural things and the knowledge that we obtain about them.

2. **Write the name of any two institutes in Nepal that work in the field of innovation and research.**

   Two institutes that work in the field of innovation and research are:

   Nepal Academy of Science and Technology (NAST), National Innovation Centre (Rashtriya Avishkar Kendra).

3. **The metric prefix is used frequently. Give reason.**

   The metric prefix is used frequently because it helps express higher or lower magnitudes of a physical quantity easily.

4. **Differentiate between physics and biology.**

   The differences between physics and biology are:

Physics	Biology
Physics is the branch of science which deals with the study of 'matter' and 'energy'.	Biology is the scientific study of living things, from the tiniest cells to the largest whales.
It is applied to develop technologies.	It is applied to understand various life forms, develop medicines, etc.

5. **Express the following numbers in scientific notation.**

   i. Given measurement is 250000000m/s

   Moving decimal point 8 places to left, 250000000m/s = 2.5×10^{8}m/s

   ii. Given measurement is 0.00000000275m

   Moving decimal point 9 places to right, 0.00000000275m = 2.75×10^{-9}m

6. **Science and technology have dramatically contributed to the development and progress of people's life. However, it is not without the challenges. List two major achievements in the field of science and the challenges associated with them.**

Achievements in science	Associated challenges
Petrol engine	Air pollution
X-ray machine	Overdose of radiation can cause cancer

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

   a. Which branch of science deals with matter, energy, and their relationship?

   i. chemistry ii. biology
   iii. physics iv. geology and astronomy

   b. What is studied under physical science?

   i. living things ii. organic compound
   iii. matter and energy iv. doing exercise

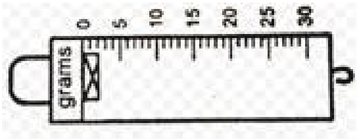
   c. Which branch of science deals with the study of the heavenly bodies?

   i. genetics ii. archaeology
   iii. astronomy iv. meteorology

   d. Which of the following represents the prefix 'giga'?

   i. 10^{12} ii. 10^{15}
   iii. 10^{9} iv. 10^{6}

   e. What is the least count of the spring balance shown in the given figure?



   i. 1g ii. 2g
   iii. 0.5g iv. 5g

2. **Define the following with required examples.**

a. Science
b. Scientific method
c. Metric prefix
d. Science process skill
e. Least count
f. Scientific notation

3. **Short question answers.**

a. Give two examples to show the scope of biology.
b. Write the name of two branches of physics.
c. Give two examples to show the scope of chemistry.
d. Write any four examples of commonly used metric prefixes.
e. Give examples of any two major achievements of science and technology.

Step 2

4. **Give reason.**

a. Science is called a systematic body of knowledge.
b. Instruments with the minimum value of least count give a precise measurement.
c. Geology is an interconnected field of science.
d. Science and technology have a wide scope.

5. **Differentiate between the following.**

a. Biology and chemistry
b. Physic and chemistry

Step 3

6. **Answer the following questions.**

a. Make a chart to show the different fields of science and their corresponding branches.
b. Lets suppose you are in a science laboratory experimenting on certain hypothesis. What safety measures should you follow?
c. Write two advantages of writing large or small numbers in scientific notation.
d. We should always measure the least count of tool before experimenting. Discuss the importance of calculating least count of tools before experimenting.

e. A stopwatch has the least count of 0.1s. Discuss the meaning of the statement.

f. Explain the role of taking an average of measurement while experimenting in the laboratory.

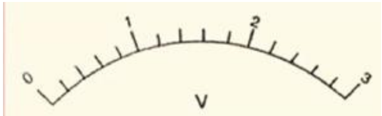
Numerical

a. Write the following measurements in scientific notation

i. 0.00003s ii. 0.000000072m iii. 0.0000000016g

iv. 6400000m v. 300000000m/s

b. Find the least count of a voltmeter with scale as shown in the given figure.



Step 4

8. Long question answers.

a. Which branch of science is more interesting for you? Write any two points about your interest. What scopes do you expect in the corresponding branches of science?

b. Explain the achievements of science in the following fields and the corresponding challenges associated with these achievements:

i. Energy ii. Medicine

iii. Communication iv. Transportation

c. Use the internet or consult seniors in your locality to search for the scope of different branches of science. Based on your findings, prepare a presentation or report on the scope of science.

d. How does the use of prefixes make each expression and conversion of measurement easier? Write with examples.

e. Make a chart to show branches of science. Search in reference study materials about the scopes of different branches of science and write them on your chart paper to present in the classroom.

UNIT

2 CLASSIFICATION OF LIVING THINGS

ESTIMATED TEACHING PERIODS

TH	PR
4	2

Carlous Linnaeus
(1707-1778)

Curriculum issued by CDC

- Introduction to classification of organisms
- Introduction to binomial system of nomenclature with examples
- Introduction to genus and species of the organisms
- Concept of classification of organisms based on five kingdom system
- Characteristics of monera, protista and fungi with examples

Learning outcomes

After completion of this unit, students will be able to:

- introduce binomial system of nomenclature and to write the name of organisms based on this system.
- introduce genus and species.
- clarify the concept of classification of organisms based on five kingdom system.
- explain the characteristics of monera, protista and fungi.

Terms and terminologies

1. Classification of organisms: Classification of organisms is the act of grouping organisms based on their similarities and dissimilarities.

2. Binomial system of nomenclature: The process of giving two names for each organism, the first name from the genus and the second name from the species, is called the binomial system of nomenclature.

3. Taxonomy:	The branch of science in which organisms are identified, given names and classified is called taxonomy.
4. Identification:	Identification is the process of distinguishing the type of organism based on its characteristics.
5. Genus:	The group of closely related species is called genus.
6. Species:	The group of individual organisms that are completely similar to each other and can interbreed to produce fertile offspring is called species.
7. Five kingdom system:	The system of classification where organisms are divided into five distinct kingdoms is called the five-kingdom system.
8. Monera:	The kingdom of unicellular prokaryotes is called Monera.
9. Protista:	The kingdom of unicellular eukaryotes is called Protista.
10. Fungi:	The kingdom of non-green saprophytic organisms is called fungi.

Introduction

Classification of organisms is the act of grouping organisms based on their similarities and dissimilarities. It was first done by Swedish biologist Carolus von Linnaeus in the 1750s. Carolus introduced a system known as the binomial system of Nomenclature in which the plants and animals were given a unique name called the scientific name. The scientific name consists of two Latin words: the first word is called the genus or the generic name and the second one is called the species or specific name or epithet. The process of giving two names for each organism, the first name from the genus and the second name from the species, is called the binomial system of nomenclature. Today, all known organisms in the world have a universal scientific name that every biologist understands irrespective of his language and country. The system Carolus started is well developed into a branch of biology known as the Taxonomy. The branch of science in which organisms are identified, given names and classified is called taxonomy. Carolus von Linnaeus is known as the father of taxonomy.

Fact and Reason

Carolus von Linnaeus is known as the father of taxonomy, why?

Carolus von Linnaeus started the systematisation in the classification process through the binomial system for the first time. So, Carolus von Linnaeus is known as the father of taxonomy.

Memory Note

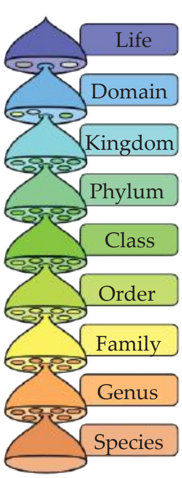
1. *There are about 8.7 million species of living things on the earth.*
2. *Taxonomy is the branch of biology which deals with the identification, classification, and nomenclature of organisms.*

Discovery, Identification, Classification, and Nomenclature

When a new species of an organism is discovered, its characteristics are studied and the kind of organism is identified. Identification is the process of distinguishing the type of organism based on its characteristics. Then, the discovered organism is classified under a proper taxon. After that, the organism is given a binomial name which completes the process of systematic classification.

Hierchi in classification

The hierchi in the classification of organisms is given below:



Kingdom
Phylum or Division
Sub-phylum or Sub-division
Class
Order
Family
Genus
Species

Importance of classification

The advantages of the classification of organisms are as follows:

i. Classification helps us to learn about the characteristics of a large number of plants and animals in a group.

ii. It is systematic and scientific. Hence, it is an easy and understandable method of studying the characteristics of organisms.

iii. It projects a basic idea about the inter-relationship between similar and dissimilar species.

iv. Classification helps study the trend of diseases, evolution, growth, and decline in the population of creatures.

Memory Note

Kingdom, Phylum or Division, Sub-phylum or Sub-division, Class, Order, Family, Genus, Species

Fact and Reason

Why is classification of organisms necessary?

Classification of organisms is necessary to identify, group, and properly name the organisms with the help of a standardised system based on similarities found in the organisms.

The genus or generic name

Genus represents the group of those organisms that have similar physiology, anatomy, and feeding habit. For example, tiger and lion belong to a similar genus called Panthera. The group of closely related species is called the genus. The organisms of the same genus but different species generally do not interbreed with each other.

Memory Note

The scientific name consists of two Latin or Greek words. the first word is called the genus or the generic name and the second one is called the species or specific name or epithet.

The species or specific name or epithet

The group of individual organisms that are completely similar to each other and can interbreed to produce fertile offspring is called species. For example, a male cat and a female cat belong to the same species. They can interbreed with each other to produce the same species type.

Memory Note

In some organisms, interbreeding between different species of the same genus is also possible.
Example:
i. Male tiger + female lion = tigon
ii. Male lion + female tiger = liger
These animals are called hybrids. They have selected the qualities of their parents.

Activity

What other members belong to our genus? Collect information from the internet.

Method of writing scientific names

The scientific names of organisms should be written with the following rules:

i. The first letter of the genus should be capital and all the remaining letters should be small.
ii. A space should be given between the genus and the species.
iii. Both the genus and the species should be separately underlined in handwritten form.
iv. The genus and the species should be italicised (as in *Panthera*) in printed form.

Common name	Generic name	Specific name
Potato	*Solanum*	*tuberosum*
Paddy	*Oryza*	*sativa*
Human	*Homo*	*sapiens*
Tiger	*Panthera*	*tigris*
Lion	*Panthera*	*leo*
Cat	*Felis*	*catus*
Pea	*Pisum*	*sativum*
Apple	*Malus*	*domestica*
Maize	*Zea*	*mays*

Fact and Reason

Why is the two-kingdom classification system inadequate?

Two-kingdom classification system is inadequate because this system puts together Eukaryotes and Prokaryotes. It also groups non-green fungi with green plants.

Five kingdom system

The two-kingdom system could not distinguish between prokaryotes and eukaryotes, autotrophs and heterotrophs, unicellular and multicellular organisms. Many organisms did not fit in the two-kingdom system satisfactorily. Therefore, American Biologist Robert H. Whittaker proposed the five-kingdom system, adding three more kingdoms: Monera, Protista, and Fungi, in addition to the earlier two kingdoms: Plantae and Animalia. The system of classification where organisms are divided into five distinct kingdoms is called the five-kingdom system.

Significance of five kingdom system

The five-kingdom system is the best among all classification systems. It is based mainly upon the differences in nutrition. The significances of the five-kingdom system are:

i. The prokaryotes are differentiated from eukaryotes.

ii. Fungi are differentiated from plants.

iii. Unicellular organisms are separated from multicellular ones.

iv. It is based on the mode of nutrition and evolution so it will be easy to understand their lifecycle.

Criteria for division of organisms into five kingdoms

The living things are divided into five kingdoms based on the following criteria:

i. Cell structure: Complex eukaryotic cells and simple prokaryotic cells

ii. Thallus organisation

iii. Mode of nutrition: autotrophic or heterotrophic

iv. Mode of reproduction

v. Phylogenetic relationships

The five-kingdom system is explained in brief below:

1. Kingdom Monera

This kingdom includes all types of bacteria (e.g., cyanobacteria or blue-green algae, coccus, bacillus, etc.). They are single-celled microscopic prokaryotes having no nuclear membranes. The kingdom of unicellular prokaryotes is called Monera. They are both autotrophic and heterotrophic.

Monera kingdom is further divided into Archaebacteria, Eubacteria and Cyanobacteria.

i. Archaebacteria: They are found in extreme environments such as underwater volcanoes, acidic environments, hot springs etc. So, they are also called extremophiles.

ii. Eubacteria: They are the most common bacteria. They are found almost everywhere. They are called true bacteria. They can be either heterotrophs or autotrophs.

iii. Cyanobacteria: They are mostly autotrophic. They contain chlorophyll. They are also called blue-green algae. They are found in moist places, ponds, lakes etc.

Memory Note

Kingdom Monera consists of one-celled organisms, both autotrophs, and heterotrophs that are extremely simple in structure.

Characteristics of Monera are:

i. Monera are unicellular organisms.

ii. They have prokaryotic cells.

iii. They do not have a well developed nucleus. DNA works as a nucleic core.

iv. Some of them are parasites. Some are either free-living or saprophytic or symbiotic or autotrophic.

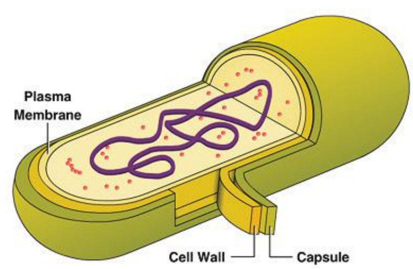


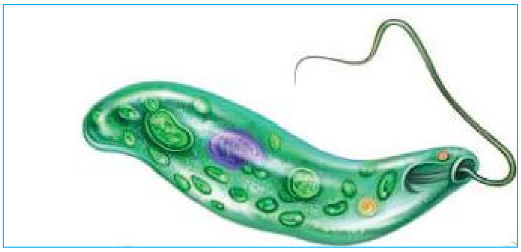
Figure of Monera

2. Kingdom Protista

This kingdom includes single-celled microscopic eukaryotes. i.e., they contain a well-defined nucleus with membrane-bound cellular structures.

The kingdom of unicellular eukaryotes is called Protista. For example, amoeba, paramecium, euglena, etc. Their locomotory organs are primitive. Some Protista species are close to fungi such as slime mould and water mould.


amoeba


euglena


paramecium

The figure of a few Protista

Activity

Observe some members of protozoa through a compound microscope.

Characteristics of Protista are:

i. They are unicellular eukaryotic animals.
ii. They are both free-living and parasitic.
iii. They have locomotory organs like pseudopodia (in amoeba), cilia (in paramecium), flagella (in euglena), etc.
iv. Some of them like an amoeba, plasmodium, giardia, etc. cause diseases in humans.
v. All protozoa are heterotrophic except euglena which is both autotrophic and heterotrophic.

3. Kingdom Fungi

Fungi may be single or multi-celled. The kingdom of non-green saprophytic organisms is called fungi. They have to depend upon dead and decayed matter for food. Most of the fungi are filamentous and thread-like in structure.

Characteristics of fungi are:

i. Habitat: Most fungi are terrestrial but some are aquatic too.

ii. Body: The fungi are both unicellular (e.g., yeast) and multicellular (e.g., mushroom) but thallus in nature. The plant body is filamentous and has thread-like branches called mycelium.

iii. Nutrition: Fungi do not bear chlorophyll and are non-green. So, they are heterotrophic. Some are saprophytic while the rest are parasitic and symbiotic.

iv. Food storage: The fungi store food in the form of glycogen.

v. Cell wall: The cell wall of fungus is made up of a modified carbohydrate called chitin.

vi. Reproduction: They reproduce both by asexual and sexual methods.

Fact and Reason

Why is the five-kingdom classification system most accepted?

In the five-kingdom classification system, organisms are grouped into five kingdoms. This grouping is based on the complexity of Cell Structure (Prokaryote or Eukaryote), Complexity of the Organism's Body (Unicellular or Multicellular and Complex), and Mode of their Nutrition (autotrophs and heterotrophs). So, the five-kingdom classification is the most accepted system of classification.

Types of fungi

Based on the mode of nutrition fungi are divided into the following groups:

i. Saprophytic fungi: The fungi that absorb nutrition directly from dead and decaying organisms are called saprophytic organisms.
For example, mucor and mushroom.

ii. Parasitic fungi: The fungi that absorb nutrition from other living organisms are called parasitic fungi.
For example, Puccinia and Taphrina

iii. Symbiotic fungi: The fungi that absorb water and mineral for the algae and get food in return are called symbiotic fungi. The combination of algae and fungi is called lichen.

Activity

Observe the mucor through the compound microscope.

Answer writing skill

1. Define classification.

Classification of organisms is the act of grouping organisms based on their similarities and dissimilarities.

2. What is binomial system of nomenclature?

The system in which an organism is given a name of two Latin words: generic and a specific name is called a binomial system of nomenclature.

3. Why do protozoa belong to Protista?

Protozoa belong to the Protista kingdom because of the following traits:

i. They are unicellular eukaryotic animals.
ii. They are both free-living and parasitic.
iii. They have locomotory organs like pseudopodia (in amoeba), cilia (in paramecium), flagella (in euglena), etc.

4. Differentiate between genus and species.

The differences between genus and species are:

SN	Genus	SN	Species
1	Genus represents the group of those organisms that have similar physiology, anatomy, and feeding habit.	1	Species represent organisms that are completely similar to each other and can interbreed to produce fertile offspring.
2	They cannot interbreed.	2	They can interbreed.

5. Monera are probably the oldest organisms in the earth. Enlist few of their distinguishing features.

Characteristics of Monera are:

i. Monera are unicellular organism.

ii. They have prokaryotic cells.

iii. They do not have a well developed nucleus. DNA works as a nucleic core.

6. There are different methods of classification of organisms. But, among them the five-kingdom system of classification is accepted the most. Discuss the significance behind it.

The points below show the significance of the five-kingdom system:

i. The prokaryotes are differentiated from eukaryotes.

ii. Fungi are differentiated from plants.

iii. Unicellular organisms are separated from multicellular ones.

iv. It is based on the mode of nutrition and evolution so it will be easy to understand their lifecycle.

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. Which organism is Panthera tigris?

i. lion	ii. tiger
iii. cat	iv. dog

b. Which kingdom do blue-green algae belong to?

i. monera	ii. protista
iii. fungi	iv. plantae

c. What is the locomotory organ of the amoeba?

i. flagella	ii. cilia
iii. setae	iv. pseudopodia

d. Which one of the following is Protista?

i. yeast	ii. bacteria
iii. amoeba	iv. cat

e. Which kingdom does yeast belong to?

i. animalia	ii. plantae
iii. fungi	iv. monera

2. Define the following with required examples.

a. Taxonomy
b. Classification
c. Binomial system of nomenclature
d. Identification
e. Five kingdom system
f. Fungi

3. Short question answers.

a. Who is called the father of taxonomy?
b. Write scientific names of humans.
c. Who introduced the five-kingdom system?
d. Write the rules for writing the scientific name.
e. Which kingdom does euglena belong to?

Step 2

4. Give reason.

a. Carlous Linnaeus is called the father of taxonomy.
b. Living things must be classified.
c. The five-kingdom system is better than the two-kingdom system.
d. Cyanobacteria belong to the kingdom Monera.

5. Differentiate between the following.

a. Genus and Species
b. Monera and Protista
c. Protista and Fungi

Step 3

6. Answer the following questions.

a. What is the importance of classification?

b. List points to show the significance of the five-kingdom system.

c. What are the bases on which living things are divided into five kingdoms?

d. What are the characteristics of Monera?

e. Enlist the distingushing features due to which euglena is classified as a Protista?

f. Write the characteristics of fungi.

Step 4

7. Long question answers.

a. Five kingdom system is better than two kingdom system. Support the statement

b. What are fungi? Based upon the mode of nutrition, there are three types of mushrooms. Collect information on each of them.

c. Discuss the interrelationship between various levels of classification of living things.

d. Make a classification chart of five kingdom system and draw pictures of any two organisms of each kingdom.

e. Observe the given diagrams of organisms and write down their kingdom.

(a)

(b)

(c)

UNIT

3 MUSHROOM

ESTIMATED TEACHING PERIODS

TH	PR
4	1

Job Bicknell Ellis
(1829-1905)

Curriculum issued by CDC

- Lifecycle of mushroom
- Importance of fungi (cultivation of mushroom and products made from mushroom)
- Importance of mushroom in human health.
- Identification of edible and non-edible mushroom.

Learning outcomes

After completion of this unit, students will be able to:

- explain lifecycle and importance of mushroom.
- identify edible and non-edible mushroom.
- study the mushroom cultivation technology.

Terms and terminologies

1. Mushrooms: The spore bearing, fleshy and non-chlorophyllus fruiting bodies are called mushrooms.
2. Mycelium: The underground vegetative thallus part of the mushroom is called mycelium.
3. Fruiting body: The fruiting body is the reproductive part of the mushroom.
4. Stipe: Stipe is the main support of pileus.
5. Pileus: The upper coloured part of the mushroom that protects the gills is called pileus.
6. Gills: Gills are thin spongy slits stacked side by side under the cap.
7. Trama: Trama is an inner fleshy portion of a mushroom's basidiocarp.

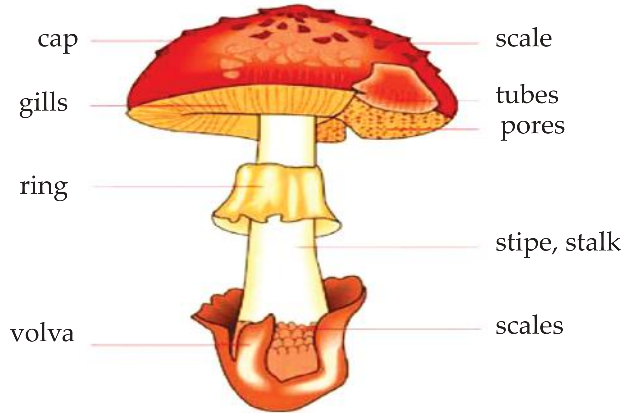
8. Hymenium:	The outermost layer of the gills is called hymenium.
9. Paraphyses:	Paraphyses are infertile erect filaments of hymenium.
10. Basidium:	Basidium is a microscopic club-shaped spore-bearing fertile structure at the gills of fungus.
11. Sterigmata:	The finger-like projection of basidium is called sterigmata.

Introduction

Mushrooms belong to the kingdom Fungi. This group is very distinct from plants, animals and bacteria. Fungi lack the most important feature of plants, viz. the ability to use energy from the sun directly through chlorophyll. Thus, fungi depend on other organisms for food. They absorb nutrients from the organic material in which they live. The living body of the fungus is mycelium, which is made out of a tiny web of threads called hyphae. Under specific conditions, sexually compatible hyphae will fuse and start to form spores. The spore bearing, fleshy and non-chlorophyllus fruiting bodies are called mushrooms. In nature, this is the most striking part of the organism, but in fact, it is just the fruiting body and the major part of the living organism is found under the ground or inside the wood.

3.1 Structure of mushroom

The mushroom is composed of an underground part called mycelium and an aboveground part called the fruiting body.



mushroom

Mycelium


Mycelium

Mycelium is a vegetative part of the mushroom. It is a collection of hyphae. It is produced from spore germination. It is an underground part of the fungus. The underground vegetative thallus part of the mushroom is called mycelium. The fruiting body grows from mycelium. The fruiting body is the reproductive part of the mushroom. Hyphae is a single microscopic filament. It is white. It draws water and organic materials for mushrooms.

The above-ground part of the mushroom contains a stipe, annular ring and pileus.

Fact and Reason

Why does mycelium grow in decaying organic material?

The mycelium grows in decaying organic material to collect nutrition and water.

Activity

Observe the mycelium under a powerful compound microscope.

Stipe

Stipe is the main support of pileus. It contains a ring.

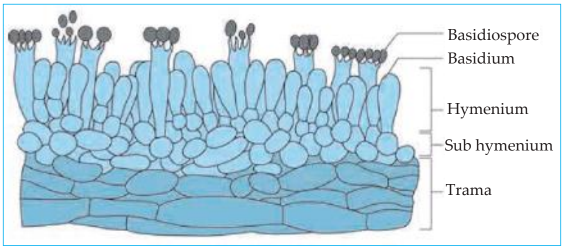
Pileus

The upper coloured part of the mushroom that protects the gills is called pileus. It has a different shape for different species of mushrooms.

Gills

The gills grow on the lower part of the pileus. Gills are thin spongy slits stacked side by side under the cap. They have three layers. These are trama, hymenium and sub hymenium. Trama is an inner fleshy portion of a mushroom's basidiocarp. The outermost layer of the gills is called hymenium.

It contains basidium and paraphyses. Paraphyses are infertile erect filaments of hymenium. It provides support to basidium. Basidium is a microscopic club-shaped spore-bearing fertile structure at the gills of fungus. Basidium is binucleated. It contains a plus strain and a minus strain. The fusion of plus strain and minus strain produces a diploid nucleus. The diploid nucleus undergoes meiosis cell division to produce four haploid nuclei. Two of them have positive strain and two of them have negative strain. These haploid nuclei will move at the end of sterigmata. The finger-like projections of the basidium are called sterigmata. The haploid nuclei will change into basidiospores with respective strains.



structure of gills

3.2 The life cycle of mushroom

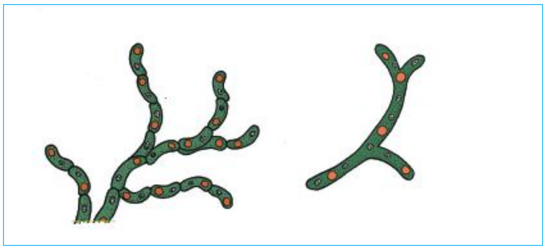
Dropping of the spores

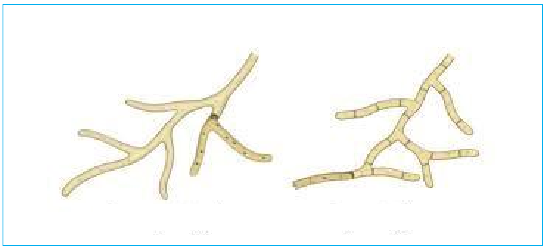
Mushroom produces basidiospores in the gills. On maturity, basidiospores are released from gills into the surrounding. Spores are either plus strained or minus strained. Spores can travel far away with the help of air and water.


dropping of spores

Formation of hyphae

Each spore under suitable conditions produces hyphae. Hyphae of opposite traits fuse to produce mycelium with the diploid nucleus.


plus strain hyphae


minus strain hyphae

Memory Note

The world's most expensive mushroom is the rare European white truffle which costs 2,200 euros for each pound.

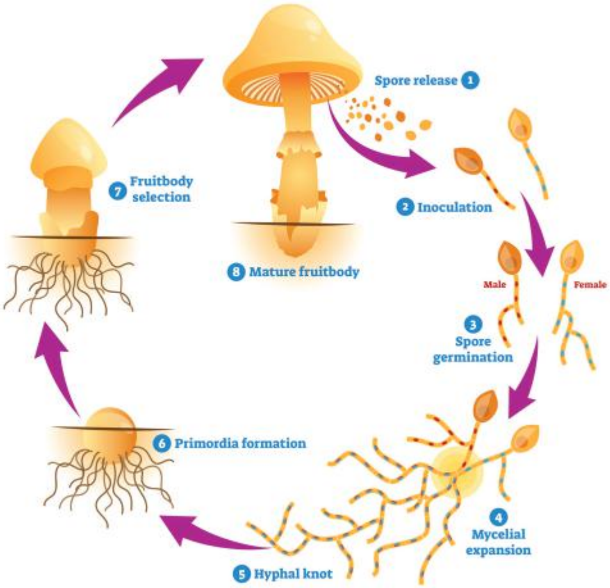
Mycelium

mycelium

Mycelium appears like a root of the mushroom. It remains rooted to the ground. The web-like system gives its stability. It grows pinheads. Pinheads are the tiny fruiting body.

Fruiting body

The pinhead will grow and change into a basidiocarp. It has stipe and pileus. It grows gills. Gills contain basidium which produces spores.



life cycle of mushroom

Hence the life cycle of mushrooms continues.

Fact and Reason

The fruiting body is a reproductive part.

The fruiting body is a reproductive part because it has gills or pores to produce spores.

Activity

Observe the structure of gills through a microscope.

3.3 Use of mushroom

Mushroom is a healthy diet. It is available in wild. It can be farmed as well. It is a very nutritious source of food. It has lots of health benefits.

1. Importance of mushrooms as a diet

i. Source of protein

Mushrooms have a very high protein content compared to rice, wheat and chicken. It is the best alternative to meat. Mushrooms are a good powerhouse of energy, too.

ii. Source of vitamin

Mushroom contains Riboflavin, biotin, vitamin B12, thiamine etc.

iii. Source of minerals

Mushroom is a good source of electrolytes in our body. It provides potassium, sodium, calcium, copper, iron and phosphorus for us.

iv. Medicine

It reduces the risk of obesity, diabetes, cardiac diseases.

It boosts up the immunity system.

2. Economic importance

Mushroom is delicious and nutritious. It has lots of health benefits. Therefore, its demand is increasing every day in the local market. It sells at a high price. So, farmers are interested in farming mushrooms.

Pleurotus ostreatus and *Agaricus bisporus* are the most cultivated mushroom types in Nepal. It has helped thousands of farmers to earn their livelihood. It has increased the gross domestic product of the country. Dried mushrooms, pickles and fresh mushrooms are available in the market.

3.4 Mushroom farming

Agaricus bisporus or the button mushroom is the most cultivated mushroom for vegetables. Its mycelium spreads well at a temperature of 25°C. Its fruiting body grows well around 17°C. Higher temperatures are harmful to the mushroom. Lower temperature delays the growth of the mycelium and fruiting body. The mushroom house can be any available room, shed, basement, tent, etc. The growing house must be well ventilated.

Mushroom farming is done by following procedures.

i. Natural compost can be prepared by cutting down the straw or hay into tiny pieces. The hay is usually cut in between 1 and 2 inches in length. It is then boiled for about 20 minutes to kill any microbes living in it. It is now dried and packed in a plastic bag.

ii. While packing, 8 to 10 inches of straw is kept in a plastic bag. Mushroom spore is sprayed in it. Then another layer is added above it. Multiple layers are made in a single plastic bag and spore is spread in each layer.

iii. Layers of straw along with the spores are gently pressed in the plastic bag. Multiple holes are punched in the plastic bag. It is now stored in a dark room for a week.

iv. White mycelium will be seen in the compost after a week. Few holes are punched and mycelium is watered.

v. The new fruiting body starts to grow after 10 days of planting. Mushroom's fruiting body grows from the holes after 17 days. It can be harvested after 25 days.

mushroom growing in natural compost

Memory Note

Amazingly some species of mushrooms glow in the dark which is caused by the chemical reaction known as bioluminescence.

Fact and Reason

The temperature of the mushroom house must be around 25°C for the first 2 weeks.

The temperature of the mushroom house must be around 25°C for the first 2 weeks so that mycelium can grow properly.

Activity

Visit a mushroom farm with your guardians.

3.5 Storage and use of mushroom

Storing the mushroom in the refrigerator is the best way to preserve mushroom but it will last for a week only. Moisture and heat will destroy the mushroom. Dried mushrooms will last longer and even can enhance the taste of the mushroom. To prepare dried mushroom, it should be washed, cut into tiny pieces and boiled. Then it should be dried. It can be dried in sun, oven, stove etc. or it can be dried chemically. The mushroom pieces must be dried in the sunshine in summer at a temperature above 25°C. It can be dried in an oven at a temperature of 40°C to 45 °C. It can be stored for 120 days.

Mushroom pieces can be soaked in the solution of 1% potassium bisulphate, 0.2% of citric acid, 6% sugar and 3% salt for 16 hours and can be heated up to 60°C to 62°C in micro-oven for 8 hours. It will produce the best-dried mushroom.

Dried mushrooms should be stored in an airtight container.

Mushroom ketchup and pickles will also last for half a year. Powdered mushroom soup and curry is available in the market. It can be stored for a long duration.

Fact and Reason

Why is mushroom dried?

The mushroom is dried so that it can be stored for a longer duration.

Memory Note

One of the deadliest mushrooms is the Death cap mushroom. These contain amatoxin which is fatal.

3.6 Edible and poisonous mushroom

The disadvantage of the mushroom is some of them are poisonous. Its consumption can disrupt digestion and induce paralysis. Some of them can cause hallucinations, vomiting and stomach cramp. A very poisonous mushroom can push a person into a coma or even kill the person. So, we must be able to identify the poisonous mushroom from the edible ones. Most of the mushrooms from the genus Amanita are poisonous. For example, *Amanita phalloides* the death cap, Amanita species the destroying angels, Jack O' Lantern, false morels etc. are deadly mushrooms. It is never a good idea to collect mushrooms from the wild and consume them. The edible mushroom also can absorb toxins and kill people if they are stored with poisonous mushrooms.

Amanita phalloides the death cap

Amanita species the destroying angels

Omphalotus illudens the Jack O Lantern

Some of the edible mushrooms are *Boletus badius*, Button mushroom, Caesar's mushroom, cauliflower mushroom etc.

Boletus badius

Button mushroom

Caesar's mushroom

cauliflower mushroom

Activity

Observe the mushroom and try to guess if it is poisonous or not.

Tips for identifying poisonous mushroom

A poisonous mushroom can be identified with the following tips:

i. Red pileus usually suggests poisonous mushroom.

ii. The presence of rings and volva in the stipe suggests poisonous mushrooms.

iii. White gills are a major red flag. Never eat them.

iv. Most of the bright coloured mushrooms are poisonous.

v. There are no insects around the poisonous mushrooms.

vi. Yellow slime in the pileus means poisonous.

Answer writing skill

1. What is a mushroom?

The spore bearing, fleshy and non-chlorophyllus fruiting bodies are called mushrooms.

2. Give an example of four edible mushrooms.

Four examples of the edible mushrooms are Boletus badius, Button mushroom, Caesar's mushroom, cauliflower mushroom etc.

3. Why are there no insects around bright mushroom with white gills?

There are no insects around the bright mushroom with white gills because it is poisonous.

4. Differentiate between paraphyses and basidium.

The differences between paraphyses and basidium are:

SN	Paraphyses	SN	Basidium
1	Paraphyses are infertile erect filaments of hymenium.	1	Basidium is a microscopic club-shaped spore-bearing fertile structure at the gills of fungus.
2	It provides support to basidium.	2	It produces basidiospores.

5. List any three uses of the mushroom.

The uses of mushrooms are listed below:

i. It is consumed as vegetables, pickles and soup.

ii. It is a good source of vitamins, protein, electrolytes and metals for our body.

iii. It is used as a sedative to calm down the body and relieve stress.

6. Discuss the economic importance of mushroom in our country.

The economic importance of mushrooms are:

i. It is cheap to start mushroom farming.

ii. It generates a source of income for local farmers.

iii. It increases the gross domestic product of the country.

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. Which one is a reproductive part of the mushroom?

i. fruiting body	ii. hyphae
iii. mycelium	iv. all

b. Which one of them is fertile?

i. paraphyses	ii. basidium
iii. trama	iv. hyphae

c. Which mushroom is edible?

i. false morels	ii. destroying angles
iii. death cap	iv. button mushroom

d. Which one of the given mushrooms is poisonous?

i. *amanita phalloides*	ii. *boletus badius*
iii. cauliflower mushroom	iv. all of them

e. What is the suitable temperature for the growth of the fruiting body?

i. 25°C	ii. 17°C
iii. 40°C	iv. 55°C

2. Define the following, with examples.

a. Mushroom	b. Hyphae	c. Stipe
d. Pileus	e. Gills	f. Hymenium
g. Trama	h. Sterigmata	i. Basidiospore

3. Short question answers.

a. Write the name of the reproductive part of the mushroom.

b. Which part of the gills is fertile?

c. What is the suitable temperature for the growth of mycelium?

d. How long does a dried mushroom last?

e. Give an example of an edible mushroom.

Step 2

4. Give reason.

a. Mushroom is called a saprophyte.

b. Why is mushroom good for our health?

c. Mushroom cultivation is growing popular among farmers.

d. Straw is boiled for 20 minutes before spraying mushroom spores.

5. Differentiate between the following.

a. Paraphyses and basidium.

b. Mycelium and fruiting body

Step 3

6. Answer the following questions.

a. Describe the structure of the mushroom.

b. Draw a labelled diagram of the mushroom.

c. Describe the structure of the gills of the mushroom.

d. Draw a labelled diagram of gills.

e. How is spore formed in basidium?

f. List the health benefits of mushrooms.

Step 4

7. Long question answers.

a. Describe the life cycle of mushrooms. Draw a well-labelled diagram to represent the life-cycle of mushrooms.

b. If you are going to farm mushrooms, how should you do it?

c. Let's suppose we have to store a kilogram of mushroom for next month. How should we do it? Suggest the multiple ways to do so.

UNIT

4 EVOLUTION

ESTIMATED TEACHING PERIODS	TH	PR
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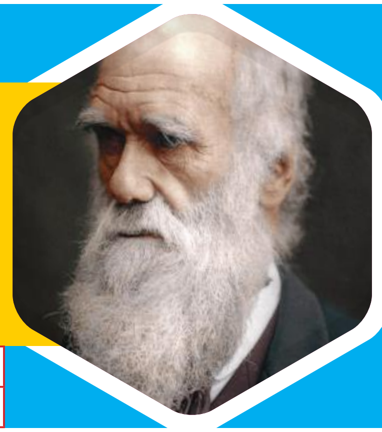


Charles Darwin
(1809-1882)

Curriculum issued by CDC

- Concept of evolution
- Evidences of evolution
- Lamarck theory of evolution
- Darwin theory of evolution
- Hugo de Varies theory of variation
- Importance of variation and mutation in evolution

Learning outcomes

After completion of this unit, students will be able to:

- explain the concept of evolution based on evidences.
- clarify the concept of Lamarck theory of evolution.
- explain the concept of Darwin theory of evolution.
- explain the concept of Hugo de Varies theory of variation.
- study the importance of variation and mutation in evolution.

Terms and terminologies

1. Chemical evolution: The process by which simpler compounds arranged themselves to form complex compounds like DNA, RNA, proteins etc. is called chemical evolution.
2. Biological evolution: The transformation of lower organisms into complex and higher organisms by modifying themselves is called organic or biological evolution.

3. Fossils:	Fossils are the remains of ancient organisms or their imprints on the rocks that are visible on careful digging.
4. Palaeontology:	The branch of science that studies fossils is called palaeontology.
5. Morphology:	Morphology is the study of external structures of organisms.
6. Anatomy:	Anatomy is the study of the internal structures of organisms.
7. Homologous organs:	The organs having similar structure and origin but different functions in the real world are called homologous organs.
8. Analogous organs:	The organs that are similar in function but different in origin and structure are called analogous organs.
9. Vestigial organs:	The organs which had typical functions in the past but have become functionless are known as vestigial organs.
10. Bridge organism:	The organism having the characteristics of two or more groups of other organisms is known as a bridge organism or connecting link.
11. Embryology:	The study of the embryo is called embryology.
12. Darwinism:	The overall concept proposed by English naturalist and geologist Charles Robert Darwin regarding how evolution occurs is known as Darwinism.
13. Variation:	The difference in the structural and behavioural characteristics between the organisms is called variation.
14. Struggle for existence:	The struggle of any organism with others and nature for food, habitat and mating is called struggle for existence.
15. Heredity:	The transfer of characteristics from parents to their offspring is called heredity.
16. Heredity variation:	The type of variation which is caused due to the usual changes in the genes of the parental gametes is called hereditary variation.
17. Environmental variation:	The variation in the phenotype of the organisms which occurs due to environmental factors like climate, nutrition, lifestyle, culture, etc. is known as environmental variation.

18. Continuous variation:	The variation that occurs in the following generations in a variety of possible limits is known as continuous variation.
19. Discontinuous variation:	The variation that occurs within a limited range of options is known as the discontinuous variation.
20. Mutation:	Mutation is the sudden permanent change in the DNA or genes that alter the genotype or phenotype of an organism.
21. Neutral mutation:	Neutral mutations are changes in DNA sequences that are neither beneficial nor disadvantageous to the organisms.
22. Beneficial mutation:	Beneficial mutations are changes in DNA sequences that are useful for organisms.
23. Harmful mutation:	Harmful mutations are changes in the DNA sequence that are harmful to organisms.
24. Natural selection:	The process in which organisms with suitable variations survive and those with unsuitable variation die is called natural selection.

Introduction

The earth is a planet with varieties of life forms. There are simpler forms of life like the unicellular organisms and complex ones like the mammals in the same biosphere. Were these creatures the same in the past as they are now? If not, what were they like in the distant past? How did life originate in the first place? The best possible explanation of how life originated on the earth can be put forward in two steps. They are chemical evolution and organic evolution.

Memory Note

Evolution is defined simply as a genetic change over time.

Fact and Reason

Why are there living things on the earth?

There are living things on the earth because of chemical evolution.

Chemical evolution

The process by which simpler compounds arrange themselves to form complex compounds like DNA, RNA, proteins etc. is called chemical evolution. Due to chemical evolution, complex substances like proteins were organised to form the cell of the first organism.

Organic Evolution

The first organism to get originated was a unicellular organism (e.g. bacteria). But what happened after that? Where were the monkeys, tigers, trees and humans? The answer is: life gradually became complex from the simpler forms. Some unicellular organisms gradually and continuously developed to convert into multicellular organisms. Likewise, invertebrates developed into vertebrates and gymnosperms into angiosperms and so on. The transformation of lower organisms into complex and higher organisms by modifying themselves is termed organic or biological evolution. The living organisms that we see around today were not the same in the past. Biological evolution is currently the most scientific and accepted theory in the community of scientists.

Memory Note

All organisms on the earth were formed from some pre-existing organisms in the past.

Fact and Reason

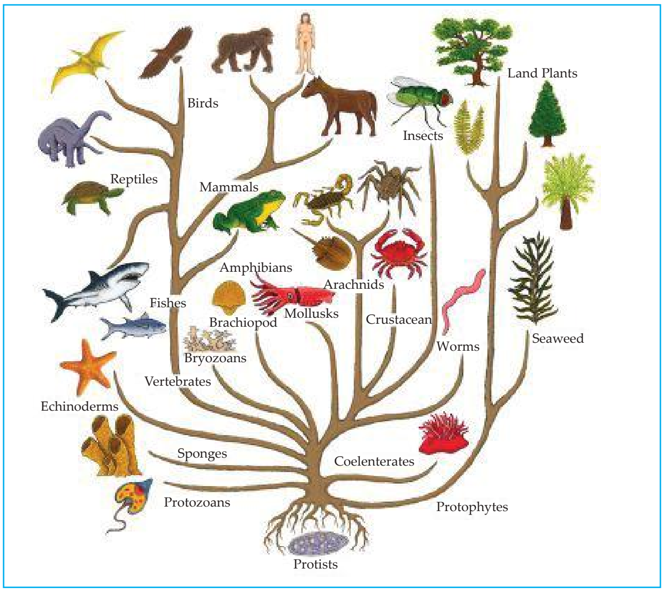
Why are there so many different species of living things on the earth?

There are so many different species of living things on the earth because of organic evolution.

Activity

How many species of plants and animals are there on the earth? Investigate in the internet.

The central idea of biological evolution is that most of the species existing now shared a common ancestor. It is in the same way that your father and uncle share the same grandfather. Hence, it suggests that all the organisms living today were cousins at some point in history. For example, all mammals, amphibians, reptiles and birds were fishes living in the oceans millions of years ago. Similarly, it forms a tree-like structure to suggest which organism evolved from which form of the ancestor. This structure is called an evolution tree.



A small segment of the tree of evolution.

Evidence of organic evolution

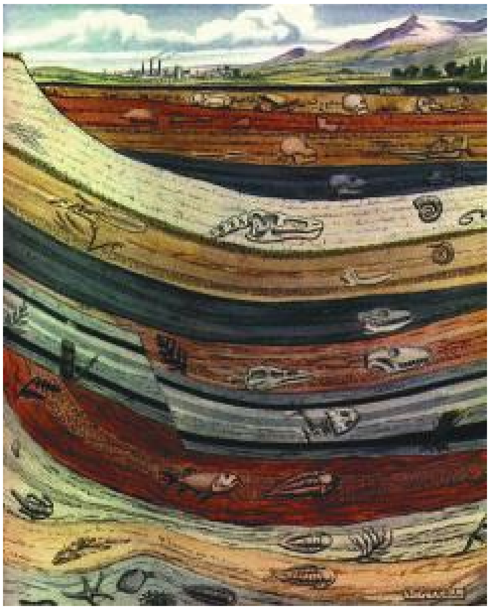
Several branches of science reach a similar conclusion that organic evolution is real. Evolution continuously changed organisms in the past and present and will gradually and continuously transform organisms in the future, too. But it is a very slow process that is not observed directly. The change in organisms is so slight that we do not observe it in our lifetime or several lifetimes. Some of the pieces of evidence that support evolution are:

a. Evidence from palaeontology: The study of fossils

Fossils are the remains of ancient organisms or their imprints on the rocks that are visible on careful digging. When organisms die and get buried in the soil without much decomposition, they get crushed upon by the sediments and harden over millions of years. During this process, they leave a mark

fossil

of their bodies on the underlying rocks. In this way, fossils are formed. The branch of science that studies fossils is called palaeontology.


sedimentary rock layers

The fossils of organisms buried in the past are depicted in different strata or layers. The fossils of organisms found at the deeper strata lived on this earth earlier compared to the fossils of organisms buried at the upper strata. This is because the sediments were mostly deposited on one layer upon the other and got pushed successively inside the earth. The actual fossils found on these rocks had a certain trend as follows:

i. Different strata of rocks had different structures of fossils of the same creature.

ii. The deeper strata had primitive and less developed fossils of creatures and the upper strata had developed and advanced fossils of creatures.

iii. Some of the fossils of organisms found deep inside the earth do not exist today.

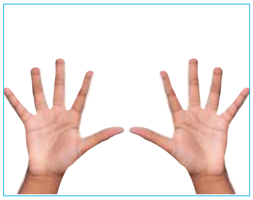
From the points above, we can conclude that the organisms buried earlier in the deeper part of the earth were primitive. In millions of years, they transformed gradually into advanced species. Some of them could not survive due to unfavourable conditions and got extinct. This proves the idea of organic evolution.

b. Evidence from comparative morphology and anatomy.

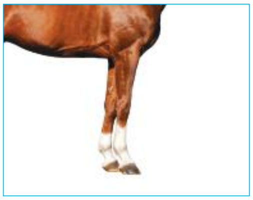
Morphology is the study of external structures and forms while anatomy is the study of internal structures of organisms. The same organs of different species may either be similar in structure and function or might differ. Based on the origin, structure and function, these organs show some evidence in support of evolution.

Homologous organs

Observe the picture of the flipper of a seal, wing of a bird, patagium of a bat, forelimb of a horse and arm of a human. These organs are similar in structure. The placements of bones and muscles and the distribution of blood vessels are also similar. But these organs have different functions in the real world. For example, the human arm is for holding things but the horse limbs are for running.



arms of human



forelimbs of a horse

flippers of whale

patagium of a bat

The organs having similar structure and origin but different functions in the real world are called homologous organs. The presence of homologous organs suggests that the organisms having them belong to a certain common ancestor. Thus, it proves that it is an evolution that modifies the organs of organisms over time.

Memory Note

Our species arose about 300,000 years ago.

Fact and Reason

Why do horses and humans have a similar structure of bones in the limbs?

The horse and the humans have a similar structure of bones in the limbs because both had the same ancestors millions of years back.

Activity

Taking the help of internate, compare the x-ray images of forelimbs of whales, dolphins, humans and horses.

Analogous organs

The organs that are similar in function but different in origin and structure are called analogous organs. These organs differ in external and internal features and origin but can perform similar tasks. Let us take an example of three analogous organs: the wing of a bat, a bird and an insect. All these organs are adapted to flying despite having different structures. These organs have evolved from organs of different ancestors but they evolved for the same cause i.e., flying. Bat has a heavier body than that of an insect. That's why its wings are muscular to induce more force in flying. Analogous organs provide evidence for evolution by stressing that organs of different species can modify over time to perform the desired function. Since it suggests modification of a body part over time, it suggests the point of evolution.


wings of insects


wings of birds

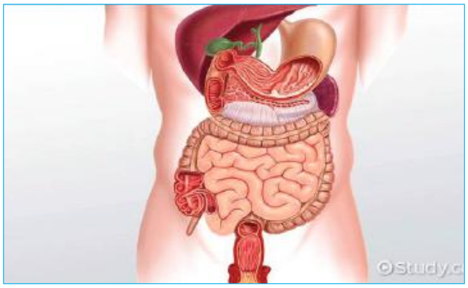

wings of bats

Fact and Reason

Analogous organs suggest evolution. Explain.

Animals from different ancestors modify their organs for common function. Such organs are analogous organs. And modification is the root of evolution.

c. Evidence from vestigial organ



vestigial organs

The human body is the overall package of organs and systems having different functions. In the past, as humans were on the verge of physical and mental development, they got several organs modified due to environmental and genetic causes. Some of these organs failed to perform a particular function but were still carried on to successive generations. The organs which had typical functions in the past but have become functionless or rudimentary are known as vestigial organs. Humans have numerous vestigial organs which are functionless. Some of such organs are illustrated in the table:

Vestigial Organs	Functional in	Function
Vermiform appendix	Herbivores	digesting cellulose
Ear muscles	Animals	locating the sound source
Nictitating membrane	Frogs, crocodiles etc.	moistening and protecting the eye
Coccyx bone	Chimpanzee, horse etc.	helping in moving and balancing
Wisdom teeth	Human ancestors	chewing cellulose
Breast nipples in men	Mammalian females	milk feeding

The presence of functionless vestigial organs in humans suggests that humans and other organisms that have these fully functional organs had a common ancestor in the past.

Memory Note

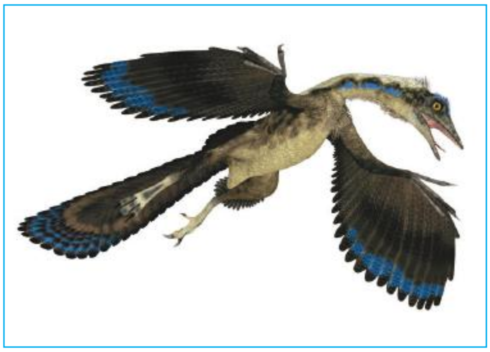
Human beings have a vermiform appendix because our ancestors might have had lots of plant diets.

Activity

What are the vestigial organs present in the snake? Research.

d. Evidence from bridge animals

platypus



archaeopteryx

There are various groups of organisms in biology divided based on specific characteristics. These organisms are grouped under heads like reptiles, amphibians, mammals etc. A reptile differs from a mammal and a mammal differs from a bird. Some organisms, on the other hand, have the characteristics of two or more groups and thus resemble more than one group of organisms.

The organism having the characteristics of two or more groups of other organisms is known as a bridge organism or connecting link. Connecting links are the ancestors of two definite groups of organisms that they resemble. Some of those species are Archaeopteryx (fossilised), platypus (Australian) and lungfishes (fish with lungs). The table above depicts their characteristics with their resembling groups. The existence of connecting link is the evidence that some groups of organisms had a common ancestor in the past or evolved from that group. This strongly supports the theory of evolution.

Connecting link	Between the group
Archaeopteryx	Reptiles and birds
Cycas	Pteridophytes and gymnosperms
Euglena	Animals and plants
Duck-billed platypus	Reptiles, birds and mammals
Protopterus (lungfishes)	Bonny fishes and amphibia
Rickettsia	Virus and bacteria
Virus	Living and non-living

Fact and Reason

Why is platypus called a connection between reptiles, birds and mammals?

Platypus is called the connection between reptiles, birds and mammals as it lays eggs, has a beak, is cold-blooded and has mammary glands and hair on their body.

Activity

How is archaeopteryx a connecting link? Discuss in group.

e. Embryonic evidence

When a zygote grows, it turns into a structure called the embryo. The study of the embryo is called embryology. Embryology tells us that we turn into a typical structure based on information stored on our genes (specific groups of DNA). The point is: if organisms have evolved from a common ancestor, they have similar genes and thus their bodies show some similarities to each other at least in the embryonic stage of development. Certain species like the fish, salamander, tortoise, chick, rabbit and human resemble each other to some extent at some stage in their embryonic development. As predicted by the biogenetic theory or recapitulation theory, it is believed that they had similar genes in the past i.e. they have evolved from a common ancestor. This proves that evolution is real.

Embryological evidence suggests common ancestry

Memory Note

In humans, the term "embryo" is usually restricted to the period of development from fertilisation until the end of the eighth week of pregnancy.

Fact and Reason

Humans and cows have the same ancestors. Give reason.

Humans and cows have the same ancestors because studies of the development of the embryos of both these species suggest the same.

Theory of evolution

The explanation of the process of evolution is proposed by several biologists in the form of different theories of evolution.

Among them, three theories are prominent:

a) Lamarckism: Jean Baptiste de Lamarck's theory of evolution

b) Darwinism: Charles Darwin's theory of evolution

c) Mutation theory: Hugo De Vries' theory

Lamarckism

Lamarckism is an overall concept proposed by French biologist Jean Baptiste de Lamarck (1744 A.D. - 1829 A.D.) He was the first person to propose the theory of evolution. In general, Lamarckism as published in different books of Lamarck like the Philosophie Zoologique is based on the following points:

i) Nature's role in evolution

ii) Use and disuse of organs

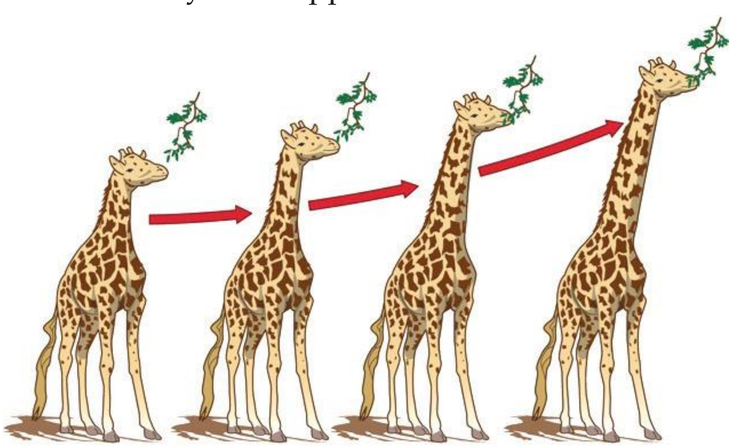
iii) Inheritance of acquired characteristics

i) Nature's role in evolution

Natural phenomena of climate, weather and habitat make organisms feel the 'need' to modify themselves according to the environment they live in. For example, yak living in cold regions realised the need to grow excessive hair on its body.

ii) Use and disuse of organs

According to Lamarckism, the organs that are repeatedly used become more advanced and develop in the successive generations while the unused organs either become rudimentary or disappear.



Elongation of neck of giraffe according to Lamarck

In a classical example of this idea, Lamarck took the long neck of the giraffe to explain the effect of overuse of an organ. He says that, in the past, giraffes were short necked and couldn't get enough food because of the presence of tall trees. Then, in each successive generation, the giraffe felt the need to get those leaves from the taller trees and so started to stretch its neck. Now, the behaviour of giraffe has changed and so the information of a longer neck is transferred to the next generation, making its successors long-necked. It consequently resulted in the long necks of the present day giraffes.

iii) Inheritance of acquired characteristics

Lamarck focused on the environmental and acquired factors. He said that these two factors make the shape of the genetic factors. He focussed that those qualities or behaviours that we acquire in our lifetime will pass on to our next generations. This also includes the information of use and disuse of an organ. Collection of acquired character can produce new species.

Criticisms on Lamarckism

i) Acquired characteristics are generally not inherited

A child of a muscular body trainer is not born with six packs.

ii) The need and desire of a species do not lead to the formation of new structures

Even though whale lives in water it could not develop gills.

iii) The use and disuse of organs do not affect its size

Despite continuous use forever, our joints, eyes, kidney etc. grow weaker instead of being stronger.

Darwinism

The overall concept proposed by English naturalist and geologist Charles Robert Darwin (1809 A.D. – 1882 A.D.) regarding how evolution occurs is known as Darwinism. Charles Darwin proposed this theory based on his five year's exploration. The distribution of vegetation, wildlife and fossils that he discovered compelled him to do detailed research. He analysed the data for many years and wrote a book called 'The Origin of Species' in 1859 A.D. His theory is often called Darwin's theory of Natural Selection or simply Darwinism.

The central idea of Darwin's theory can be summarised in the following points:

i) Overproduction in the biosphere
ii) Struggle for existence
iii) Variation and heredity
iv) Natural selection of fit organisms
v) Origin of new species

i. Overproduction in the biosphere

All organisms tend to reproduce in larger numbers to ensure their existence in the biosphere.

Memory Note

Charles Darwin discovered rare plants, birds and animals on Galapagos Island.

Fact and Reason

All of the species have enormous fertility but their population remains balanced, why?

All of the species have enormous fertility but the population remains balanced because most offspring are killed by predators, diseases and disasters.

Activity

Observe the number of offspring dogs, cats and pigs produce at a time.

ii. Struggle for existence

The organisms have to struggle with the others and nature for food, habitat and mating. The struggle of any organism with others and nature for food, habitat and mating is called struggle for existence. For example, fish lays thousands of eggs at a time but only a few survive. The ones that survive have to depend on the same food, water and mating partners. Due to this struggle for existence, the population of a species in the biosphere more or less remains constant. The death rate in the biosphere is higher because of the following reasons.

1. Intraspecific struggle: Struggle with the species of the same kind.
2. Interspecific struggle: Struggle with the other species.
3. Struggle with nature: Struggle with climate, weather, natural disasters etc.

iii. Variation and heredity

The species of organisms that survive wander in different places for food, habitat and mating partner. Due to this, organisms are influenced by the environment in many ways. The same species of organisms that are in different habitats may eat different foods due to which they might vary over time. The difference in the structural and behavioural characteristics of organisms is called variation. Variation occurs within the same species, too. The variations in offspring are transferred to the successive generations and recorded in the genes. The transfer of characteristics from parents to their offspring is called heredity.

Fact and Reason

Why do the individuals of the same species look different?

Individuals of the same species look different because of variation caused due to environment or sexual reproduction.

iv. Natural selection of fit organisms

Variations occur in every other organism in the world. These variations are of two types: favourable and unfavourable. The favourable variations are those that are suited best to the environment in which they live. Similarly, the unfavourable variations are those that do not suit them well.

Organisms having favourable variations flourish the most and are more likely to reproduce at a healthier rate. These organisms, in turn, adapt the best to nature and hence the nature selects them. On the other hand, organisms bearing unfavourable variations won't be able to cope with the environment. As a result, they become extremely rare or extinct. The process in which organisms with suitable variations survive and those with unsuitable variation die is called natural selection.

v. Origin of new species

Variations are ever-lasting. In each generation of species, it gives rise to new characteristics, behaviours and abilities. These qualities and the changing environment enable an organism to be continuously different from its former type. In the long run, these organisms will be so different from each other that they won't be able to breed with each other. In this way, new species are born. The new species experience the same rule of nature, according to Darwin, and thus this process continuously goes on.

Criticism of Darwinism

No theories and principles are universal. New advancements in technology and understanding of science keep on challenging the older theories. Darwin did his best in explaining how evolution works, but he couldn't explain how exactly new species are formed.

Memory Note

A glimpse of Darwin's theory: Variations and natural selection cause evolution.

Fact and Reason

Why do variations cause evolution?

The variations on each individual are transferred and collected in a new generation resulting in the origin of new species after certain generations.

Some of the criticisms of Darwinism are:

i. **Not scientifically proven**

Darwin's theory is not scientifically proven because it cannot be observed directly.

ii. **Variations are unlikely to create new species**

The probability of variations and errors in genes that might produce new species is extremely unlikely.

iii. **Darwin's theory can't explain the existence of vestigial organs**

According to Darwinism, parts of organisms remain only when they are suited best to nature but vestigial organs exist in organisms.

iv. **Unable to explain how variations arise.**

Darwin had no idea of how variations could occur in each successive generation.

Despite criticisms, Darwinism is considered the most scientific theory because it is based on observations on varieties of species and is consistent with the present-day study of genetics.

Memory Note

Darwin delayed the publication of his theory of natural selection for 20 years because he was criticised by the church.

Fact and Reason

Why is Darwinism still incomplete?

Darwinism is still incomplete because it cannot explain variation, mutation and vestigial organs.

Variation and mutation

No two organisms in this world are identical. Even identical twins are slightly different from each other. Organisms differ from each other genetically, physically, behaviourally, mentally and psychologically. The difference in genotype and phenotype of the organisms in each successive generation is known as variation. Variation is caused by genetic, environmental or both factors. Human beings also show variation in body structure, skin colour, hair type, behaviour, etc. The major causes of variation are:

i. Environmental factors ii. Crossing over in genes iii. Mutation

Types of Variation

Based on causes, there are two types of variation. They are:

i. **Hereditary variation:**

The type of variation which is caused due to the usual changes in the genes of the parental gametes is called hereditary variation. For example, the shape of an ear, blood group, etc. It occurs during the formation of male and female gametes by meiosis cell division. Hereditary variation is responsible for approximately 70-80% of total variations in human beings.

ii. **Environmental variation:**

The variation in the phenotype of the organisms which occurs due to environmental factors like climate, nutrition, lifestyle, culture, etc. is known as environmental variation. These include height, weight, skin colour, body size, intellectuality, etc. Due to environmental variation, small differences can be found even in identical twins that have nearly the same genotype. The environment is responsible for 20-30% of the variation in human beings.

Memory Note

About 99.9% of everyone's DNA sequence is the same, the remaining DNA make each one of us different.

Hugo De Vries' Mutation theory

mutation

Each gene of the chromosomes is responsible for controlling the phenotype of an organism. During sexual reproduction, the genes arrange themselves in the correct order to form a normal and healthy body. But, sometimes there occurs duplication, deletion and replacement of genes. These changes cause unexpected variations like the growth of 6 fingers in humans, more than 4 legs in cattle, fused heads, etc. This is called a mutation. Thus, mutation is a sudden permanent change in the DNA or genes that alters the genotype or phenotype of an organism. The mutant characters do not transfer in the successive generation. The mutation was first explained by Hugo De Vries. Therefore, it is also called Hugo De Vries "theory of evolution".

Causes of mutation

i. The mutation is caused by certain radiations like X-rays, UV rays, gamma-rays, etc.

ii. Accidental deletion, duplication or dislocation of genes during cell division causes mutation.

iii. The mutation is also caused by certain chemicals.

Fact and Reason

No two organisms look the same, why?

Sexual reproduction causes small variations in their genes. Due to these genes, there occurs a variation in the organisms. So, no two organisms look the same.

Activity

What mutations are present in humans? Observe.

The differences between variation and mutation

SN	Variation	SN	Mutation
1	Variation occurs in all generations.	1	Mutation occurs in a certain generation.
2	Variation brings out usual changes.	2	Mutation brings out unusual or sudden changes.
3	Variation is caused due to genetic and environmental factors.	3	The mutation is caused by radiation, chemicals or accidental change in genes.

Significance of mutation theory

i. A mutation is a raw material for evolution.
ii. Mutation appears all of a sudden and becomes operational immediately.
iii. Mutation is completely different from the normal character of the species.
iv. The same type of mutation can appear in several individuals or species.
v. Accumulation of variation produces new species.
vi. Useful mutations are selected by nature.
vii. Mutations are inheritable.

Criticism of Hugo De Vries' mutation theory

i. It could not explain the existence of discontinuity in distribution among individuals.
ii. Mutation theory cannot single-handedly explain evolution. It acts as evidence for other theories.
iii. Most mutations are recessive.
iv. Mutation occurs in any random possible direction.

Effects of mutation on evolution

Mutation is one of the many causes of evolution. Mutations are either harmful or useful for the organism. However, some of the mutations are neutral.

Answer writing skill

1. **Define mutation.**

   The unusual and sudden change in the phenotype or genotype of an organism is known as mutation.

2. **What is Darwinism?**

   The overall concept proposed by English naturalist and geologist Charles Robert Darwin regarding the evolutionary process is known as Darwinism.

3. **How do new species originate?**

   The difference in the way of living in each generation of species gives rise to new characteristics, behaviours and abilities. These qualities plus the changing environment enable an organism to be continuously different from its former type. In the long run, these organisms will be so different from each other that they won't be able to breed with each other. In this way, new species are born. The new species experience the same rule of nature, according to Darwin, and thus this process continuously goes on.

4. **Write any two differences between hereditary variation and environmental variation.**

   The differences between hereditary and environmental variation are given in the table below:

SN	Hereditary variation	SN	Environmental variation
1	The type of variation which is caused due to the usual changes in the genes of the parental gametes is called hereditary variation.	1	The variation in the phenotype of the organisms which occurs due to environmental factors like climate, nutrition, lifestyle, culture, etc. is known as environmental variation.
2	It occurs as a result of meiosis cell division.	2	It does not occur as a result of meiosis cell division.

5. **Among the theories of evolution, the mutation theory is the recent one. Although it does not satisfied all. In this connection, list criticisms of Hugo de Vries' mutation theory.**

   The criticisms of Hugo de Vries mutation theory are:

i. It could not explain the existence of discontinuity in distribution among individuals.

ii. Mutation theory cannot single-handedly explain evolution. It acts as evidence for other theories.

iii. Most mutations are recessive.

6. There are too many organs in the human body which are functional. They do their own functions. But a few are functioless in human body but they are functional in other organisms. These functionless organs are still in our body. So, make a list of four vestigial organs and their functions in other animals.

The list of vestigial organs is presented in the table below:

Vestigial Organs	Functional in	Function
Vermiform appendix	Herbivores	digesting cellulose
Ear muscles	Animals	locating the sound source
Nictitating membrane	Frogs, crocodiles etc.	moistening and protecting the eye
Coccyx bone	Chimpanzee, horse etc.	helping in moving and balancing
Wisdom teeth	Human ancestors	chewing cellulose
Breast nipples in men	Mammalian females	milk feeding

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. What is the study of fossils called?

i. embryology ii. palaeontology
iii. histology iv. mutation

b. Which organism is connecting link?

i. whale ii. dolphin
iii. snake iv. platypus

c. Which one is the vestigial organ in humans?

i. right lung ii. heart
iii. appendix iv. kidney

d. What is the cause of variation?

i.	environment	ii.	crossing over
iii.	mutation	iv.	all of them

e. Who proposed the theory of mutation?

i.	hugo de Vries	ii.	lamarck
iii.	darwin	iv.	none

2. Define the following, with examples.

a. Organic evolution — b. Palaeontology
c. Bridge animals — d. Fossil
e. Embryology — f. Connecting link
g. Hugo De Vries' theory of mutation

3. Short question answers.

a. Name two vestigial organs.
b. Give any two examples of mutation that you have seen in animals or humans.
c. What is natural selection based on Darwin's theory of evolution?
d. Who proposed the theory of mutation?
e. What is variation?

Step 2

4. Give reason.

a. No two organisms look the same.
b. The population of species is constant despite enormous fertility.
c. The vermiform appendix is called the vestigial organ.
d. Platypus is called connecting link.
e. Living things must struggle for existence.

5. Differentiate between the following.

a. Analogous organs and homologous organs
b. Mutation and variation

Step 3

6. Answer the following questions.

a. Explain the overproduction of species.
b. How does the evidence from homologous organs support evolution?
c. How does the study of connecting links support evolution?
d. What does Darwinism suggest about the origin of new species?
e. Explain the main idea of Darwinism regarding natural selection.
f. Explain the criticisms of Darwinism in detail.
g. Write any three causes of mutation.
h. Mention any three causes of variation in organisms.
i. What are the criticisms of Hugo De Vries' mutation theory?

Step 4

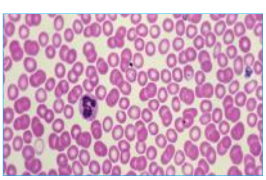
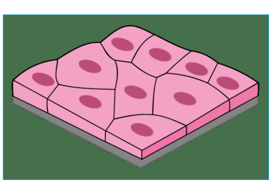
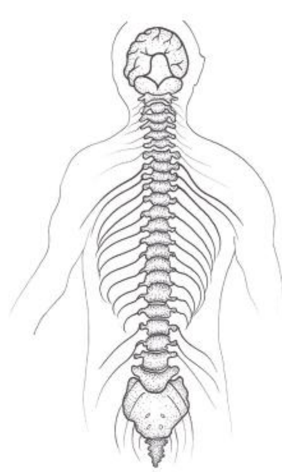
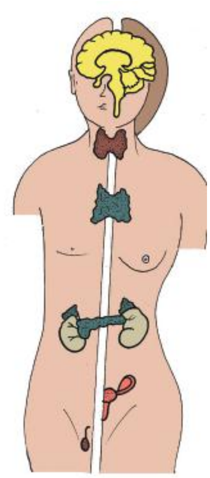
7. Long question answers.

a. Darwinism is still not a perfect theory in explaining evolution. Do you agree with this statement? Why? Or, why not?
b. A person has six fingers in his palm. What is this kind of abnormality called? Write one of its causes.
c. Classify these organs as homologous, analogous and vestigial:
   i. Flipper of a seal and wing of a bird.
   ii. The wing of a bat and the wing of an insect.
   iii. The arm of a human and the forelimbs of a horse.
   iv. Nictitating membrane and vermiform appendix.
d. Discuss the significances of mutation theory.
e. Describe the pattern of evolution of organisms based on Lamarckism.
f. A dog gives birth to dozens of puppies in street but hardly any survives to adulthood. Discuss the reasons based on Darwinism.
g. Do all organisms modify their organs as per necessity. Put forward your thoughts.
h. Must all parental characteristics transfer to the children? Write your opinion.
i. Compare Darwinism with Lamarckism.

UNIT
5
LIFE PROCESSES

Introduction

It is very easy to differentiate living beings and non-living beings. This is because living beings show various living activities such as respiration, nutrition, circulation, movement, excretion, reproduction, etc. These activities are very essential to survive for a living being. Plants do not show visible living activities like that in animals. The activities which are carried out by living organisms and essential to continue life on the earth are called life processes. Living beings cannot survive in absence of these life processes. In this topic we will discuss following sub-topics.

Unit 5.1	Unit 5.2	Unit 5.3
 *Blood Cells*  *Squamous Epithelium* *Tissue*	 *Human Nervous System*	 *Human Glandular System*

UNIT

5.1 TISSUE

ESTIMATED TEACHING PERIODS

TH	PR
4	2

Robert hook
(1635-1703)

Curriculum issued by CDC

- Introduction and types of tissues
- Plant tissue: introduction, location and function of meristematic tissue and permanent tissue (simple, complex and special)
- Animal tissue: introduction and function of epithelial tissue, muscular tissue, nervous tissue and connective tissue.

Learning outcomes

After completion of this unit, students will be able to:

- introduce animal and plant tissues.
- explain the types of animal and plant tissues along with their location and function.

Terms and terminologies

1. Life processes:	The activities which are carried out by living organisms and essential to continue life on the earth are called life processes.
2. Cytology:	The branch of biology which deals with the cell is called cytology.
3. Tissue:	The group of a large number of specialized cells with a common origin, similar structure, and function is called tissue.
4. Organs:	The group of specialized tissues makes organs.
5. Histology:	The study of tissues and their function is called histology.
6. Plant tissue:	Tissues that are found in the body of plants are called

plant tissues.

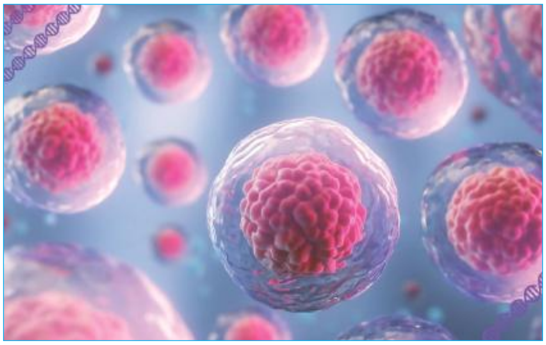
7. Meristematic tissue:	The simple and undifferentiated plant tissue which has actively dividing cells is called meristematic tissue.
8. Apical meristem:	The meristematic tissue which is present at the tip of the root, stem, and branches is called apical meristem.
9. Lateral meristem:	The meristematic tissue which is present along the side of the root and stem is called lateral meristem.
10. Intercalary meristem:	The meristematic tissue which is present at the base of the leaf, fruit, internode, etc. is called intercalary meristem.
11. Permanent tissues:	Permanent tissues are those tissues that are formed when the meristematic tissues mature and lose their ability of cell division.
12. Glands:	Glands are tissues that secrete a certain juice or enzyme material.
13. Animal tissues:	The tissues that are found in the body of animals are called animal tissues.
14. Epithelial tissue:	Epithelial tissue (Epithelium) is a thin protective tissue that is made up of one or more layers of cells covering internal and external body organs.
15. Pavement epithelium:	The single-layered, thin epithelial tissue which has cells with a centrally placed nucleus is called pavement epithelium or squamous epithelium.
16. Cubical epithelium:	The single-layered, epithelial tissue which has cubical cells with similar dimensions is called the cubical epithelium.
17. Columnar epithelium:	The single-layered, epithelial tissue which has column-shaped elongated cells is called the columnar epithelium.
18. Glandular epithelium:	The columnar epithelium with goblet cells is called the glandular epithelium.
19. Compound epithelium:	The epithelium which is composed of several layers of cells to withstand wear and tear is called compound or stratified epithelium.
20. Sensory epithelium:	The modified form of columnar epithelium which consists of elongated cells with sensory hairs on their free surface is called the sensory epithelium.
21. Simple permanent tissue:	The permanent tissues that contain only one type of identical cells are called simple permanent tissue.
22. Xylem:	The xylem is a vascular tissue that helps in the transportation of water and minerals from roots to the leaves.

23. Phloem:	The phloem is the vascular tissue that helps in the transportation of food from leaves to every part of the plant body.
24. Muscular tissues:	The soft, fibrous and elastic tissues are called muscular tissues.
25. Skeletal muscles:	The striated voluntary muscles are called skeletal muscles.
26. Smooth muscles:	The unstriated involuntary muscles are called smooth muscles.
27. Cardiac muscles:	The striated involuntary muscles present at the heart are called cardiac muscles.
28. Connective tissue:	Connective tissue is a group of tissues that maintains the form of the body.
29. Loose connective tissue:	The connective tissue made of a semi-fluid matrix and provides elasticity is called loose connective tissue.
30. Adipose tissue:	The fatty loose connective tissue that absorbs mechanical shock is called adipose tissue.
31. Dense connective tissue:	The connective tissue which is made of compactly packed fibroblast cells is called dense connective tissue.
32. Dense regular connective tissue:	The connective tissue in which fibres are arranged parallelly is called dense regular connective tissue.
33. Dense irregular connective tissue:	The connective tissue in which fibres and collagen are arranged randomly is called dense irregular tissue.
34. Cartilage:	The cartilage is tough but flexible specialized connective tissue.
35. Bones:	Bones are the hardest specialized connective tissue.
36. Lymph:	Lymph is a colourless fluid that contains WBC and washes tissues in our body.
37. Blood:	Blood is a red viscous liquid that flows in the blood vessels.
38. Neuron:	A neuron is a structural and functional unit of the nervous system.
39. Nervous tissue:	Nervous tissue is the group of neurons in the nervous system. It controls the body's movements, sends and carries signals to and from the different parts of the body.
40. Cell body:	The cell body is the site of the nerve cell where metabolic activities occur.
41. Axon:	An axon is a longest extension of the nerve cell.
42. Dendrites:	Dendrites are the branch-like extensions of the cell body.

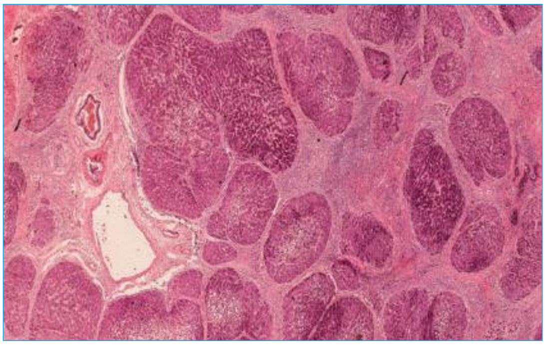
Introduction

It is very easy to differentiate living beings from non-living beings. This is because living beings show various life activities such as respiration, nutrition, circulation, movement, excretion, reproduction, etc. These activities are very essential for survival of a living being. Plants do not show visible life activities like that of animals. The activities which are carried out by living organisms and are essential to continue life on the earth are called life processes.

The cell is the basic, structural and functional unit of life that is capable of independent existence. It is a microscopic unit. Every cell of the living body is capable of conducting various processes required in the body. The cell is a building block unit of multicellular organisms. Different types of cells have different shapes, sizes, and structures depending upon their function. The branch of biology which deals with the cell is called cytology.



cells



tissues

The group of a large number of specialised cells with a common origin, similar structure, and function is called tissue. Each tissue has cells which are originated from the common parents. The cells of the tissue have more or less the same shape, size, and structure. Their arrangement is also the same. So, the cells of the tissue are organised to perform a particular function. The group of specialised tissues makes organs and a group of associated organs makes the system. Multiple systems make a living body. The study of tissues and their function is called histology. Broadly, the tissues are categorised into two types. They are animal tissues and plant tissues.

Memory note

Plant cells are the only producers of food by themselves on earth.

Fact and Reason

Blood is called a tissue, why?

Blood is called a tissue because it consists of a group of cells having a common origin and performing similar functions.

Activity

Observe plant cells through a compound microscope.

Differences between cells and tissues

SN	Cells	SN	Tissues
1	The cell is the structural and functional unit of life.	1	A group of a large number of specialised cells with similar structure and function is called tissue.
2	The study of the cell is called cytology.	2	The study of tissues is called histology.

Plant tissue

Tissues that are found in the body of plants are called plant tissue. Based on location and function, plant tissues can be divided into the following two types.

They are:

a) Meristematic tissue b) Permanent tissue

Meristematic tissue

The simple and undifferentiated plant tissue which is actively dividing cells is called meristematic tissue. Meristematic tissues are found in the growing regions of a plant. Continuous division of these cells helps in increasing the length and girth of the plant. The main function of the meristematic tissue is to form several new cells. The cells of meristematic tissue are spherical or oval or rectangular. They contain a single large nucleus, few or no vacuoles.

Memory note

Vacuole may fill 95% or more of the cell's total volume.

Activity

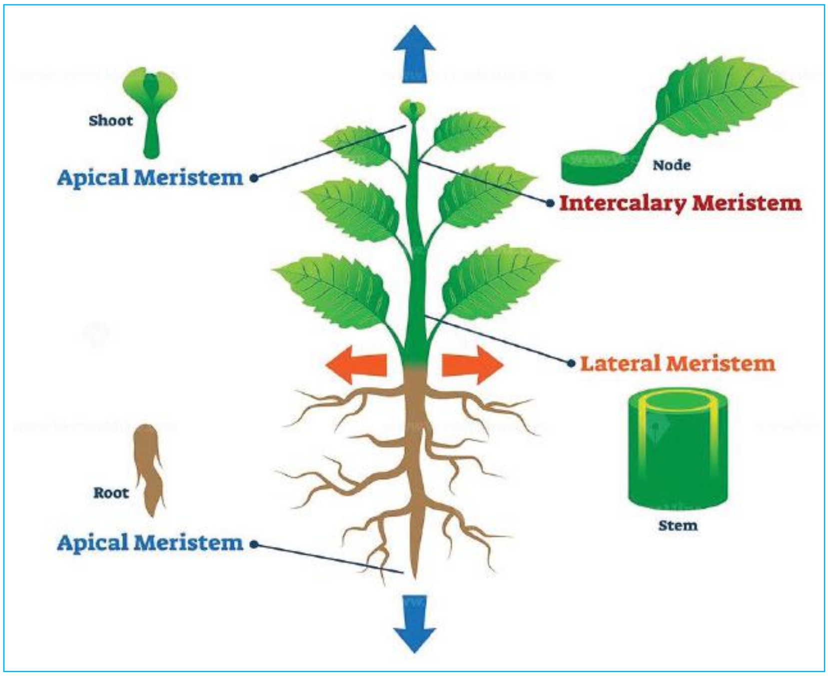
1. Take grass and wash it with water.
2. Cut its tip and put it on a glass slide.
3. Add one drop of safranine and keep some glycerol over it.
4. Put a cover slide over the glass slide and observe under a microscope.

According to the position, meristematic tissues are divided into three types. They are:

i. Apical meristem
ii. Lateral meristem
iii. Intercalary meristem

i. Apical meristem

The meristematic tissue which is present at the tip of the root, stem, and branches is called apical meristem. Apical meristem is also found at the tip of leaves. It helps in the elongation of the root, stem, branch, and leaf.



plant tissue

Memory note

Each apical meristem will produce embryo leaves and buds as well as primary meristem.

Fact and Reason

Pants with their tip cut do not achieve normal growth in their height, why?

Pants with their tip cut do not achieve normal growth in their height because when the tip of plant is cut, apical meristem responsible for growth is lost.

Activity

Cut the tip of a plant in your garden and observe it for a week. Does its height grow?

ii. Lateral meristem

The meristematic tissue which is present along the side of the root and stem is called lateral meristem. It is responsible for increasing the girth of a plant. This is called secondary growth.

Differences between apical meristem and lateral meristem.

SN	Apical meristem	SN	Lateral meristem
1	These are situated at the growing tip of the roots and stems.	1	These are found beneath the bark and in vascular bundles of dicot roots and stems.
2	It brings about the elongation of the root and stem.	2	It increases the diameter and girth of the root and stem.

iii. Intercalary meristem

The meristematic tissue which is present at the base of the leaf, fruit, internode, etc. is called intercalary meristem. It is responsible for increasing the length of petiole, internodes, etc.

Permanent tissue

Permanent tissues are tissues formed when meristematic tissues mature and lose their ability of cell division.

Types of permanent tissues based on origin and function are:

a) Simple permanent tissue

b) Complex permanent tissue

c) Special permanent tissue

Fact and Reason

Permanent plant tissues do not grow, why?

Permanent plant tissues do not grow because they do not have the cells that can undergo cell division.

Activity

Cut a stem of a herb. Make a slide from the innermost tissue of the stem and observe through a compound microscope.

a) Simple permanent tissue

These tissues are derived from the meristematic tissues. They contain only one type of cells and are thus structurally and functionally alike. Hence, they are also called simple permanent tissues. The permanent tissues that contain only one type of identical cells are called simple permanent tissues. They are further sub-divided into three types:

1) Parenchyma

Location: These permanent tissues are present chiefly in the cortex of stem and root, leaf, fruits, xylem and phloem.

Structure: They are thin-walled oval, irregular, elongated, polygonal, and round types of cells. They have gaps within individual cells called intercellular spaces. The cells are living and contain a nucleus and a vacuole.

Some parenchymatous tissues containing chlorophyll can prepare food and are called chlorenchyma. Similarly, some soft and light tissues which are air-filled are known as aerenchyma.

Memory note

Parenchyma is the most abundant among plant tissues and is found in almost all major parts of higher plants.

Fact and Reason

Some tissues of parenchyma are called chlorenchyma.

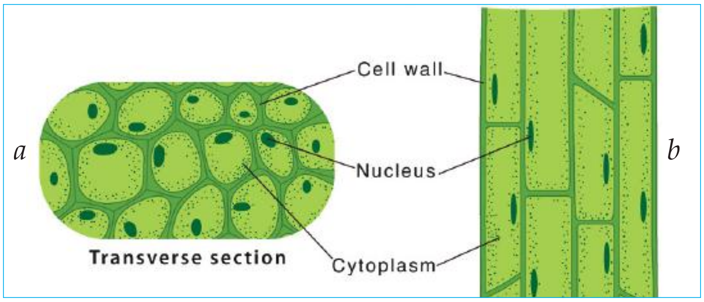
Some tissues of parenchyma are called chlorenchyma because they contain chlorophyll that helps in photosynthesis.

Function: Their functions are as follows:

i. They protect the surrounding tissues and give turgidity.

ii. They act as a support for xylem and phloem.

iii. They help in manufacturing and storing food.

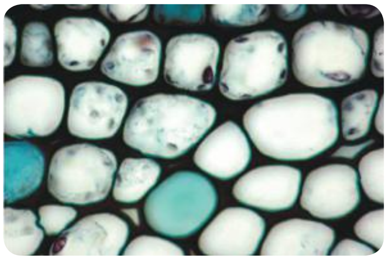


Parenchyma (a) in T.S. (b) in L.S

2. Collenchyma

Location: They are located in the epidermis of the dicot stem, petiole of leaves, mid-rib of dicot leaves, etc.

Structure: These tissues have no intercellular spaces. They are elongated and thick-walled.



Collenchyma

Function: Their functions are as follows:

i. They provide mechanical flexibility and strength to the plant.

ii. Some of them bear chlorophyll which helps in food production.

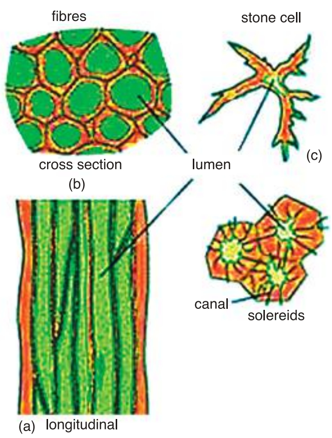
iii. They protect the leaves against the tearing effect of wind.

Fact and Reason

Parenchyma is softer than collenchyma, why?

Parenchyma is softer than collenchyma because parenchyma has intercellular space which is not present in collenchyma.

3. Sclerenchyma



Sclerenchyma (a) in L.S. (b) in T.S. (c) single fibre magnified

Location: These permanent tissues are located in the hard coats and shells of the plants like the seed coats, fruit flesh, nutshells, leaf veins, etc.

Structure: Sclerenchymatous tissues consist of elongated, narrow, and thick-walled cells. They contain dead cells with no cytoplasm. They do not have intercellular spaces.

Function: Their functions are as follows:

i. They give support and rigidity to the plant parts.

ii. They provide elasticity during movement.

iii. They protect fruits and seeds.

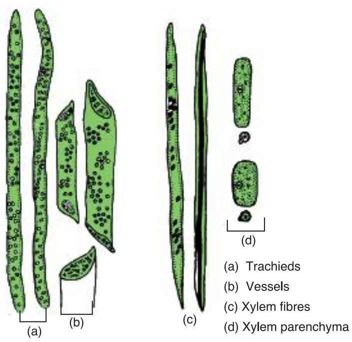
Complex permanent tissue

The complex permanent tissues are complex because they are made up of different types of cells with different functions. They help in the transportation of water and minerals along the plant body. The complex permanent tissues are made up of two vascular tissues (xylem and phloem).

xylem

Xylem is a vascular tissue that helps in the transportation of water from roots to the leaves.

Location: They are present at the central whorls of the stem and trunk. They contain dead cells except for the xylem parenchyma. The walls of the xylem cells are lignified which makes them strong and woody.



Components of xylem tissue

Structure: The xylem tissue is made up of four different types of cells: Vessels or tracheae, Tracheid, Xylem parenchyma, and Xylem fibres.

Memory note

Out of four types of cells in the xylem, three are dead cells (vessels, tracheids, xylem fibres) and only one type is of living cells (xylem parenchyma).

Fact and Reason

If we cut the outer tissues of a plant stem, the upper part swells. Why?

If we cut the outer tissues of a plant stem, the upper part swells because the outer phloem tissues are cut which prevents the produced food materials from passing through the stem downwards to the roots. This cutting process is known as girdling. Excessive girdling can kill a plant because the roots do not get food.

Function: Their functions are as follows:

i. They provide mechanical strength to the plant.

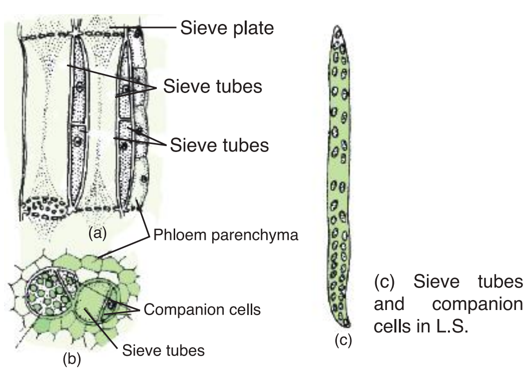
ii. They transport water and minerals from the roots to the leaves.

Phloem (Greek: 'phloos' - bark)

The phloem is the vascular tissue that helps in the transportation of food from leaves to every part of the plant body.

Location: Phloem tissues are present in the outer whorls of the plant stem. It also gives some mechanical support to the plant.

Structure: The phloem tissue is made up of four different types of cells: Sieve tubes, Companion cells, Phloem parenchyma, and Phloem fibres.



components of phloem tissue

Function: Their functions are as follows:

i. They provide mechanical strength to the plant.

ii. They transport the food prepared in the leaves to all parts of the plant.

Fact and Reason

Xylem and phloem are called vascular bundles, why?

Xylem and phloem are called vascular bundles because these complex issues in the plants help in the transportation of food, water and minerals throughout the body.

Memory note

Out of four types of cells in the phloem, three are living cells (Sieve tubes, Companion cells, Phloem parenchyma) and only one type is of dead cells (Phloem fibres)

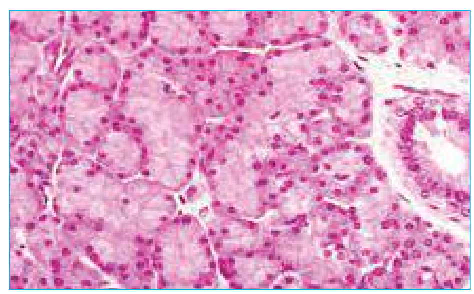
Special permanent tissue

These are the modified forms of permanent tissues that secrete special excretory or functional materials. E.g. the gum, resin, nectar, citrus juices, latex and oils.

These permanent tissues are of two types:

a. Glandular tissue

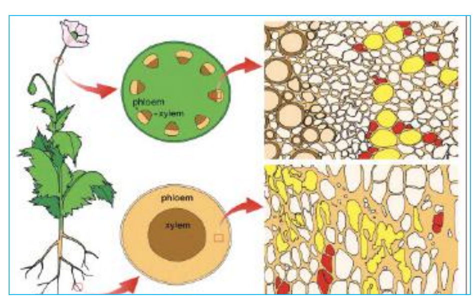
These are the special permanent tissues that contain glands. Glands are tissues that secrete a certain juice or enzyme. They secrete substances like resin, oil, mucilage, tannin, gum, etc. They are found in tulsi, citrus fruits, pudina, tobacco, lemon, orange, etc. Most insectivorous plants secrete juices from glands for trapping the insects.



glandular tissues

b. Lactiferous tissue

The thin-walled and branched tissues that secrete a yellowish milky juice known as latex. These issues are common in papaya, opium, calotropis, etc. Plants bearing these tissues are called laticifers. The latex functions as the liquid for food or waste material storage.

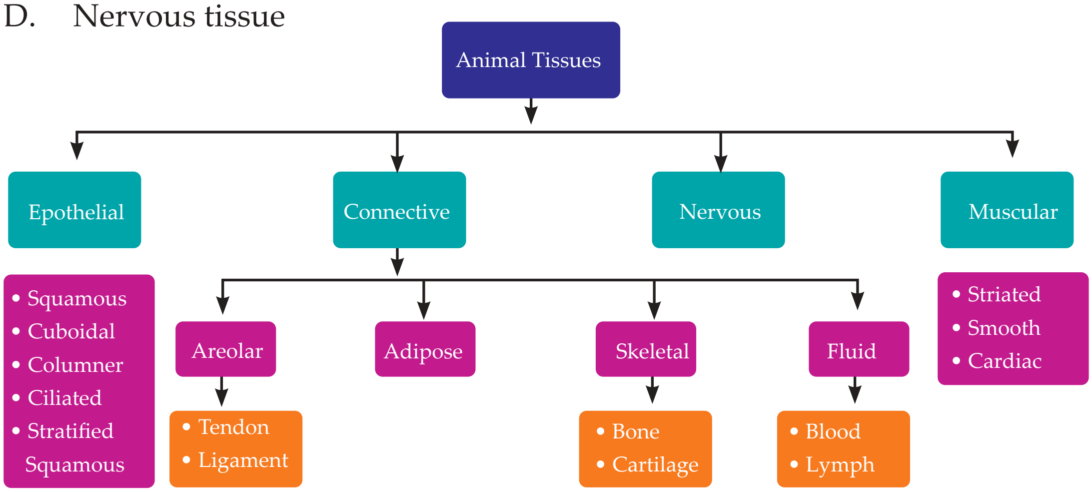


lactiferous tissue

Animal tissue

The tissues that are found in the body of animals are called animal tissues. Based on structure and function, animal tissues are classified into the following four types. They are:

A. Epithelial tissue
B. Muscular tissue
C. Connective tissue
D. Nervous tissue



Memory note

The cells of connective tissues are embedded in a great amount of extracellular material.

A. Epithelial tissue

Epithelial tissue (Epithelium) is a thin protective tissue that is made up of one or more layers of cells covering internal and external body organs. It makes the covering or lining of all internal and external body surfaces.

Functions of the epithelial tissues

i) Protection from mechanical injury.
ii) Sensation of stimuli.
iii) Secretion of enzymes, hormones, lubricating fluids, etc.
iv) Absorption of nutrients from the digested food.

v) Excretion of sweat, excess water etc.

vi) Diffusion of gases and nutrients at capillaries, lungs, etc.

Types of epithelial tissue

Based on specialised shape, size, and functions, epithelial tissues are again classified into different groups. They are:

a) Squamous or pavement epithelium

b) Cubical epithelium

c) Columnar epithelium

d) Glandular epithelium

Memory note

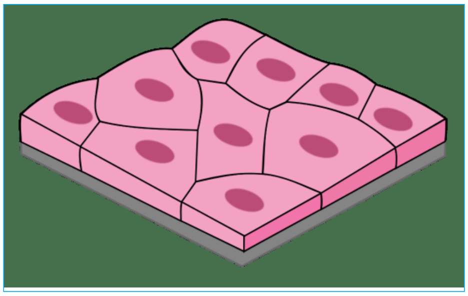
The skin is the body's first line of defence against viruses, bacteria, protozoa and other microorganisms.

Fact and Reason

Why is our body covered with skin?

Our body is covered with skin because it is the epithelial tissue that prevents the entry of germs.

Squamous or pavement epithelium



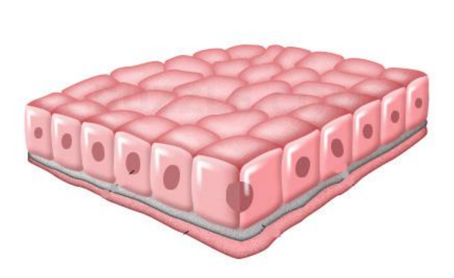
Squamous epithelium

The single-layered, thin flat epithelial tissue which has cells with a centrally placed nucleus is called pavement epithelium or squamous epithelium. This tissue seems like a mosaic floor or pavement. Squamous cells are horizontally flattened. They have elliptical nuclei. These cells are arranged edge to edge and form a thin covering.

Location: Pavement epithelium makes the lining of cavities such as the mouth, blood vessels, heart, lungs, etc. It is also found on the outer layers of the skin.

Functions: Squamous epitheliums are responsible for protection, covering, diffusion, and reducing friction.

Cuboidal epithelium



Cuboidal epithelium

The single-layered, epithelial tissue which has cubical cells with similar dimensions is called the cubical epithelium. The cubical epithelium is formed from the cells having roughly cuboidal shape. Each cell of the cubical epithelium has a spherical nucleus in its centre. The cells of this tissue are attached with their lateral surfaces.

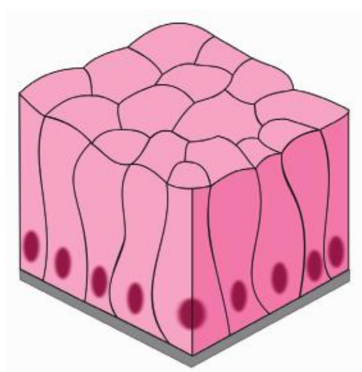
Location:

The cubical epithelium is found in the kidney, glands and ducts of glands.

Function:

The main functions of the cubical epithelium are excretion, secretion, covering, protection, and formation of the eggs and sperms.

Columnar epithelium



columnar epithelium

The single-layered, epithelial tissue which has column-shaped elongated cells is called the columnar epithelium. There are two types of columnar epithelium. They are simple columnar epithelium and ciliated columnar epithelium. Columnar epithelial cells occur in one or more layers. The nuclei of the columnar epithelium are elongated and are usually located near the base of the cells.

Fact and Reason

The columnar epithelium is also a sensory epithelium.

Some columnar cells are specialised for getting stimuli. They have sensory receptors. They are present in the nose, ears, taste buds, tongue, etc. Therefore, the columnar epithelium is also a sensory epithelium.

Location:
Columnar epithelium forms the lining of the nose, taste bud, uterus, stomach, intestines, salivary glands, urinogenital glands, and their ducts.

Function:
The functions of the columnar epithelium are protection, secretion, absorption, cleaning, excretion, sensation, etc. This tissue secretes mucus which keeps the surface smooth.

Memory note

The columnar epithelium which has fine hair-like outgrowths called cilia on their free surfaces is called the ciliated epithelium.

Activity

Collect cheek tissue and observe them through a powerful compound microscope.

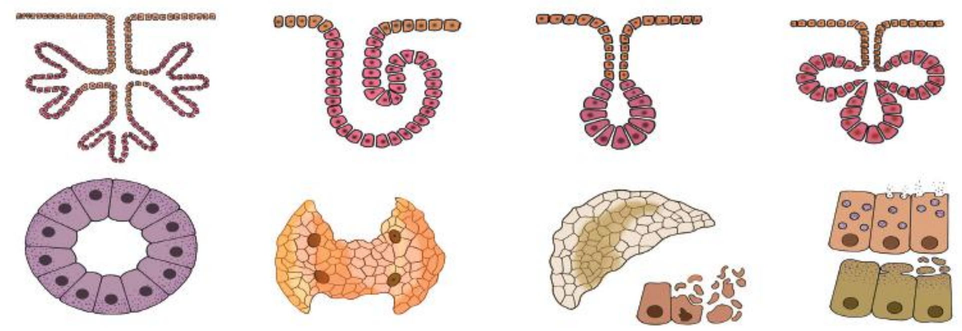
Glandular epithelium

The columnar epithelium with goblet cells is called the glandular epithelium. Often columnar and cuboidal epithelial cells become specialised for glandular cells.

Location
The glandular epithelium is located in various endocrine and exocrine glands.

Function

The main function of the glandular epithelium is to secrete certain substances such as enzymes, hormones, milk, mucus, sweat, wax, saliva, etc.



glandular epithelium

Fact and Reason

The glandular epithelium is also called secretory epithelium, why?

The main function of the glandular epithelium is to secrete certain substances such as enzymes, hormones, milk, mucus, sweat, wax, saliva, etc. So, the glandular epithelium is also called the secretory epithelium.

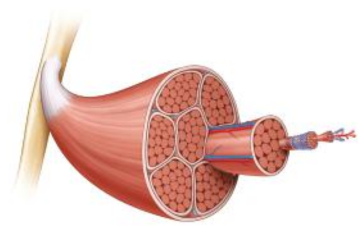
B. Muscular tissue

Muscular tissues are soft tissues. They make different types of muscles in animals. They are fibrous. Based upon the function and location, muscular tissues vary. The muscular tissues provide the ability to contract the muscles. The soft, fibrous and elastic tissues are called muscular tissues.

There are three types of muscular tissues in mammals. These are skeletal muscle, smooth muscle, and cardiac muscle.

Skeletal muscle

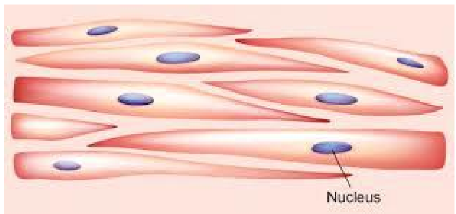
Skeletal muscles are the muscles attached to the bones. They are made of long fibres. They are involved in the functioning of different parts of the body. They can move the body parts. These are also called voluntary muscles. They can be controlled according to our will. They have a light band and a dark band. Therefore, they are called striated muscles. The striated voluntary muscles are called skeletal muscles.



Skeletal muscles

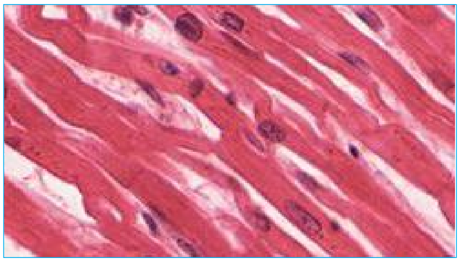
Smooth muscle

A smooth muscle is an involuntary muscle. It cannot be controlled by our will. It is present in the wall of the intestine and blood vessels. They contract and relax automatically. They are thick in the middle and thin at the edges. The nucleus is found at the centre of the cell. They do not have a light band and dark band. They are unstriated muscles. The unstriated involuntary muscles are called smooth muscles.



Smooth muscles

Cardiac muscles


cardiac muscles

Cardiac muscles are the strongest muscles. They are found in the heart. They help the heartbeat. They are made up of fibres. They have a light band and a dark band. They are striated muscles. The striated involuntary muscles at the heart are called cardiac muscles. The cardiac muscle moves automatically. It cannot be controlled by us. It is an involuntary muscle.

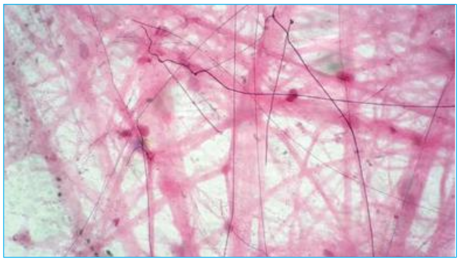
C. Connective tissue

Connective tissue is a group of tissues that maintains the form of the body. It is mostly made up of fibres. It is found in between other tissues everywhere in the body. It is made of clear, colourless, and viscous fluid. The function of connective tissue varies based upon its type. It is further divided into soft connective tissue, dense connective tissue, and specialised connective tissue.

Loose (Soft) connective tissue

Loose connective tissue is present all over the body. It supports the body and provides elasticity. The connective tissue made of a semi-fluid matrix that provides elasticity is called loose connective tissue. They form a subcutaneous layer under the skin. It contains a semi-fluid matrix. The cells and the fibres are loosely arranged. They act as shock absorbers, insulators, and store salt. There are two types of loose connective tissue. These are areolar tissue and adipose tissue.

a. Areolar tissue


Areolar tissue

Areolar tissue is present under the skin. It is a fibrous connective tissue. It attaches skin to the muscles. It supports the organ in the abdomen. It does not store fats. The fibrous connective tissue binds and gives shape to the organs. The loose connective tissue that binds the skin to muscles is called areolar tissue.

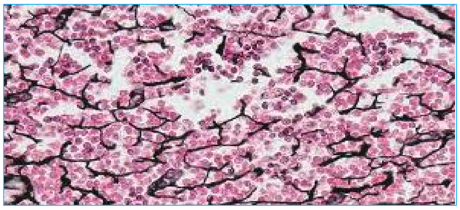
b. Adipose tissue

Adipose tissue is present under the skin. They store fat and keep us warm. They absorb mechanical shocks. The fatty loose connective tissue that absorbs mechanical shock is called adipose tissue.

Adipose tissue

c. Reticular connective tissue:

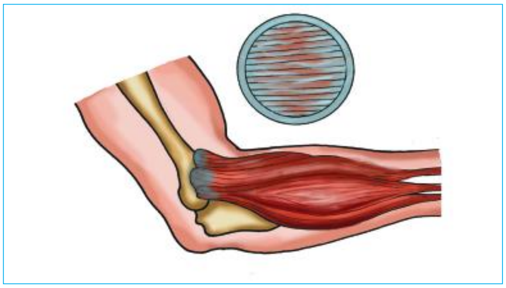
It is a fibrous connective tissue. It supports the framework of the liver, lymph nodes, and spleen.



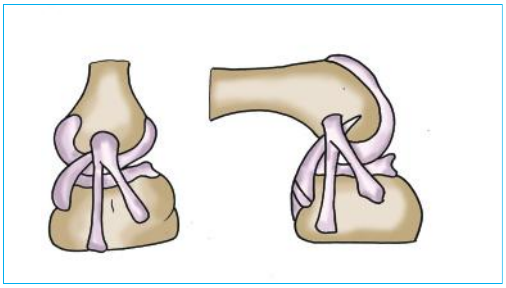
Reticular connective tissue

Dense connective tissue

The connective tissue which is made of compactly packed fibroblast cells is called dense connective tissue. It is also a fibrous connective tissue. Example: Tendon and ligament. Tendon is strong and tensile. It connects skeletal muscles to the bone. Ligaments attach a bone to another bone.



tendon



ligament

Specialised connective tissue

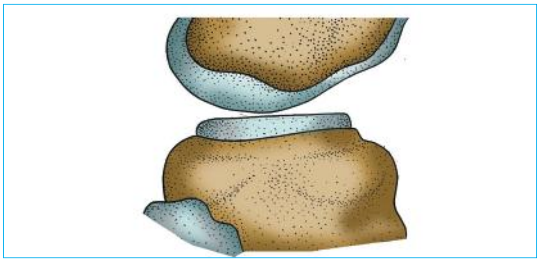
Specialised connective tissue has special functions. It may be supportive connective tissue such as cartilage and bone. Cartilage and bone are also called hard connective tissues.

Cartilage: It is comparatively softer than the bone. It is made of chondrocytes cells which are enclosed in a hard rubbery matrix. The cartilage is tough but flexible specialised connective tissue. It is elastic. It makes the tip of the nose, pinnae of ear, and throat. It is also found between bones of the vertebral column. It absorbs mechanical shock.

Bones: Bones are the hardest specialised connective tissue. Bones make the frame of our body. They protect internal organs. The cells of bones are called osteocytes. Bones make the head, arms, and legs of our body. The bones contain bone marrow. It produces blood.

Some specialised connective tissues are fluid connective tissues. These are blood and lymph.

Blood: Blood is a red viscous liquid that flows in the blood vessels. It contains various blood cells and plasma. The blood cells are made of RBC, WBC, and platelets.



cartilage

bones

RBC is red because of haemoglobin. RBC absorbs nutrients and oxygen from the intestine and lungs respectively. It is supplied to the cells.

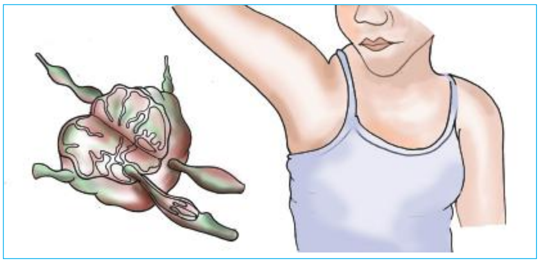
WBC makes the immunity system of the body and protects us from germs.

Platelets help in the clotting of blood in the wounds.

Plasma helps to regulate temperature, balance hormones, salts, etc.

Lymph: Lymph contains some amount of WBC. Lymph is a colourless fluid that contains WBC and washes tissues in our body. They are outside the blood vessels. They help to prevent infection and transport fat. They do not contain haemoglobin.

blood cells



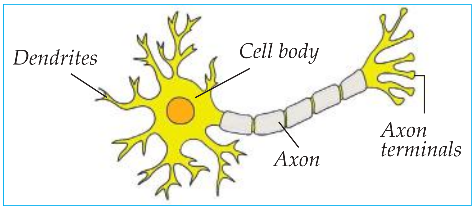
lymph

D. Nervous tissue

Activity

Make a model of the neuron using different coloured cardboard pieces. Attach threads around the edges of the cardboard to make the dendrites. Show the axon and cell body with different colours. Construct myelin sheath, axon terminals, and cell nucleus.

A neuron is a structural and functional unit of the nervous system. They are interconnected to form the desired brain circuitry. A neuron is divided into three parts. These are the cell body, axon, and dendrites.



neuron

Memory note

Our body has billions of nerve cells and may look different from one another.

Fact and Reason

Why is a neuron called the structural and functional unit of the nervous system?

A neuron is called the structural and functional unit of the nervous system because billions of neurons combine to make the nervous system and every neuron is capable of processing the impulses like that of the whole brain.

Structure of neuron

a. Cell body or cyton or soma

The cell body is the site where metabolic activities occur. The cell of a neuron contains a nucleus and cytoplasm.

b. **Axon**

An axon is a long extension of the nerve cell. It carries an electrical impulse away from the cell. It is covered by a sheath, called myelin sheath. Axon terminals are present at the end of the axon. They carry the signals to the desired part of the body.

Fact and Reason

Why is the axon covered with myelin sheath?

The axon is covered with a myelin sheath because it helps to increase the speed of the transfer of impulses.

c. **Dendrites**

Dendrites are the branch-like extensions of the cell body. They transmit the electrical signals from other neurons towards the cell.

Answer writing skill

1. **Define life process.**

The activities which are carried out by living organisms and are essential to continue life on the earth are called life processes.

2. **What is a tissue?**

The group of a large number of specialised cells with a common origin, similar structure, and function is called tissue.

3. **Why is leaf made of sclerenchyma?**

Leaf is made of sclerenchyma because it provides mechanical strength and prevents tearing of leaf during storms.

4. **Differentiate between skeletal muscle and smooth muscle.**

The differences between skeletal muscle and smooth muscle are:

SN	Skeletal muscle	SN	Smooth muscle
1	The striated voluntary muscles are skeletal muscles.	1	The unstriated involuntary muscles are smooth muscles.
2	It is attached to the bones.	2	It is not attached to the bones.
3	It helps to move the body.	3	It helps in automatic activities such as the movement of food in the intestine.

5. **Discuss the functions of glandular tissue in plant body.**

The functions of the glandular tissue of plants are:

i. They produce oil, resin, and gum.

ii. Insectivorous plants secrete juices from glands to attract insects and trap them.

iii. Some glands are the digestive type. They help the insectivorous plant to digest insects.

6. **There are different types of tissues in the human body. They have differeent shape, size and charateristics. Among them write the characteristics of epithelial tissue.**

The characteristics of epithelial tissue are:

i. The cells of epithelial tissue generally have large nuclei, a clear outline, and a large amount of granular protoplasm.

ii. Epithelial cells are packed tightly together with almost no inter-cellular spaces.

iii. Epithelial tissues do not contain blood vessels.

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

a. What is the study of the cell called?

i. histology	ii. mycology
iii. cytology	iv. virology

b. Which tissue transports water in the plant?

i. phloem	ii. apical meristem
iii. xylem	iv. collenchyma

c. Which one is a voluntary muscle?

i. skeletal muscle	ii. cardiac muscle
iii. smooth muscle	iv. none

d. What is a cytoplasmic extension called?

i. dendrite	ii. cell body
iii. myelin sheath	iv. none

e. Which tissue connects skin to the muscle?

i. areolar ii. adipose

iii. blood iv. cartilage

2. Define the following, with required examples.

i. Cytology ii. Histology

iii. Meristematic tissue iv. Permanent tissue

v. Organ vi. Epithelial tissue

vii. Neuron viii. Axon

ix. Dendrite x. Cardiac muscle

3. Short question answers.

a. Which tissue protects the leaves from the tearing effect?

b. Write the locations of the apical and lateral meristems.

c. Which plant cell cannot do cell division?

d. Where is the xylem located?

e. Where is a cardiac muscle found?

f. Which connective tissue attaches skin to muscle?

g. What does adipose do?

h. Write a function of lymph.

Step 2

4. Give reason.

a. The exocarp of fruit is made of parenchyma.

b. Xylem and phloem are called vascular bundles.

c. Epithelial tissue covers important organs.

d. Skeletal muscle is called voluntary muscle.

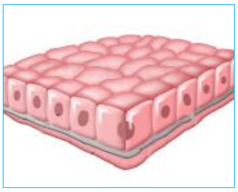
e. Smooth muscle is called involuntary muscle.

f. Cells have different shape and size.

5. **Differentiate between the following.**
   a. Cells and tissues
   b. Xylem and phloem
   c. Apical meristem and lateral meristem
   d. Simple permanent tissue and complex permanent tissue
   e. Bone and cartilage

Step 3

6. **Answer the following questions.**
   a. Explain the types of meristematic tissues.
   b. Name the types of simple permanent tissues and describe them.
   c. Write down the functions of meristematic tissue.
   d. Write a short note on special permanent tissues.
   e. Write the names of different tissues present in an animal body.
   f. Name four different types of epithelial tissues.
   g. List out the major functions of the epithelial tissues.
   h. Draw a labelled diagram of a neuron.
   i. Identify the tissue from the given diagram.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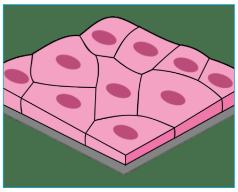
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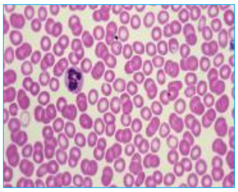
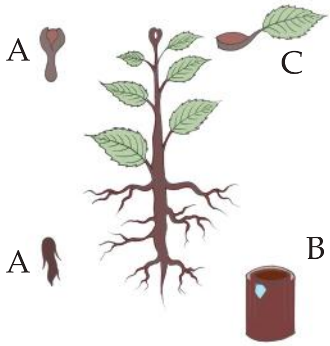

(iii)


(iv)

   j. Study the given diagram and answer the following questions.
      i. What happens if A is removed from the plant?
      ii. Write the name of B and mention its function.
      iii. What is C?



Step 4

7. Long question answers.

a. Write down the location of the following epithelial tissues.

i. Pavement epithelium   ii. Columnar epithelium

iii. Cubical epithelium   iv. Stratified epithelium

v. Glandular epithelium   vi. Sensory epithelium

b. Write down the function of the following epithelial tissues.

i. Pavement epithelium   ii. Columnar epithelium

iii. Cubical epithelium   iv. Glandular epithelium

c. Draw a well-labelled diagram for the following:

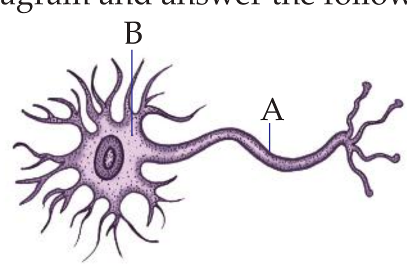
i. Pavement epithelium   ii. Columnar epithelium

iii. Cubical epithelium   iv. Glandular epithelium

vi. Location of meristematic tissue in plants.

d. Describe soft connective tissue in brief.

e. Study the given diagram and answer the following questions.



i. What is shown in the diagram?

ii. Write the names of A and B.

iii. Write the function of A.

UNIT

5.2 HUMAN NERVOUS SYSTEM

ESTIMATED TEACHING PERIODS

TH	PR
4	1

Marshall Hall
(1790-1857)

Curriculum issued by CDC

- Introduction to nervous system
- Structure and function of different parts of nervous system
- Central nervous system (brain and spinal cord)
- Peripheral nervous system
- Autonomic nervous system
- Inter-relation among the parts of nervous system based on structure and function
- Introduction to reflex action

Learning outcomes

After completion of this unit, students will be able to:

- introduce the human nervous system.
- explain the structure and function of parts of human nervous system.

Terms and terminologies

1. Nervous system: The nervous system is a network of organs and tissues that controls and coordinates all the activities of the body with the help of nerves.
2. Neuron: A neuron is the structural and functional unit of the nervous system.
3. Brain: The main part of the CNS that processes the overall information of the body and coordinates various functions is called the brain.
4. Cerebrum: The largest part of the brain that controls intelligence, vision etc. is called the cerebrum.

5. Cerebellum:	The cerebellum is the second largest part of the brain that controls muscle coordination.
6. Medulla oblongata:	The medulla oblongata is the lowest part of the brain stem that controls involuntary life processes.
7. Meninges:	The three layers of the protective membrane that cover the brain and spinal cord are called meninges.
8. Cerebrospinal fluid:	Cerebrospinal fluid is a clear alkaline fluid made up of water, minerals, glucose, proteins, and wastes that surround the brain and spinal cord.
9. Spinal cord:	The spinal cord is a long cylindrical structure that arises from the terminal part of the medulla to the two-thirds of the backbone.
10. Nerve:	A nerve is a bundle of specialized neurons.
11. Sensory neurons:	The neurons that carry the electrical impulses from the body to the brain and spinal cord are known as the sensory neurons.
12. Motor neurons:	The neurons that carry the electrical impulses from the brain and spinal cord to the rest part of the body are known as the motor neurons.
13. Interneurons:	The neurons that carry the nerve impulse from sensory neuron to motor neuron are called interneurons.
14. Peripheral nervous system:	The peripheral nervous system is the network of nerves that exchange information between the nervous system and other parts of the body.
15. Cranial nerve:	The 12 pair of nerves that arise from the brain is called the cranial nerves.
16. Spinal nerves:	The 31 pairs of nerves that originate in the spinal cord and form a part of the peripheral nervous system are called spinal nerves.
17. Reflex action:	Reflex action is an immediate involuntary response to a stimulus controlled by the spinal cord.
18. Reflex arc:	The reflex arc is a neural path through which reflex action is controlled.
19. Autonomic nervous system:	The part of the nervous system that controls the involuntary action of the organs like the heart, kidney, lungs, etc. is known as the autonomic nervous system.
20. Sympathetic nervous system:	The part of the autonomic nervous system which prepares the body for emergencies is called the sympathetic nervous system.
21. Parasympathetic nervous system:	The part of the autonomic nervous system which prevents the effects of the sympathetic nervous system is called the parasympathetic nervous system.

Introduction

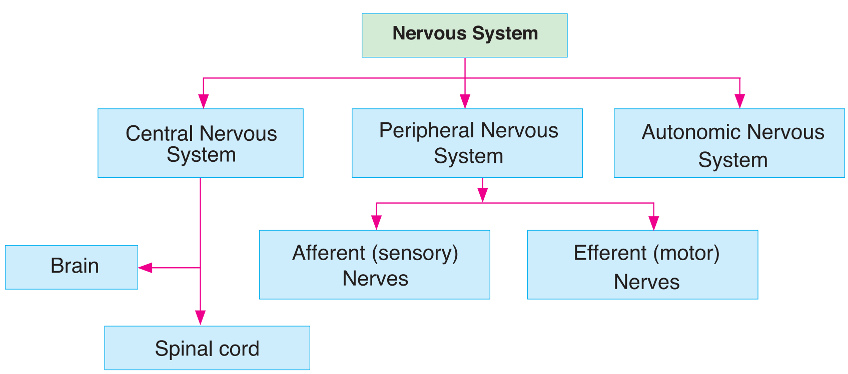
Our body performs various activities and biological processes in our daily life. All these functions and processes are controlled and coordinated by a group of organs and tissues called the nervous system. Thus, the nervous system is a network of organs and tissues that controls and coordinates all the activities of the body with the help of nerves. The nervous system is made up of networks of several cells and tissues. The specialised cells of the system are called neurons. A neuron is the structural and functional unit of the nervous system. It works by sending and receiving electrical messages throughout the body. There are billions of neurons in the nervous system. The nervous system is formed by the combination and networking of these neurons. There are various divisions in the nervous system which carry out a particular function. These divisions of the nervous system are:

a. **Central nervous system (CNS):** It includes the brain and the spinal cord.

b. **Peripheral nervous system (PNS**): It includes the cranial and spinal nerves.

c. **Autonomic nervous system (ANS):** It includes ganglia and nerve tissues that control the involuntary functions of the body.

The following chart presents the idea of parts of the nervous system:



flow chart of the nervous system

Memory note

Neurons are programmed to do different things. There is a nervous system for controlling the body at rest.

Central nervous system

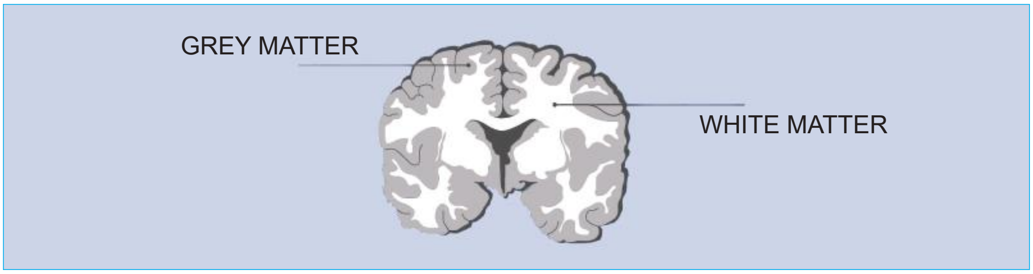
The central nervous system consists of the brain and spinal cord. It is the central part through which all kinds of nerve signals pass. The CNS is made up of two kinds of cells, viz. neurons, and glia. The glial cells are the supporting cells that surround the neurons. There are two regions in the brain. They are grey matter and white matter.

i. Grey matter

It is the pinkish-grey region of the brain and spinal cord. It has cell bodies, dendrites, synapses, and axon terminals.

ii. White matter

The white region of the brain and spinal cord containing axons of the nerve cells is called white matter.



grey matter and white matter

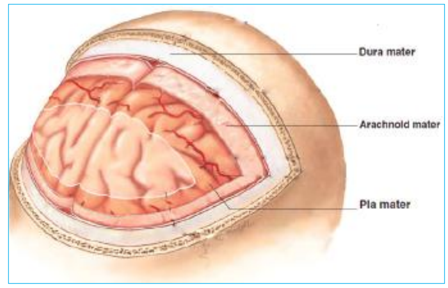
Parts of the central nervous system

1. Human brain

The human brain is a delicate structure present inside the cranium. It controls and coordinates the functions of the body. The main part of the CNS that processes the overall information of the body and coordinates various functions is called the brain. Its weight is about 1.2kg to 1.5kg. The brain is covered by a triple-layered protective membrane. The three layers of the protective membrane that cover the brain and spinal cord are called meninges. These layers are the dura mater (outermost layer), arachnoid (middle layer), and the pia mater (inner layer). There is a cavity between the arachnoid and the pia mater called the subarachnoid space. This sub-arachnoid space is filled with a special type of fluid called cerebrospinal fluid (CSF). This fluid surrounds the brain and the spinal cord. Cerebrospinal fluid is a clear alkaline fluid made up of water, minerals, glucose, proteins, and wastes that surround the brain and spinal cord. The functions of the cerebrospinal fluid are as follows:

i. The cerebrospinal fluid protects the brain from mechanical injury by absorbing mechanical shocks.

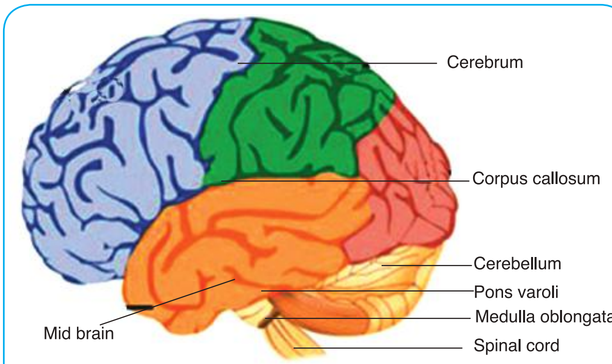
ii. It transports nutrients and chemicals and removes waste materials from the brain.



meninges

Parts of brain

The brain is divided into three major regions, viz. the forebrain, the midbrain, and the hindbrain.



Structure of human brain

a. Cerebrum

The cerebrum is the largest part of the brain. It is divided into two hemispheres, viz. left hemisphere and right hemisphere by a central median groove called the corpus callosum. The corpus callosum helps in the interaction between these two hemispheres. The largest part of the brain that controls intelligence, vision etc. is called the cerebrum. The outer layer of the cerebrum is made up of a grey matter called the cerebral cortex.

Functions

It carries out higher functions like intelligence, sensation, perception, thoughts, etc.

An injury or damage to the cerebrum can lead a person to the loss of senses, memory, skill, coordination, or even a coma depending on the severity and the location of the injury.

Memory note

The main functions of the cerebrum are thinking, learning, reasoning, memorising, intelligence, feeling, love, respect, hate, motivation, anger, mood, emotion, speech, vision, etc.

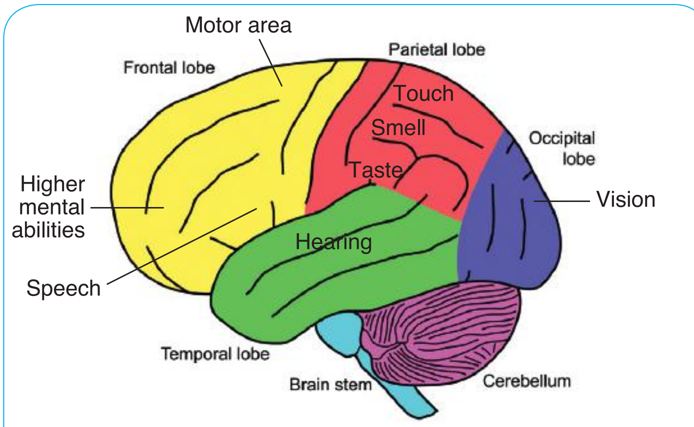
Fact and Reason

Why does damage in the cerebrum result in a coma?

The damage to the cerebrum can result in a coma because it is the site that controls senses, memory, and coordination.

b. Cerebellum

The cerebellum is the second largest part of the brain that controls muscle coordination. It occupies 10% of the total volume of the brain. It helps to control and coordinate the movement of muscles to carry out a specific function. It is regularly controlled by the actions of the cerebrum.



various functions of cerebrum

Functions

The cerebellum also helps us to maintain posture while walking, sitting, and standing. It helps in balancing our bodies and maintains our muscle tone.

An injury or damage to the cerebellum can lead a person to paralysis of the voluntary muscles or even death.

c. Medulla oblongata

The medulla oblongata is the lowest part of the brain stem that controls involuntary life processes. It is present between pons Varolii and the spinal cord. It is a very important part of the brain as it regulates the most involuntary functions like respiration, heart function, and circulation. It emerges out from a hole in the base of the skull called the foramen magnum.

The major functions of the medulla oblongata are:

i. It regulates blood pressure, breathing, and heart function.
ii. It acts as a centre for coughing, swallowing, sneezing, and vomiting.
iii. It enables the contraction and dilation of blood vessels.
iv. It controls peristalsis i.e., a series of muscle contractions that moves food through the alimentary canal.

Injury or damage to the medulla oblongata results in instant death because the vital functions of the body like respiration, circulation, etc. come to a stop.

2. Spinal cord

The spinal cord is a long cylindrical and slender structure that arises from the terminal part of the medulla to the two-thirds of the backbone. The spinal cord is enclosed inside the vertebral column, which protects it from mechanical injuries. The spinal cord connects the rest of the body with the brain with the help of nerves. Like the brain, it is covered with the meninges and cerebrospinal fluid. They prevent the damage of the spinal cord during falls and mechanical shocks.

Spinal cord is present witin vertebral column

Memory note

Smoking negatively impacts the spine and can increase back pain by decreasing blood and nutrients.

Fact and Reason

Why is CNS inside the bone cages?

The CNS is inside the bone cages because it protects the brain and spinal cord from mechanical damage.

Activity

Make a fine model of CNS using the locally available materials.

Structure

The spinal cord is almost 45cm long and 2cm in diameter. It is divided into two regions: the inner layer of grey matter and the outer layer of white matter. The spinal cord is connected to the body through 31 pairs of nerves called the spinal nerves. These nerves arise from the left and right sides of the spinal cord into the opening of the vertebrae.

Functions of the spinal cord

i. It acts as a relay station between the brain and the body.

ii. It regulates reflex actions.

An injury or damage to the spinal cord causes paralysis to the parts just below the damage and also loss of sensitivity. This condition is called spinal injury.

Nerve fibres

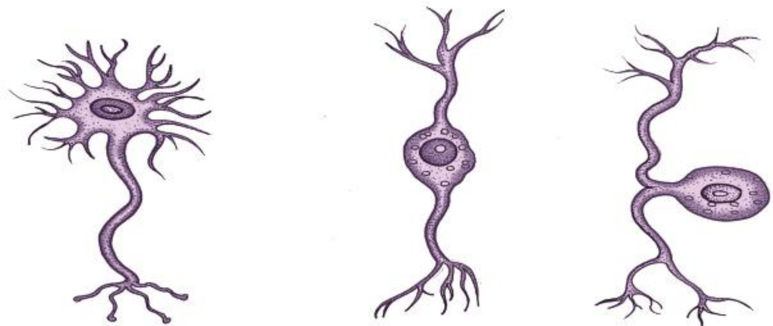
A nerve is a bundle of specialised neurons. Nerves carry messages from the brain and the spinal cord to the different parts of the body and vice-versa in the form of electrical signals.

Based on function, neurons are of three types:

Afferent (sensory) neuron:

The neurons that carry the electrical impulses from the body to the brain and spinal cord (CNS) are known as the sensory neurons.

Examples: the optic nerve that carries sensory information for the sense of vision, etc.



different types of neurons

Efferent (motor) neuron:

The neurons that carry the electrical impulses from the brain and spinal cord to the rest of the body are known as the motor neurons.

Examples: the oculomotor nerve that moves the eyeball and ciliary muscles, etc.

Inter neuron (association neuron):

The interneuron serves as a connector of neurons. It transmits the signal from sensory neuron to motor neuron. The neurons that carry the nerve impulse from sensory neuron to motor neuron are called interneurons.

Memory note

The groups of small nervous tissues located near the spinal cord are called ganglia. They are made up of grey matter. They create the relationship between the spinal cord and the brain.

Bundles of sensory fibre and motor fibre together form a mixed nerve.

The nerves that are both sensory and motor in function are known as the mixed nerves.

Examples: spinal nerves, facial nerves, etc.

Peripheral Nervous System

The peripheral nervous system is the network of nerves that exchange information between the nervous system and other parts of the body. It includes the following:

a. Cranial nerves

There are 12 pairs of cranial nerves. They arise from the brain, connect different organs and end back in the brain. They connect different organs like sense organs, face, heart, lungs, muscles, glands, etc. The 12 pairs of nerves that arise from the brain are called cranial nerves. Some examples of cranial nerves are optic nerve, olfactory nerve, oculomotor nerve, pathetic nerve, facial nerve, etc.

Memory note

The transmission speed of electricity is 150,000km/h and that of nerve impulse is 360km/h (100m/s). However, the speed of nerve impulses varies enormously in different types of neurons.

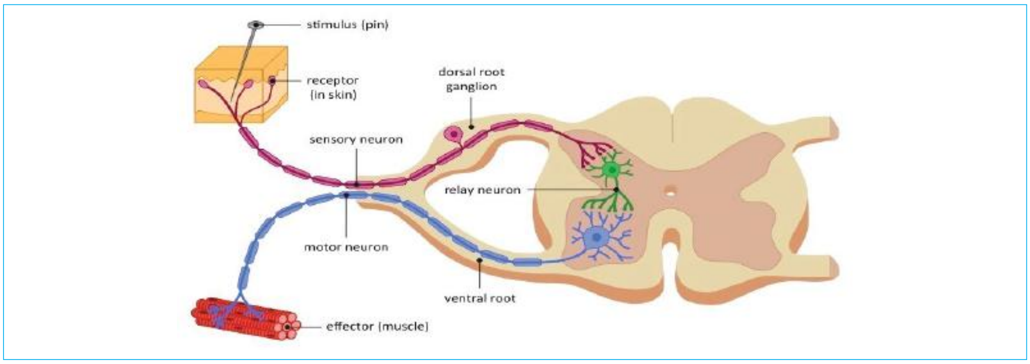
b. Spinal nerves

The 31 pairs of nerves that originate in the spinal cord and form a part of the peripheral nervous system are called spinal nerves. They send the signals that pass from the brain and spinal cord towards the desired organs.

Reflex action

Reflex action is an immediate involuntary response to a stimulus controlled by the spinal cord. It occurs below the level of consciousness. It is a sudden, automatic, spontaneous, and involuntary action generated by the spinal cord in response to a stimulus. A reflex is made possible by a neural path called a reflex arc. The reflex arc is a neural path through which reflex action is controlled. Receptors receive the impulses. The sensory nerve transfers it to the spinal cord. The spinal cord sends instructions through the motor nerve to the effector. Then the body moves in response to the stimulus.

It is a safety mechanism controlled by the spinal cord. It prevents overloading of the brain and prevents harm to the body.



reflex arc

The reflex action occurs in the following way when stepped on a pin.

Receptor: The nerve cells at the leg will receive pressure from the pin.

Sensory nerve: It transfers impulses from the foot to the spinal cord.

Spinal cord: Spinal cord processes the information and sends orders.

Motor neuron: The motor neuron receives orders from the spinal cord and gives them to the effector.

Effector: The effector receives the information from motor neurons and responds.

Stimulus (Hot object) → **Receptors (Sensory cells)** → Sensory neuron → **Spinal cord**

Spinal cord → Motor neuron → **Effectors (muscle)** → **Response**

Autonomic nervous system

The part of the nervous system that controls the involuntary action of the organs like the heart, kidney, lungs, etc. is known as the autonomic nervous system. The ANS controls the functions which we are not aware of. There are two parts to it:

a. **Sympathetic nervous system**

The part of the autonomic nervous system which prepares the body for extremes and emergencies is called the sympathetic nervous system. The sympathetic nervous system increases the heartbeat, increases perspiration, stimulates urination, slows down digestion, and causes a rise in blood pressure.

b. Parasympathetic nervous system

The part of the autonomic nervous system which prevents the effects of the sympathetic nervous system is called the parasympathetic nervous system. It decreases the heartbeat, lowers perspiration, stimulates digestion, slows down urination, and lowers the blood pressure to bring the body into normal conditions.

Memory note

Sympathetic and parasympathetic nervous systems act in a reverse manner. For example, when we sense danger, the sympathetic nervous system increases the heartbeat and blood pressure, whereas the parasympathetic nervous system brings them to normal.

Fact and Reason

Why does our heartbeat increase during dangerous situations?

Our heartbeat increases during dangerous situations because the sympathetic nervous system increases heartbeat to be ready for an emergency.

Answer writing skill

1. Define the nervous system.

The network of organs and tissues that controls and coordinates all the activities of the body with the help of nerves is called the nervous system.

2. What is white matter?

The white region of the brain and spinal cord containing axons of the nerve cells is called white matter.

3. Why should we not hit anyone in the back of head?

We should not hit anyone in the back of head because there is medulla oblongata. Damage to oblongata can cause instant death.

4. **Differentiate between axon and dendrite.**

The differences between axon and dendrite are:

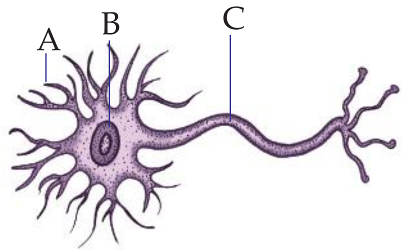
SN	Axon	SN	dendrite
1	Axon is the longest cytoplasmic extension.	1	Dendrites are numerous cytoplasmic extensions.
2	Axon takes information away from the cell.	2	Dendrites take information into the cell.

5. **Lets suppose an earthquake hit during the class. During such disaster our body can automatically enters flight or fight mode. Discuss the role of sympathetic nervous system in flight and fight response.**

The role of the sympathetic nervous system during flight and fight mode are listed serially:

i. To increase the heartbeat and blood pressure.
ii. To slow digestion.
iii. To increase the rate of respiration.
iv. To distribute adrenaline all over the body.

6. **Observe the following diagram and answer the given questions.**



i. **What is shown in the diagram?**

Axon is shown in the diagram.

ii. **What is the direction of the impulse in this neuron?**

The direction of the movement of impulse is from A to B to C.

iii. **Label A, B and C.**

A – dendrite, B – cell nucleus, C – axon

Step 1

1. **Choose the best answer from the given alternatives.**

a. Which part of the brain controls memory?

i. cerebrum   ii. cerebellum
iii. medulla oblongata   iv. pons Varoli

b. Which part of the brain controls muscle coordination?

i. cerebellum   ii. cerebrum

iii. spinal cord | iv. medulla oblongata

c. Which nerve fibre transfers impulses from the receptor to the spinal cord?
   i. sensory nerve | ii. motor nerve
   iii. interneuron | iv. all of them

d. Which part of the brain controls respiration?
   i. cerebrum | ii. cerebellum
   iii. medulla oblongata | iv. spinal cord

e. How many cranial nerves are there in our body?
   i. 12 | ii. 31
   iii. 9 | iv. 5

2. Define the following, with necessary examples.

i. Nervous system | ii. Neuron
iii. Meninges | iv. Medulla oblongata
v. Spinal cord | vi. Grey matter
vii. White matter | viii. Reflex action

3. Short question answers.

a. Name the fluid present between the arachnoid and pia mater.
b. Which part of the brain controls the movement of muscles?
c. Write full form of CNS, ANS and PNS.
d. Mention the number of cranial nerves and spinal nerves.
e. Which organ controls reflex action?

Step 2

4. Give reason.

a. The damage of the medulla oblongata causes instant death.
b. A drunkard cannot firmly stand on the ground.
c. Animals respond faster than plants.
d. Reflex action is an important mechanism.
e. The brain is surrounded by Cerebrospinal fluid.

5. Differentiate between the following.

a. Cerebellum and cerebrum

b. Sensory neuron and motor neuron
c. Cranial nerve and spinal nerve
d. CNS and PNS

Step 3

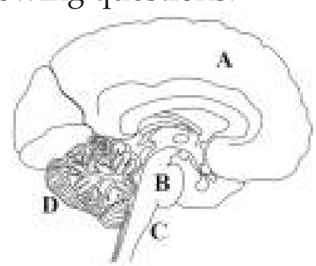
6. Answer the following questions.

a. Write any two functions of CSF.
b. Write short notes on a meninges.
c. Draw a well-labelled diagram of a neuron.
d. Write the functions of the cerebrum.
e. Write the functions of the cerebellum.
f. Mention any two functions of the spinal cord.
g. What happens if the cerebrum is damaged?
h. What happens if the cerebellum of a person is damaged?
i. What are the major functions of the medulla oblongata?
j. What is the consequence if medulla oblongata is seriously damaged?

Step 4

7. Long question answers.

a. Study the given diagram and answer the following questions.
   i. Label the parts A, B, C, and D.
   ii. What happens if part B is damaged?
   iii. Where does the spinal cord start from?
   iv. Write the function of each of A, B, C, and D.



b. Describe the structure of a neuron.
c. Let's suppose we sudeenly stepped in a sharp nail. How does reflex action occur? Draw a diagram of reflex arc to show the process.
d. During emergency situations such as falling down from ladder our body will enter flight and fight mode. Later our body will be normal again. How does sympathetic and parasympathetic nervous system handle flight and fight response?

UNIT

5.3 HUMAN GLANDULAR SYSTEM

ESTIMATED TEACHING PERIODS

TH	PR
4	1

Claude Bernard
(1813-1878)

Curriculum issued by CDC

- Glandular system: Introduction and types (endocrine and exocrine glands)
- Human glandular system: introduction, function and effects
- Plant hormone: introduction and function of plant growth hormone (cytokinin and auxin)
- Application of plant growth hormones (tissue culture, horticulture and floriculture)

Learning outcomes

After completion of this unit, students will be able to:

- introduce glandular system and compare between endocrine and exocrine glands.
- explain human hormones along with their function and effects.
- explain plant hormones along with their function and importance.

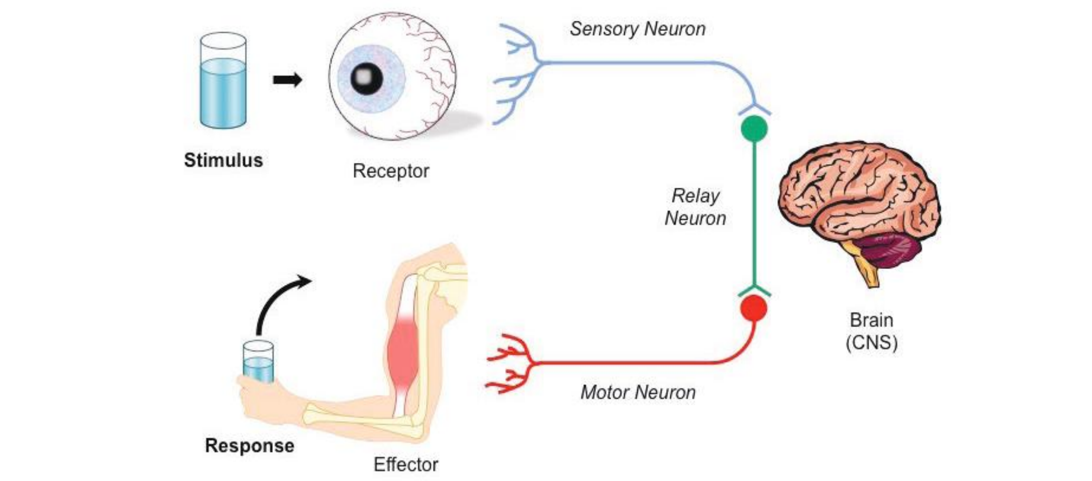
Terms and terminologies

1. Stimulus: The stimulus is a change in the environment that brings about a response in an organism.
2. Reaction: The response shown by an organism towards or away from the stimulus is called reaction.
3. Glandular system: The system of various glands is called the glandular system.
4. Exocrine glands: The glands that secrete enzymes and juices and pour this secretion in the duct to an organ are called exocrine glands.

5. Endocrine glands:	The glands that secrete hormones and pour directly into the bloodstream without passing through ducts are known as endocrine glands.
6. Endocrine system:	The system formed by a group of ductless glands which produce hormones and release them into the bloodstream is known as the endocrine system.
7. Pituitary gland:	The pituitary gland is a pea-shaped gland present at the base of the brain, below the hypothalamus.
8. Growth hormone:	The hormone that stimulates cell division and helps in the growth of bones, fat and muscles of the body is called growth hormone.
9. Gigantism:	Gigantism is a condition in which a person is tall or broad abnormally.
10. Acromegaly:	Acromegaly is a condition in which the person has abnormal growth of hands, feet and face.
11. Thyroid gland:	The bi-lobed gland present on either side of the trachea in the neck is called the thyroid gland.
12. Parathyroid glands:	The four glands present on either lobe of the thyroid gland in the neck are called parathyroid glands.
13. Pancreas:	The pancreas is the largest gland of the human body located behind the stomach, attached to the duodenum.
14. Adrenal glands:	The two glands present on the top of each kidney that helps in an emergency is called adrenal glands.
15. Gonads:	Gonads are reproductive glands.
16. Testes:	The testes are the two ball-like glands present on either side of the scrotum.
17. Ovaries:	Ovaries are the two gonads on either side of the lower abdomen near the fallopian tubes in females.
18. Plant hormones:	Plant hormones are organic substances that control the growth and development of the plant.

Introduction

The body of a living being is a chemical machine. It responds and reacts to the changes in the environment. The response and reaction are due to the physical and chemical changes inside our body. Our action, sadness, happiness, anger, mood, personality, psychology, etc. are controlled by the interaction of several chemicals present in our body. The changes in our surroundings affect us. They are called stimuli. Thus, the stimulus is a change in the environment that brings about a response in an organism. Heat, light, cold, poking by physical objects, food, water, etc. are some examples of stimuli.



stimulus and response

A stimulus causes a positive or negative impact on our body. According to the impact, we show a reaction. Thus, the response shown by an organism towards or away from the stimulus is called a reaction. Examples of reactions are taking out of our hands from fire, closing of eyes instantly when dust hits the face, watering of mouth on seeing food, anger against abuse, etc. All kinds of stimulations and reactions are mainly controlled by two systems of our body called the nervous system and the glandular system. Due to this, we can respond fast to a stimulus. But in plants, there is only a glandular system to respond to a stimulus. So, they cannot respond fast to a stimulus.

Memory note

The term "hormone" is only about a century old.

Fact and Reason

Why do animals respond faster than plants?

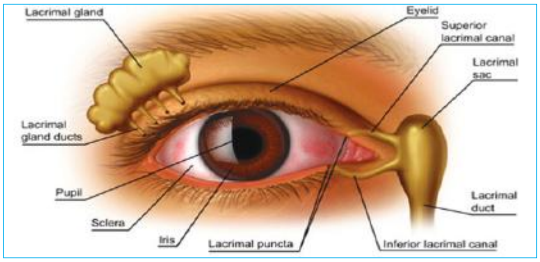
Animals have both nervous system and glandular system to control and coordinate the stimulation and reaction but plants have only a glandular system to do the same. So, animals respond faster to a stimulus than plants.

Activity

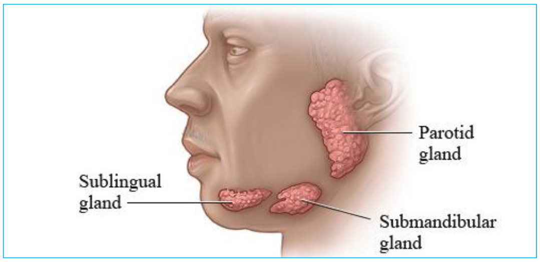
Does the plant respond to stimulus? Discuss in a group.

The glandular system

The system of various glands is called the glandular system. It is a part of the human body. The glandular system secretes chemicals called hormones, enzymes, juices, etc. They perform several functions in the body. For example, digestion, excretion, reproduction, protection, growth, etc. There are two types of glands. They are exocrine gland and endocrine gland.



tear gland



salivary gland

a. Exocrine glands

The glands that secrete enzymes and juices and pour this secretion in the duct (vessel) to an organ are called exocrine glands. So, exocrine glands are ducted glands. For example, sweat glands, tear glands, salivary glands, etc.

b. Endocrine glands

The glands that secrete hormones and pour them directly into the bloodstream without passing them through ducts are known as endocrine glands. So, they are ductless glands. For example, pituitary gland, thyroid gland, adrenal gland, pancreas etc.

Differences between endocrine and exocrine glands

SN	Endocrine glands	SN	Exocrine glands
1	Endocrine glands are ductless glands.	1	Exocrine glands are ducted glands.
2	They secrete hormones.	2	They secrete enzymes and juices.
3	They release the hormones directly into the bloodstream.	3	They release enzymes into the desired organ and not into the bloodstream.
4	They are located near the site of location	4	They are located away from the site of location.

Endocrine system

The system formed by a group of ductless glands which produce hormones and release them into the bloodstream is known as the endocrine system. Hormones are the chemical messengers produced by the endocrine system that activate, inhibit or control the function of a certain organ or a group of organs. Their site of production and the site of action are different. So, hormones are known as chemical messengers.

Memory note

Alcohol has widespread effects on the endocrine system.

Fact and Reason

Hormones are called chemical messengers, why?

Hormones are produced from a certain site but activate, deactivate, control or coordinate the function of an organ or a group of organs in the desired site. So, hormones are known as chemical messengers.

Activity

Make a clay model to show the position of endocrine glands.

Functions of hormones

i. Hormones help in physical, mental and psychological growth of body.

ii. The hormones control, excite or inhibit the function of certain organs.

iii. They help to control various chemicals like glucose and cells like sperm.

iv. They help to maintain a balance between salt and water in the body.

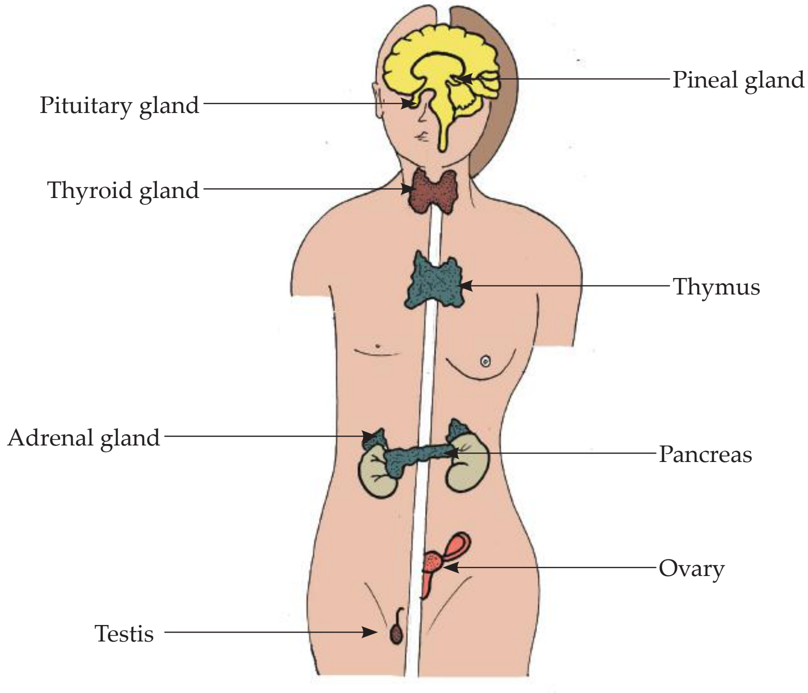
v. They carry out sexual development in men and women.

vi. They control amount of minerals in our body.

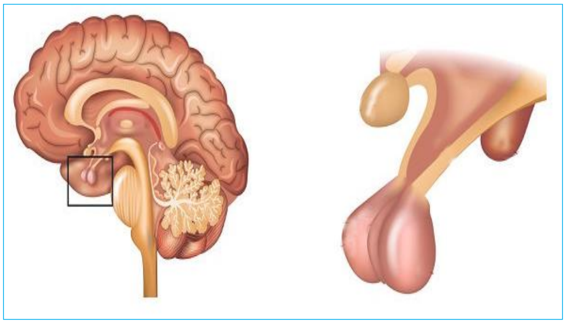
Endocrine glands, their location and the number

S.N.	Name of gland	Number	Location
1.	Pituitary gland	1	The base of the brain
2.	Thyroid gland	2	Neck (in front of the trachea)

3.	Parathyroid gland	4	Neck (behind thyroid)
4.	Adrenal gland	2	On the top of both kidneys
5.	Pancreas	1	Behind the stomach; near the duodenum
6.	Testes (in males)	2	Inside the scrotum
7.	Ovaries (in females)	2	Right and left lower abdomen



a. Pituitary gland



pituitary gland

The pituitary gland is a pea-shaped gland present at the base of the brain, below the hypothalamus. It is a round-shaped organ almost 1cm in diameter and weighs 0.5 grams. The pituitary gland itself produces several hormones. Mainly, the pituitary gland secretes two types of hormones, viz. stimulating hormone and growth hormone.

Memory note

In response to stress, the endocrine system quickly secretes various hormones at a higher level than normal, to adapt to new circumstances which are bad for our health.

Fact and Reason

The pituitary gland is called a master gland, why?

The hormones secreted by the pituitary gland activate, control and coordinate all other glands. Hence, it is also called a master gland.

Growth hormone (GH)

Growth hormone controls the overall development or growth of muscles and bones. It increases the rate of protein synthesis.

Disorders due to hypoactivity and hyperactivity of Growth hormone

Hypoactivity or deficiency: The hyposecretion of GH causes dwarfism. The person suffering from dwarfism has short height and underdeveloped physical structure.

Hyperactivity or excess: The hypersecretion of GH causes the gigantism. Gigantism is a condition in which a person is tall or broad abnormally.

Stimulating hormone

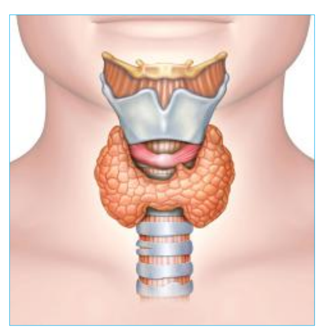
Stimulating hormone activates, controls and coordinates all other glands. Hence, it is also called the master gland.

Memory note

Not all hormones come from the endocrine system.

b. Thyroid gland

The bi-lobed gland present on either side of the trachea in the neck is called the thyroid gland. It is a butterfly-shaped gland present in the neck below Adam's apple. The two lobes are joined by a thin layer of the connective tissue called the isthmus. The thyroid gland secretes Thyroxin (t4), Triiodothyronine (t3) and Calcitonin.



thyroid gland

The functions of thyroxin are to regulate cell metabolism and oxygen consumption. Thyroxin is made up of 65% iodine. Therefore, our diet should include iodine for the formation of this hormone. People living near the seas can easily get iodine from seafood and vegetables. But, for people who have no access to seafood, iodine is added to common salt (NaCl).

Fact and Reason

Why does the thyroid gland grow large into a goitre if our diet lacks iodine?
The thyroid gland grows in size if our diet lacks iodine so as to increase its chance to collect iodine.

The function of calcitonin is to regulate the calcium level by decreasing it in the blood and depositing it in the bones. It works with parathrmone.

Disorders caused due to hypoactivity and hyperactivity of thyroxin

Hypoactivity: The under secretion of thyroxin hormone causes **simple goitre.** In goitre, the thyroid gland swells and results in a large mass in the neck. It also causes cretinism. It causes physical and mental retardation in children. Patient may suffer from myxoedema. It causes fattiness, puffy and dry skin, low blood pressure, low body temperature, etc.
Hyperactivity: The over secretion of thyroxin causes exophthalmic goitre or grave's disease. Its symptoms are higher metabolism, restlessness, decrease in body weight, bulging of the eyes, insomnia, nervousness, high heart rate and high body temperature.

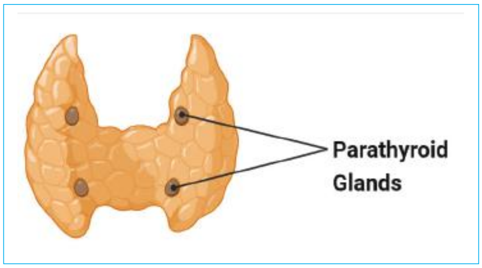
Memory note

The thyroid sets your body's pace which is affected by the number of hormones produced by it.

Fact and Reason

A goitre is a form of malnutrition. Give reason.
Goitre is caused due to the lack of minerals, mainly iodine, in the diet, which are necessary for a proper functioning of the thyroid hormone. So, goitre is a form of malnutrition.

c. Parathyroid gland



parathyroid gland

The four glands present on either lobe of the thyroid gland in the neck are called parathyroid glands. They secrete a hormone called parathyroid hormone or parathormone. Its function is just the opposite to calcitonin. It regulates the level of calcium in the bones and blood by breaking bone cells and releasing calcium in the blood. Thus, the parathyroid hormone increases the level of calcium in the blood.

Disorders due to hypoactivity and hyperactivity of parathyroid hormone

Hypoactivity: Under-secretion of parathyroid hormone causes painful jerking of muscles of neck, face, hands and feet. This condition is called tetany.

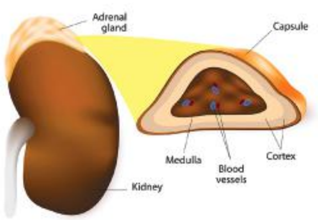
Hyperactivity: Over-secretion of parathyroid hormone causes high blood calcium levels in the blood. It results in soft and weak bones. These bones are easily fractured or broken. Similarly, it can lead to kidney stones due to excess deposition of calcium in kidney tubules and ureters. It also leads to tumours.

Memory note

Hyperparathyroidism may be treated by the surgical removal of the parathyroid gland.

d. Adrenal glands

The two glands present on top of each kidney that help in an emergency are called adrenal glands. They have two main parts:



adrenal glands

i) **Adrenal cortex (occupies 80%):** It produces aldosterone, cortisone, cortisol, etc. The hormone cortisone is a stress hormone that also acts as a sex hormone.

ii) **Adrenal medulla (occupies 20%):** This part of the adrenal gland produces emergency hormones called adrenaline (epinephrine) and noradrenaline (norepinephrine). They are called emergency hormones as they prepare the body for the emergencies like anger, excitement, fight or flight, etc. They control blood pressure, heartbeat, digestion and secretion during an emergency.

Disorders caused due to hypoactivity and hyperactivity of adrenaline

i) **Hypoactivity of adrenaline:** Under-secretion of adrenaline can cause low BP, low blood sugar, inactiveness, low blood glucose level, nausea, etc.

ii) **Hyperactivity of adrenaline:** Over secretion of adrenaline causes high BP and even death.

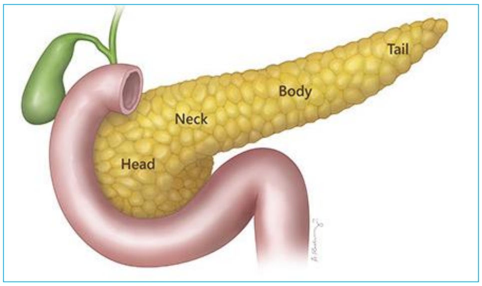
Fact and Reason

Adrenaline hormone is called emergency hormone. Give reason.

Adrenaline gets released from adrenal glands during emergencies like anger, excitement, fight or flight, etc. It increases the heartbeat and supply of oxygen to the brain and muscles to produce energy. So, adrenaline is called the emergency hormone.

e. Pancreas

The pancreas is the largest gland of the human body located behind the stomach, attached to the duodenum. It is about 12-15cm long. As it produces both juice (pancreatic juice) and hormones, it acts as both an endocrine gland and exocrine gland. Hence, it is called a heterocrine or mixed gland.



pancreas

i) **Alpha cells secrete glucagon:** It increases the level of glucose in the blood by converting glycogen to glucose in the liver.

ii) **Beta cells secrete insulin:** It decreases the level of glucose in the blood by converting the glucose into glycogen and storing it in the liver.

Memory note

The pair of hormones that work exactly the opposite way to reverse the effect of each other are known as antagonistic hormones. E.g. a. insulin and glucagon b. parathormone and calcitonin.

Activity

What enzymes does the pancreas produce?

Disorders caused due to hypoactivity and hyperactivity of insulin

Hyposecretion: Hyposecretion of insulin causes diabetes mellitus (DM), commonly known as diabetes. It is caused due to high level of glucose in the blood (hyperglycaemia). It affects several organs like the kidney, eye, brain, etc. The symptoms of DM are frequent urination, intense thirst, weakness, loss of weight, slow healing of wounds, or even diabetic coma, etc.

Hypersecretion: Hypersecretion of insulin causes hypoglycaemia and eventually insulin shock. Its symptoms include dizziness, fainting, convulsions, diabetic coma due to low glucose, brain damage and even death.

Fact and Reason

Why is the pancreas called a mixed or heterocrine gland?

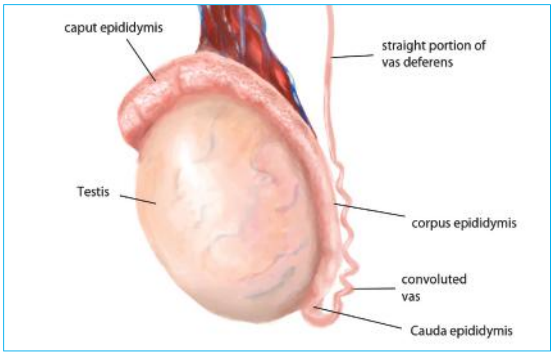
The pancreas is both endocrine and exocrine because it secretes both digestive juice (pancreatic juice) and hormones (insulin, glucagon, etc.). Hence, it is also called a mixed or heterocrine gland.

f. Gonads (Testes and Ovaries):

There are two sex glands in males called testes. Also in females, two sex glands are present in the lower abdomen, on each side, called ovaries. Testes and ovaries are collectively called gonads. Gonads are reproductive glands.

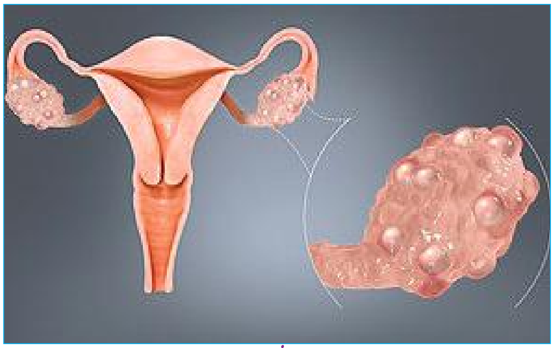
i. Testes (singular testis):

The testes are the two ball-like glands present on either side of the scrotum. The seminiferous tubules release a group of male sex hormones called androgens like testosterone. The testosterone stimulates the formation of sperms and the development of secondary sexual characteristics like the growth of penis and scrotum, beard, moustache, hoarse voice, pubic hair, etc.



testes

ii. **Ovaries (singular: ovary):** Ovaries are the two gonads on either side of the lower abdomen near the fallopian tubes in females. They produce eggs and also many female sex hormones like oestrogen and progesterone. The oestrogen stimulates the maturation of eggs, development of secondary sexual characteristics like shrill voice, pubic hair, enlargement of breasts, etc. Similarly, progesterone helps in the formation of the placenta during pregnancy, releases an egg during ovulation etc.



ovaries

Fact and Reason

Why do some males show feminine characters and females show masculine characters?

The excess growth of the adrenal cortex in adult males causes an increase in the cortisone hormone in the blood. This results in the appearance of feminine characteristics in males. Similarly, in females, the higher levels of cortisone result in the appearance of masculine characteristics.

Plant hormone

Plant hormones are chemical compounds present in very low concentrations in the plant. Plant hormones can be produced from any part of the plant body. The plant does not have any particular organ to produce hormones. It plays important role in germination, phototropism, geotropism, chemotropism, hydrotropism etc. Plant hormones are organic substances that control the growth and development of the plant. These hormones transfer to a different part of the plant body through the xylem and phloem. Plant hormones are not nutrients. These are chemical messengers. They help various plant cells and plant parts to communicate.

Some of the plant hormones are auxins, abscisic acid, gibberellins, cytokinin, ethylene, salicylic acid, brassinosteroids and peptides.

Auxin, cytokinin, gibberellins and abscisic acid are some examples of plant growth hormones. They are also called regulators.

Plants need hormones at very specific times during plant growth and specific locations.

Auxin is produced by the tip of the stem. It is found in apical parts such as bud of stem and roots. It helps in the growth of the height of plants, length of branches and length of the roots. It allows the shoot system to grow toward the light. It is called phototropism. It also allows roots to grow toward the fertiliser. It is called chemotropism.

Fact and Reason

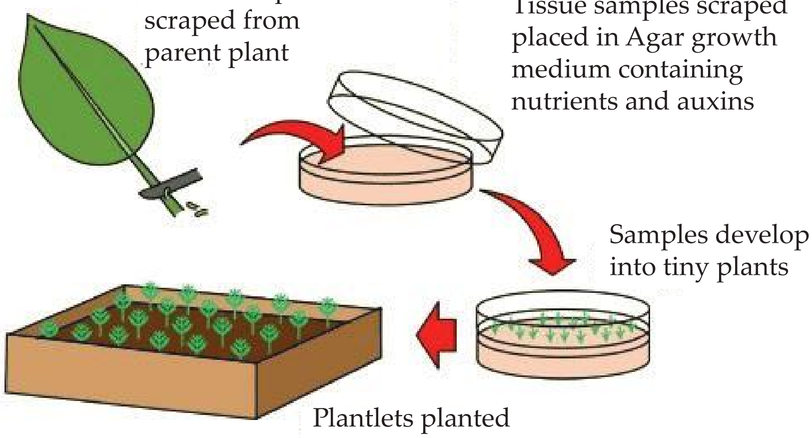
Why is auxin the most important hormone in a plant?

The auxin is the most important hormone in a plant because it controls the overall growth and shape of the plant.

Activity

What plant hormones are used in tissue culture? Discuss in a group.

A cytokinin is a group of plant regulators. It helps in cell division in plant roots and the shoot system. It helps in apical dominance, cells growth etc.



plant tissue grown in tissue culture

Advantages of plant growth hormone are listed below:

i. Plant hormones can be used artificially to grow plants in tissue culture industries.

ii. Auxin helps in the growth of the roots system and cytokinin helps in the growth of the shoot system.

iii. It helps in the growth and development of the plant body.

iv. It helps in the growth of flowers and fruit.

v. It is used while growing off seasonal vegetables.

Answer writing skill

1. **Name a hormone secreted by the parathyroid gland.**
   The name of the hormone secreted by the parathyroid gland is a parathyroid hormone or parathormone.

2. **Define exocrine gland.**
   The glands that secrete enzymes and juices and pour this secretion in the duct (vessel) to an organ are called exocrine glands.

3. **Why is the pituitary gland called a master gland?**
   The pituitary gland is called a master gland because it secretes hormones that control and co-ordinate the functions of all other glands and hormones.

4. **Write any two differences between endocrine glands and exocrine glands.**

The differences between endocrine glands and exocrine glands are tabulated below:

SN	Endocrine gland	SN	Exocrine gland
1	They are ductless glands.	1	They are ducted glands.
2	They secrete hormones.	2	They secrete enzymes and juices.

5. **Write any two functions of the human growth hormone (HGH).**

The two functions of the human growth hormone are:

i. It helps the growth of bones and muscles in the body.
ii. It stimulates the synthesis of proteins in the body.

6. **It is the age of science and technology. Scientists prepare different types of growth hormones in the industries to use in agriculture. Mention the advantages of these growth hormones.**

The advantages of plant growth hormone are:

i. Plant hormones can be used artificially to grow plants in tissue culture industries.
ii. Auxin helps in the growth of the roots system and cytokinin helps in the growth of the shoot system.
iii. It helps in the growth and development of the plant body.
iv. It helps in the growth of flowers and fruit.

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

a. Which gland is an exocrine gland?

i. salivary gland	ii. thyroid gland
iii. adrenal gland	iv. parathyroid gland

b. Which hormone is produced by the thyroid gland?

i. thyroxine	ii. adrenaline
iii. growth hormone	iv. androgen

c. What do excess growth hormones cause?

i. gigantism	ii. cretinism
iii. goitre	iv. infertility

d. Which one is the heterocrine gland?

i. adrenal	ii. pancreas
iii. thyroid	iv. parathyroid

e. Which hormone decreases the amount of sugar in the blood?

i. glucagon	ii. insulin
iii. thyroxine	iv. progesterone

2. Define the following with required examples.

i. Glandular system	ii. Chemical messenger
iii. Insulin	iv. Gonads

3. Short question answers.

a. Which is an emergency hormone? Which glands secrete it?
b. Which gland secretes insulin? Write its function.
c. Write the function of auxin.
d. Which cell of the pancreas secretes insulin?
e. Which gland is called the master gland?
f. Where is the parathyroid gland found?
g. What is the cause of gigantism?
h. Give any two examples of plant hormones.

Step 2

4. Give reason.

a. The pituitary gland is called a master gland.
b. The salivary gland is an exocrine gland.
c. The thyroid gland is an endocrine gland.
d. Pancreas is called a mixed gland.
e. The adrenal gland is called an emergency gland.
f. Iodine must be supplied in our diet.
g. Hormones are called a chemical messenger.
h. The plant needs growth hormone.

5. Differentiate between the following.

a. Pancreas and thyroid gland
b. Endocrine gland and exocrine gland

6. Answer the following questions.

a. Which disease is caused by the lack of:

i. Thyroxin ii. Growth hormone iii. Insulin

b. Which disease is caused by the excess of:

i. Thyroxin ii. Growth hormone iii. Parathormone

c. Write a short note on growth hormones.

d. Describe the functions of pituitary gland.

e. Draw the diagram of the human body. Label glands.

f. Write down the hormones secreted by gonads with one function of each.

g. Mention two hormones secreted by the pituitary gland with one function of each.

h. Mention the functions of hormones in a human body.

i. Enlist the importance of plant hormones.

j. Malfunction of pancreas causes diabetes. Explain.

Step 4

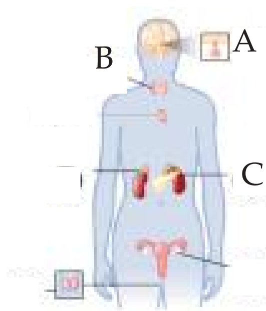
7. Long question answers.

a. Explain the structure and role of thyroid gland in our body.

b. Describe the structure and function of the adrenal gland.

c. Insulin reduces sugar. What if all sugar is lost? Is there any hormone that increase the sugar? How do the hormones control amount of sugar in our body? Which gland is probably malfunctioning to cause diabetes?

8. Study the given diagram and answer the following question.



i. Label the parts A, B and C.

ii. What happens if gland A is malfunctioning?

iii. Which one is called the emergency gland and why?

iv. What happens if gland B is secreting a lesser amount of hormone?

v. Which gland is related to diabetes?

9. Some people grow gigantic than average human beings. What is such disorder called? Discuss the reasons for such disorders.

UNIT

6 NATURE AND ENVIRONMENT

ESTIMATED TEACHING PERIODS

TH	PR
4	2

A.G. Tansley
(1871-1955)

Curriculum issued by CDC

- Inter-relationship between abiotic and biotic components in the aquatic ecosystem.
- Introduction to food chain and food web
- Inter-relationship among the organisms in an ecosystem.
- Interaction among the organisms in an ecosystem (competition, predation, parasitism, commensalism and mutualism)

Learning outcomes

After completion of this unit, students will be able to:

- explain inter-relationship between abiotic and biotic components of the aquatic and terrestrial ecosystem.
- introduce food chain and food web in ecosystem along with inter-relationship of the organisms.
- explain types of interaction among the organisms in an ecosystem.

Terms and terminologies

1. Environment: The group that includes all the living and non-living components that exist on this earth either visible or invisible is called the environment.
2. Biome: The biosphere is divided into smaller fragments of areas with similar climates and vegetation called the biome.
3. Community: The group of various species that live in an ecosystem is called community.
4. Ecosystem: An ecosystem is a small unit of an environment that consists of living and non-living components that exchange matter and energy.

5. Ecology:	The branch of biology which studies the ecosystem and the interrelationship between its different components is known as ecology.
6. Abiotic components:	The non-living components present in the ecosystem are known as the abiotic components.
7. Climatic abiotic components:	The non-living components of the ecosystem that are related to climate and weather are known as the climatic abiotic components.
8. Edaphic abiotic components:	The non-living components that are related to the characteristics of the soil are known as the edaphic abiotic components.
9. Biotic components:	The living components present in the ecosystem are known as the biotic components.
10. Producers:	The organisms that produce food in the ecosystem are known as the producers.
11. Consumers:	Consumers are organisms that depend on others for their food.
12. Primary consumers:	The consumers that directly depend on plants for food are known as primary consumers.
13. Secondary consumers:	The consumers that depend on the primary consumer for food are known as the secondary consumers.
14. Tertiary consumers:	The consumers that depend on the primary and secondary consumers for food are known as the tertiary consumers.
15. Decomposers:	Decomposers are the microorganisms in the ecosystem that recycle the dead and decomposed substances and convert them into simpler forms.
16. Food chain:	The transfer of food from the lower to higher trophic levels in the ecosystem by the process of eating and being eaten is known as the food chain.
17. Grazing food chain:	The food chain that starts with autotrophs is known as the grazing food chain.
18. Detritus food chain:	The food chain that starts with dead organic matter is known as the detritus food chain.
19. Food web:	A food web is the combination of several food chains that are integrated.
20. Terrestrial ecosystem:	The ecosystem in which organisms exchange food and energy mostly on land is known as the terrestrial ecosystem.
21. Grassland ecosystem:	The ecosystem that runs in meadows is called the grassland ecosystem.
22. Aquatic ecosystem:	The type of ecosystem in which the exchange of food and energy takes place inside water bodies is called the aquatic ecosystem.

23. Pond ecosystem:	The ecosystem that runs inside the pond is called the pond ecosystem.
24. Symbiosis:	Symbiosis is the relationship where two organisms of different species work together to survive. It benefits both organisms.
25. Commensalism:	Commensalism is the interaction between organisms where one is benefited and the other is not affected at all.
26. Parasitism:	Parasitism is the interaction between organisms where the host is harmed by the parasite.
27. Competition:	The relation between organisms in which both organisms struggle for the same resources is called competition.
28. Predation:	Predation is the interaction in which an organism feed upon another.

Introduction

The Earth's environment is home to millions of species: tiny to big, plants to animals, and aquatic to terrestrial. The word 'environment' is derived from the French word 'Environner' meaning 'to surround'. The group that includes all the living and non-living components that exist on this earth, either visible or invisible, is called the environment. The largest unit of the environment is called the biosphere. We all live in the part of the earth called the biosphere that sustains life.

In the earth, the lithosphere (land part), hydrosphere (water part), and a small part of the atmosphere (air) make up the biosphere. The biosphere is divided into smaller fragments of areas with similar climates and vegetation called the biome. For example, aquatic biome, terrestrial biome, etc. A biome is the combination of several systems. The group of various species that live in an ecosystem is called a community. The unit of a biome is called an ecosystem. The community bears many species of organism. Each species of organism is known as the population.

What is an ecosystem?

The word 'eco' means environment and 'system' means the structure. Thus, the ecosystem represents a systematic structure of the environment. In this structure, there is everything that we have around: plants, animals, microbes, sunlight, air, soil, etc. They share food and energy. The word 'ecosystem' was coined by British ecologist Arthur Tansley in 1935 A.D.

Memory note

Half of the world's species live in tropical rainforests.

An ecosystem is a small unit of an environment that consists of living and non-living components that exchange matter and energy. The ecosystem is automatically regulated by natural forces. Some ecosystems are simple while others are complex. Most of the ecosystems are natural while some are created by humans. But the common feature in every ecosystem is that they are made up of living and non-living components. The branch of biology which studies the ecosystem and the interrelationship between its different components is known as ecology.

Fact and Reason

The ecosystem is dynamic, why?

The ecosystem is dynamic because there is a continuous exchange of food and energy among its different components.

Activity

Observe your surrounding environment. List biotic and abiotic factors you find in it.

Ecological components

The components that run and sustain an ecosystem are known as ecological components. There are two kinds of ecological components. They are biotic components and abiotic components.

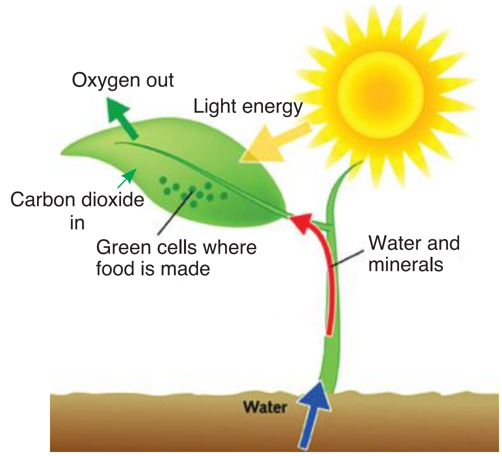
Abiotic components

The non-living components present in the ecosystem are known as the abiotic components. The soil, air, water, sunlight, minerals, etc. are the abiotic components. These components provide a basis for the biotic components for survival. Without abiotic components, the living components have no physical basis for life.

Some important abiotic factors

a. Sunlight and temperature

The solar energy we get from the sun is heat energy and light energy. The heat energy heats the earth's crust, evaporates water, sustains the water cycle, and keeps a habitable temperature on the earth. In the absence of sunlight, everyone will freeze to death. Different ecosystems require different variations of temperature. Land organisms can bear certain temperature changes, but aquatic organisms are very sensitive to it. Temperature directly affects reproduction, seeding, fertilisation, seed dispersal, prey-predator relationship, etc. in an ecosystem. A balanced temperature helps to regulate several aspects of the ecosystem.



process of making food by green plants

Likewise, light energy is the source of energy for photosynthesis. Light makes it possible to form glucose and oxygen from carbon dioxide and water. Without light energy, no food is produced without which ecosystems are impossible.

Memory note

The sun is halfway through its life.

Fact and Reason

Sunlight is a very important component of the ecosystem.

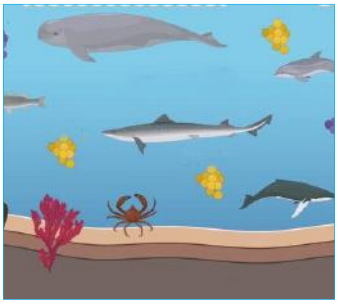
Sunlight is a very important component of the ecosystem because it helps in photosynthesis which is the only source of food in the ecosystem.

b) Air

The air is a mixture of various vital gases like carbon dioxide, oxygen, nitrogen, etc. which are important to the living organisms in the ecosystems. Carbon dioxide is used up by the plants during photosynthesis to prepare food. This food is transferred to the animals successively. In the same way, oxygen makes respiration possible by which energy is released in both plants and animals. Likewise, nitrogen is directly needed by the plants. They take it through the soil. Nitrogen is a key element in the formation of a plant body made up of mostly proteins.

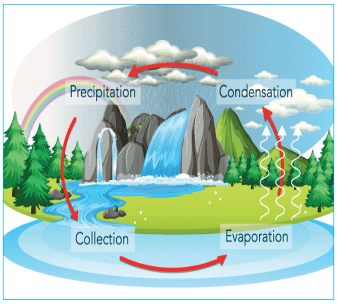
c) Water

Water constitutes about 70 % to 90 % of all living bodies. It helps to circulate useful materials in the cell and to excrete wastes. It also forms a 2/3rd part of the earth sustaining the life of millions of aquatic animals and plants directly. The vital processes of circulation, excretion, reproduction, etc. cannot occur without water.



aquatic animals

kid drinking water



water cycle

d) Soil

The soil is the region on the earth's crust where food grows. The roots of the plants are fixed to it from where they absorb nitrates, water, minerals, etc. Soil is also the habitat for all organisms on the earth. The acidity and alkalinity of the soil, its water and air content, and its texture determine the habitat of plants. Soil is home to most animals like earthworms, scorpions, ants, etc.

plant growing on soil

agriculture

earthworm in soil

Biotic components

The living components present in the ecosystem are known as the biotic components. In the terrestrial ecosystem, the leopard, zebra, hyena, trees, vultures, and even termites are the biotic components. They include plants, animals, and microbes present in the ecosystem. For any ecosystem to work, it needs energy and food. The availability of food and energy should be unlimited. If this process stops, the ecosystem crashes and everyone dies. The biotic components in the ecosystem are divided into three types. They are:

a. Producers

The organisms that produce food in the ecosystem are known as the producers. Generally, the producers in the ecosystem are green plants and phytoplankton. The sunlight helps in the process of photosynthesis. The producers generate food and transfer it to the consumers.

Memory note

The coastal redwood is the tallest plant on earth.

Fact and Reason

Plants are called producers, why?

Plants are called producers because they produce food using air, water, and sunlight.

Plants are called transducers, why?

Plants are called transducers because they produce food by transforming solar energy into chemical energy (starch) using sunlight, water, and air in presence of chlorophyll in the leaves.

b. Consumers

Consumers are organisms that depend on others for their food. There are many levels of consumers based on a hierarchy of food transfer:

Primary consumer:

The consumers that directly depend on plants for food are known as primary consumers. Herbivores fall under this category. Some of the examples of primary consumer are goat, horse, grasshopper, zooplanktons, etc.

Fact and Reason

Goat is a primary consumer, why?

Goat is a primary consumer because it depends on the plant for its food.

Secondary consumer:

The consumers that depend on the primary consumer for food are known as the secondary consumers. Weaker carnivores and weaker omnivores are mostly secondary consumers. As they depend upon the primary consumers, they indirectly depend on plants. For example, dog, cat, fox, fish, bird, snake, etc.

Tertiary consumer:

The consumers that depend on the primary and secondary consumers for food are known as the tertiary consumers. They are also referred to as top carnivores. For example, lion, tiger, hyena, eagle, whale, crocodile, etc.

c. Decomposers

Decomposers are the microorganisms in the ecosystem that recycle the dead and decomposed substances and convert them into simpler forms. These simpler forms of nutrients obtained can again be used up by the plants. Decomposers are the armies of nature. They are at work every time something lies dead. Examples of decomposers are bacteria and fungi (mushroom, mucor, etc).

Memory note

Fungi can also cause disease.

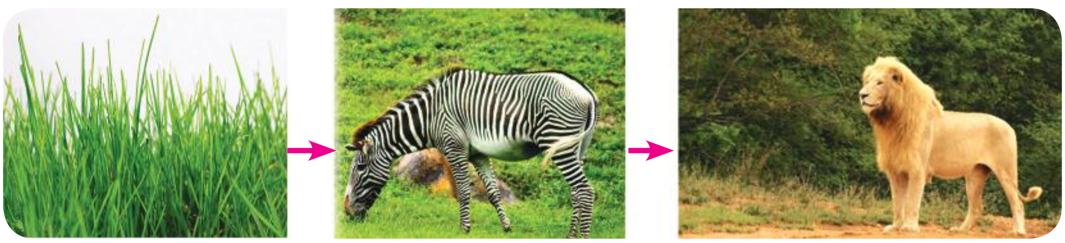
Fact and Reason

Why are bacteria inseparable components of the ecosystem?

The bacteria are an inseparable component of the ecosystem because they are decomposers that help minerals from dead organic materials return to earth.

Food chain

The transfer of food from the lower to higher trophic levels in the ecosystem by the process of eating and being eaten is known as the food chain. A simple food chain undergoes three processes: production, consumption, and recycling. The food is produced at the producer level by the green plants. The animals eat the plant products and other animals and thus the food gets transferred from lower level to higher level of consumers. Finally, after the producers and consumers are all dead, the decomposers recycle the nutrients present in their bodies and return them to the soil so that the plants can use them again. This food cycle continues so that there is a continuous supply of food to every other organism on the earth. The food chain that starts with autotrophs is known as the grazing food chain. The food chain that starts with dead organic matter is known as the detritus food chain.

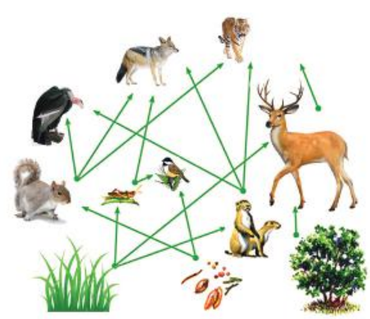


Food chain of forest ecosystem

Food chain of grassland ecosystem

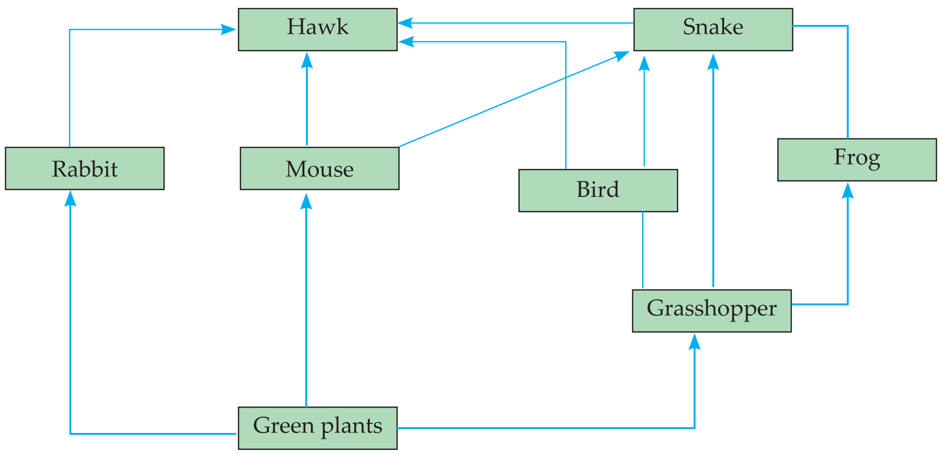
Food web

A single organism has various choices of food in the ecosystem. In the same way, that organism can also be eaten by a variety of other organisms. An ecosystem is thus a web of several food chains that are linked together by the process of eating and being eaten. This is called a food web. A food web



food web of a terrestrail ecosystem

is the combination of several food chains that are integrated. There are several levels of producers, primary consumers, secondary consumers, tertiary consumers, and so on in a food web.



food web of a grassland ecosystem

Different types of ecosystems and their components

Sub-type	Components	
	Biotic	Abiotic
Grassland	a. Grasses, herbs, shrubs, etc.: producer b. Deer, frogs, insects, rabbits, etc.: primary consumer c. Birds, foxes, jackals, wolves, etc.: secondary consumers d. Tiger, lion, hyena, hawk, vultures, eagles, etc.: tertiary consumers	a. Soil b. Minerals c. Air d. Temperature e. Humidity f. Sunlight g. Water h. Rocks
Pond	a. Phytoplankton like diatoms, hydrilla, lemna, algae, etc.: producers b. Zooplanktons, protozoa, larvae, etc.: primary consumer c. Small fish, frogs, insects, etc.: Secondary consumers d. Big fishes, a water snake, kingfisher, heron, eagle, etc.: tertiary consumer	a. Water b. Minerals c. Organic deposits d. Inorganic salts e. Temperature f. Soil g. Air h. Sunlight

Memory note

If a single level of a food chain is missing then the whole balance will be lost.

Activity

Observe the surrounding environment. Make a list of the food chain you find.

Fact and Reason

The number of the producer is always more than the consumer in the ecosystem, why?

The number of the producer is always more than the consumer in the ecosystem because producers are the sources of food. If by any chance producers are fewer in number, consumers will die of starvation.

Terrestrial Ecosystem

The ecosystem in which organisms exchange food and energy mostly on land is known as the terrestrial ecosystem. It can either be natural or man-made. Natural ecosystems are more diverse and broader than artificial ones. The natural ones are tundra, forest, desert or dry land, grassland ecosystems, etc. Likewise, the artificial ecosystems are crop fields, gardens, aquarium ecosystems, etc.

Grassland ecosystem

The grassland is a plain land with lots of shrubs. The ecosystem that runs in meadows is called the grassland ecosystem. It is a terrestrial ecosystem. The biotic and abiotic components of the grassland ecosystem are discussed below.

a. Abiotic factors

Soil, air, water, minerals, humidity, and heat are some abiotic factors of the grassland ecosystem. These are sources of raw materials for living things to survive. Soil provides minerals for plants. Water is also available underground. Air provides carbon dioxide for photosynthesis and oxygen for respiration. Solar heat energy keeps the earth warm and helps in the germination of the plant.

b. Biotic components

The biotic components include all life forms present in the grassland. They are producers, consumers, and decomposers.

i. Producers

The green algae, herbs, bushes, and trees are producers in the grassland ecosystem. They produce food by using carbon dioxide, minerals, water, and sunlight.

ii. Consumers

The consumers of the grassland ecosystem are:

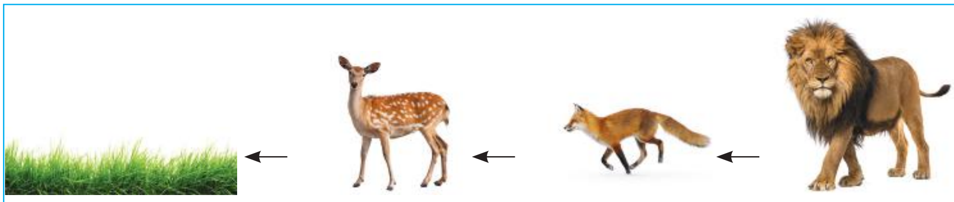
Primary consumers: Grasshopper, slugs, rabbits, etc. are primary consumers of the grassland ecosystem. They feed upon roots, leaves, seeds, and fruits of the plant.

Secondary consumers: Frog, birds, fox, wolves, etc. are secondary consumers. They feed upon primary consumers. Some of them feed upon plants, too.

Tertiary consumers: Python, snake, tiger, and leopard are some tertiary consumers in the grassland ecosystem. They are at the top of the food chain.

iii. Decomposers

Bacteria and fungi are decomposers. They are found in grasslands. They convert dead organic materials into simpler nutrients. The nutrients are mixed in the soil. Plants reuse these materials for photosynthesis.



a food chain of grassland ecosystem

Aquatic ecosystem

The type of ecosystem in which the exchange of food and energy takes place inside water bodies is called the aquatic ecosystem. It is further classified into two types: fresh water and marine ecosystems. The freshwater ecosystem includes non-salty water bodies, the pond, lake, river, spring, swamps, etc. Similarly, the marine includes salty water bodies like the seas and oceans.

Memory note

Large coral reefs are thousands of years old.

Fact and Reason

Chlamydomonas is a producer in the aquatic ecosystem.

Chlamydomonas is a producer in the aquatic ecosystem because it is an aquatic plant that uses air, water and sunlight to make food.

Pond ecosystem

Pond ecosystem

Some animals and plants live in water. An entire ecosystem runs inside the water. The ecosystem that runs inside the pond is called the pond ecosystem. The abiotic factors and biotic factors of the pond ecosystem are discussed below.

a. Abiotic factors:

The non-living things found on the pond are water, minerals, air dissolved in water, and sunlight. Oxygen gas dissolved in water is used by animals and plants for respiration. The sunlight helps in photosynthesis. Plants absorb carbon dioxide that is dissolved in the water.

b. Biotic factors:

The living things of the pond ecosystem are divided into producer, consumer, and decomposer.

Producer: Diatoms, algae, hydrilla, lotus, and other aquatic plants are the source of food in the pond ecosystem. The phytoplankton is a unicellular plant. It is a food for microscopic organisms.

Consumer: The consumers are divided into three broad groups.

Primary consumers: Cyclops, daphnia, beatles, molluscs, etc. are zooplanktons. They feed upon microscopic aquatic plants for nutrients. Little fish, the larva of frog and mosquito are also primary consumers.

Secondary consumer: Frogs, crabs, and bigger fishes are secondary consumers. They feed upon tiny fishes, invertebrates, and plants for nutrients.

Tertiary consumers: Ducks, snakes, crocodiles etc. are tertiary consumers in the pond ecosystem.

Decomposers: When the aquatic plants and animals die, decomposers convert protein, fat and carbohydrates into simple forms. They mix the materials into the soil. These nutrients are used by plants.

Decomposers help in the flow of minerals to and fro between earth and living things. Therefore, decomposers are very important.

6.2 Interaction between living beings

The ecosystem is formed by the interaction of multiple organisms. Plants depend upon abiotic factors to produce food. Herbivores feed upon the plants. Carnivores feed upon other animals. Omnivores feed upon the plant as well as animals. Some of them are free-living but some of them are parasites. Some organisms help each other survive. Some interactions between the living things are discussed below:

a. Symbiosis (mutualism)

Symbiosis is the relationship where two organisms of different species work together to survive. It benefits both organisms. It may be possible between two different species.

Symbiosis (mutualism)

Some examples of symbiosis are:

i. Digestive bacteria and humans

There are good bacteria in our intestines. They help us in the digestion of undigested food.

ii. Sea anemones and clownfish

Sea anemones give shelter for clownfish and clownfish protects anemones from butterflyfish.

b. Commensalism

Commensalism is the interaction between organisms where one is benefited and the other is not affected at all.

Commensalism

Some examples of commensalism are:

i. Orchids growing on trees

The orchid plants grow on other trees but they are not parasites. They neither harm nor help the trees. They simply use trees to grow.

ii. Shark and remora fish

The remora fish attaches to the body of sharks and whales. They use sharks for transportation. They feed upon the leftover food of the shark. These are neither harmful nor useful for the shark.

c. Parasitism

Parasitism is the interaction between organisms where the host is harmed by the parasite.

Parasitism

Some examples of parasitism are:

i. Roundworm and human

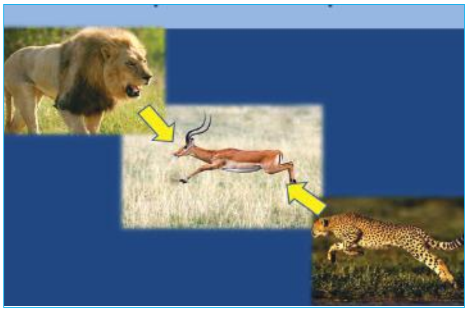
The roundworms are parasites. They live in the intestine and suck nutrition directly. It is harmful to us.

ii. Plasmodium

The unicellular organism Plasmodium is a parasite. It destroys liver and blood cells. It causes us malaria. Mosquito is also a parasite. It transfers malaria to human beings while sucking blood.

d. Competition

The relationship between organisms in which both organisms struggle for the same resources is called competition. Since the resources are limited, both organisms are harmed. Competition may occur either between individuals of the same species or different species.



Competition

Some examples of competition are:

i. The rabbits and the deer living in the same grassland ecosystem compete for food.

ii. Wolves and foxes compete for food and shelter.

e. Predation

Predation is the interaction in which an organism feeds upon another. It helps to control the population of the species. The weak predators cannot catch prey and die of hunger. The weak prey dies early so it does not pass its genes to a new generation.

Predation

Some examples of predation are:

i. Wolves hunt upon herbivores such as deer and sheep.

ii. Herbivores feed upon the plants.

Answer writing skill

1. What is ecology?

The branch of biology which studies the ecosystem and the interrelationship between its different components is known as ecology.

2. Write any two examples of decomposers.

Bacteria and fungi are two examples of decomposers.

3. Killing a snake because it is poisonous is the wrong thing to do, why?

Killing a snake is a bad thing to do because the snake is a secondary consumer of the ecosystem. If it is killed the number of rats, frogs, insects, etc. increases and this disturbs the ecosystem.

4. Write any two differences between food chain and food web.

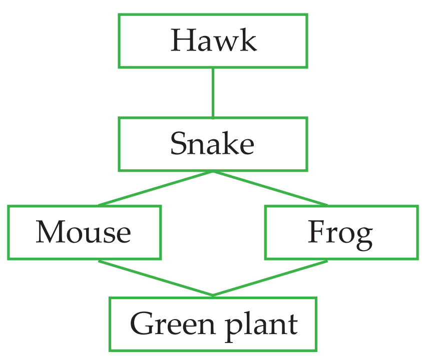
The two differences between the food chain and the food web are given below:

S.N.	Food chain	S.N.	Food web
1	A food chain contains only a single organism at a trophic level.	1	A food web can have more than one organism at a trophic level.
2	A food chain is a unit of a food web.	2	The food web is the integrated form of the food chain.

5. Explain the role of producers in sustaining the ecosystem.

Producers produce food in the ecosystem which acts as energy for the entire biotic components of the ecosystem. All organisms on the earth get their nutrients from food obtained directly or indirectly from plants. Without them, the entire ecosystem will collapse.

6. Observe the given food web. List out the food chains.



The food chains involved in making this food web are:

Green plants → Mouse → Snake → Hawk

Green plants → Frog → Snake → Hawk

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. Which one is an abiotic component?

i. sunlight	ii. goat
iii. grasshopper	iv. potato

b. Which one is a biotic component?

i. sunlight	ii. minerals
iii. carbon dioxide	iv. algae

c. Which one is a primary consumer?

i. goat	ii. fox
iii. snake	iv. tiger

d. Which one is a parasite?

i. tiger	ii. mosquito
iii. goat	iv. snake

e. Which one is a decomposer?

i. bacteria	ii. yeast
iii. fungi	iv. all of them

2. Define the following, with examples.

i. Ecosystem	ii. Abiotic components
iii. Biotic components	iv. Decomposers
v. Food chain	vi. Food web
vii. Phytoplankton	viii. Zooplankton

3. Short question answers.

a. What is ecology?
b. What is grassland ecosystem?
c. What is an aquatic ecosystem?
d. Give an example of symbiosis.
e. What is commensalism?

Step 2

4. Give reason.

a. Lions are called top carnivores in the grassland ecosystem.

b. Deer is called a primary consumer.

c. The grass is a producer.

d. Decomposers are a very important part of the ecosystem.

e. The number of consumers cannot exceed the number of producers.

f. Roundworm is a parasite.

5. Differentiate between the following.

a. Producer and consumer

b. Terrestrial ecosystem and aquatic ecosystem

c. Primary consumer and tertiary consumer

Step 3

6. Answer the following questions.

a. How is the ecosystem dynamic?

b. Give an example of a food chain that does not start with green plants.

c. How do abiotic components support life in the ecosystem?

d. Describe the grassland ecosystem.

e. Describe the pond ecosystem.

f. How does an ecosystem work?

g. Write a short note on commensalism.

h. Describe predation with an example.

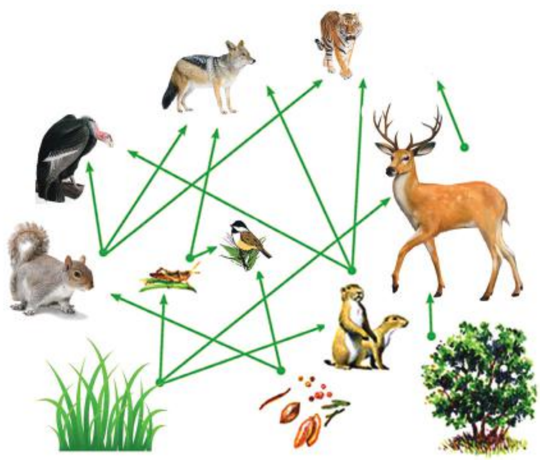
Step 4

7. Long question answers.

a. Draw the structure of a pyramid showing producers and different levels of consumers.

b. Ecosystem is a delicate interrelationship. Loss of even one of the components of ecosystem disturbs the entire ecosystem. Justify

c. Explain the exchange of food in the following food web.



d. Draw well-labelled diagrams of the food chain and food web.

e. How do biotic components and abiotic components interact?

f. How does food reach the decomposers?

g. What happens if all the vultures, foxes and tigers die in the food web shown in the question no. 7c.? Explain.

h. A balanced ecosystem is necessary for healthy environment. Justify.

i. Let's suppose the number of frogs is too much in pond. What kind of imbalance can be observed? Explain.

j. When farmers killed all rats to protect their crops, it actually decreased the crop production. Discuss the reason.

k. What type of ecological interactions are the following activities?

   i. Tiger hunting deer.

   ii. Lion and leopard sharing same hunting ground.

   iii. Honeybees collecting nectar.

   iv. Spiders makes net on walls.

UNIT 7

FORCE AND MOTION

ESTIMATED TEACHING PERIODS

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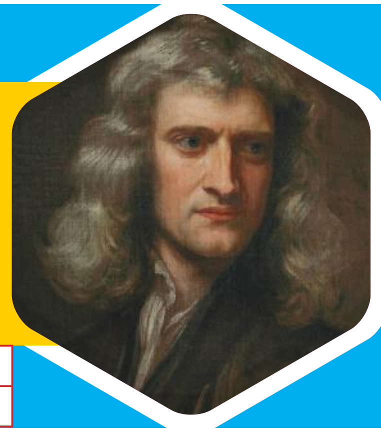


Sir Isaac Newton
(1643-1727)

Curriculum issued by CDC

- Equations of motion
- Displacement time graph
- Velocity time graph
- Numerical problems related to velocity and acceleration
- Inertia
- Newton's first equation of motion and its application in our daily life
- Newton's second equation of motion and its numerical problems
- Newton's third equation of motion and its application in our daily life
- Pairs of action and reaction
- Definition of elasticity and plasticity (Hook's law is not required)

Learning outcomes

After completion of this unit, students will be able to:

- derive the equations for straight line and solve the numerical problems.
- demonstrate uniform and non-uniform velocity and acceleration in graph as well as their explanation.
- state and explain Newton's laws of motion as well as investigation of their application in our daily life.
- clarify the concept of elasticity and plasticity.

Terms and terminologies

1. Force: Force is defined as the push or pull on a body that changes or tends to change the state of rest or uniform motion of a body in a straight line.

2. Distance:	The actual length of the path travelled by a moving body, irrespective of its direction is called the distance travelled by the body.
3. Displacement:	The shortest distance between the initial position and the final position of a moving body in a particular direction is called its displacement.
4. Speed:	The distance travelled by a body per unit time is called speed.
5. Velocity:	The distance travelled by a body per unit time in a particular direction is called its velocity.
6. Uniform velocity:	A body is said to have uniform velocity when it travels in a particular direction and covers equal distance in an equal interval of time.
7. Non-uniform velocity:	A body is said to have non-uniform velocity when it covers unequal distances in equal intervals of time.
8. Average velocity:	If the velocity of a body in a particular direction changes continuously at a uniform rate, then the arithmetic mean of the initial velocity and final velocity over a given period is called average velocity.
9. Acceleration:	The rate of change of velocity of a body with respect to time is called its acceleration.
10. Positive acceleration:	The rate of increase in velocity is called positive acceleration.
11. Negative acceleration:	The rate of decrease in velocity is called negative acceleration.
12. Uniform acceleration:	When a body travels in a straight line and its velocity changes by equal amounts in equal intervals of time, then it is said to have uniform acceleration.
13. Non-uniform acceleration:	When the velocity of a body changes by unequal amounts in equal intervals of time, then it is said to have non-uniform acceleration.
14. Distance- time graph:	The graphical relationship between the distance travelled by a body and the time taken is called the displacement-time graph.
15. Velocity-time graph:	The graphical relationship between the velocity of a body in motion and the time is called the velocity-time graph.
16. Equation of motion:	When a uniformly accelerated body travels in a straight line, then the relationship between the initial velocity (u), final velocity (v), distance travelled (s), acceleration (a), and time taken (t) is called the equation of motion.

17. Inertia:	The tendency of a body to remain in its state of rest or of uniform motion along a straight line is called inertia.
18. Inertia of motion:	The property of a body by which it resists any change in its state of uniform motion is called inertia of motion.
19. Inertia of rest:	The property of a body by which it resists any change in its state of rest is called inertia of rest.
20. Newton's first law of motion:	'Everybody continues to be in its state of rest or of uniform motion along a straight line unless it is acted upon by an external force'.
21. Newton's second law of motion:	'The acceleration produced on a body is directly proportional to the applied force and inversely proportional to the mass of the body (m).'
22. Newton's third law of motion:	'For every action, there is an equal and opposite reaction.'
23. Deforming force:	The external force which produces a change in length, volume, and shape of a body is called deforming force.
24. Deformed body:	A body that experiences a deforming force is called a deformed body.
25. Restoring force:	A force developed within a body that restores the body into its original state is called restoring force.
26. Elasticity:	The property of a material to regain its original state when the deforming force is removed is called elasticity.
27. Elastic body:	The body which possesses the property of elasticity is called the elastic body.
28. Perfectly elastic body:	A body that completely regains its original shape and size after the removal of the deforming force is said to be perfectly elasticbody.
29. Plastic:	Bodies that do not exhibit the property of elasticity are called plastic.
30. Perfectly plastic:	Bodies that do not exhibit the property to return to their own shape and size after removing a deforming force are called perfectly plastic.
31. Plasticity:	The property of a body by which it tends to retain the altered shape and size on the removal of deforming force is called plasticity.
32. Partially elastic:	The bodies which partially regain their original form after removing a deforming force are called partially elastic.
33. Elastic limit:	The limit beyond which permanent deformation occurs is called the elastic limit.

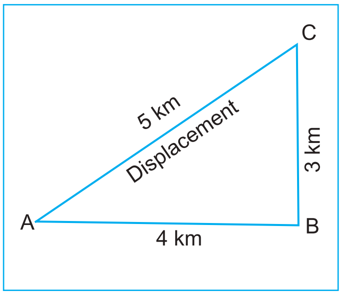
Introduction

In our daily life, we push the door handle to open the door and pull the handle to close it. The push or pull on a body that changes or tends to change the state of rest or uniform motion of a body in a straight line is called force. Forces are used in our everyday actions, pushing, pulling, lifting, walking, pressing, etc.

Memory note

The SI unit of force is newton (N) and the CGS unit of force is dyne.

Distance and Displacement



The actual length of the path travelled by a moving body is called the distance. It is a scalar quantity. The SI unit of distance is metre (m). The shortest distance between the initial position and the final position of a moving body in a particular direction is called its displacement. It is a vector quantity.

Speed and Velocity

Speed describes the rapidity of a body in motion at a particular moment. Whenever we try to find out which of the two or more vehicles is moving faster, then we compare the distance moved by them in a unit time. The distance travelled by a body per unit time is called speed.

i.e. $\boxed{\text{Speed} = \frac{\text{Distance travelled}}{\text{time taken}}}$

It is a scalar quantity. In the SI system, the unit of speed is metre per second written as m/s.

Fact and Reason

Why is speed considered a scalar quantity?

Speed has only magnitude but no direction. So, speed is a scalar quantity.

Velocity is the physical quantity that has both the direction of motion and the distance travelled. The distance travelled by a body per unit time in a particular direction is called its velocity. If a body covers a distance of 's' in time 't' in a specific direction, then its velocity 'v' is given by

$$v = \frac{\text{distance travelled in a particular direction}}{\text{time}} = \frac{s}{t}$$

It is a vector quantity. In the SI system, the unit of velocity is m/s. If velocity of an object moving in a particular direction is positive then the velocity of another object moving in its opposite direction should be negative.

Fact and Reason

Why is velocity considered a vector quantity?

Velocity has both magnitude and direction. So, velocity is a vector quantity.

Average velocity

If the velocity of a body changes continuously at a uniform rate, then the arithmetic mean of the initial velocity and final velocity over a given period is called average velocity.

i.e. $\text{Average velocity} = \frac{\text{Initial velocity (u)} + \text{Final velocity(v)}}{2}$,

in case the body is moving with a uniform rate of change of velocity.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

Acceleration

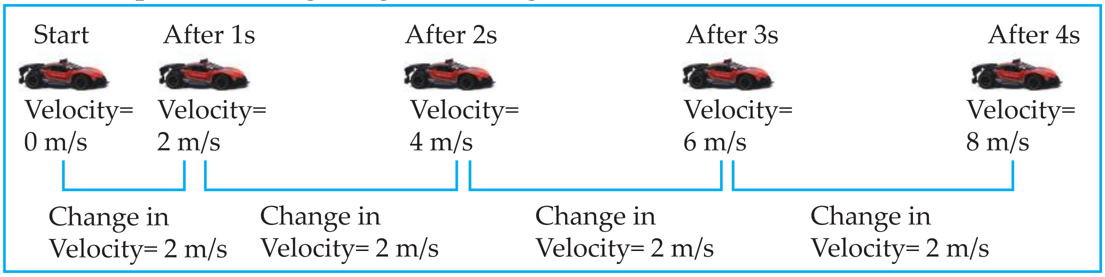
Objects in motion may not have uniform velocity. For example, a bus starts from rest and after a certain time interval, it attains a constant velocity. If a person comes on the road in front of the bus, then the driver applies brakes and the velocity gradually decreases. Finally, the velocity of the bus becomes zero when it stops. The rate of change of velocity of a body with respect to time is called its acceleration.

i.e., $\text{Acceleration (a)} = \frac{\text{Final velocity (v) -Initial velocity (u)}}{\text{time taken (t)}}$

or, $$a = \frac{v - u}{t}$$

The SI unit of acceleration is 'metre per second square' written as m/s^2.

For example, in the figure given alongside



$$\text{Acceleration} = \frac{\text{Final velocity - Initial velocity}}{\text{time taken}}$$

$$\text{or, } a = \frac{8\ m/s - 0}{4\ s} = \frac{8\ m/s}{4\ s} = 2\ m/s^2.$$

Meaning of Acceleration: An acceleration of $2 m/s^2$ means that the velocity increases by 2m/s every second.

Fact and Reason

Why does an object at uniform velocity has zero acceleration?

When a body is moving with a uniform velocity, the change in velocity (i.e., v – u) becomes zero. So, the acceleration of a body moving with a uniform velocity is zero.

SOLVED NUMERICAL- 7.1

A car moving with a speed of 36km/h speeds up to 72km/h in 5 s. Calculate its acceleration.

Solution

Here, initial speed (u) = 36km/h

$$= \frac{(36\times1000)m}{(60\times60)\ s} = 10\ m/s$$

Final speed (v) = 72 km/h

$$= \frac{(72\times1000)m}{(60\times60)\ s} = 20\ m/s$$

Time taken (t) = 5 s

Now, acceleration is given by $a = \frac{v - u}{t}$

$$\text{or, } a = \frac{20 - 10}{5} = \frac{10}{5}$$

$\therefore$ $a = 2m/s^2$

So, the acceleration of the car in 5 s is 2 m/s^2.

Memory note

Even though the earth moves at a very high velocity we cannot feel it because it is in almost uniform motion with negligible acceleration.

Positive acceleration

The increase in velocity of a body in motion with time causes positive acceleration. The rate of increase in velocity is called positive acceleration. For example, a body falling toward the earth has a positive acceleration.

Memory note

The acceleration of a freely falling object on the surface of the moon is 1.67m/s2 means that its velocity increases by 1.67m/s every second.

Negative acceleration (Retardation)

The decrease in velocity of a body in motion with time causes negative acceleration. The rate of decrease in velocity is called negative acceleration. Negative acceleration is also called retardation. For example, a ball thrown upward from the earth has a negative acceleration up to the maximum height.

Memory note

The acceleration of a ball thrown up from the surface of the earth is - 9.8m/s2 means that its velocity decreases by 9.8 m/s every second.

Graphical Representation of Linear Motion

The motion of a body can be described by using line graphs. In the line graphs, we can show the dependence of distance, velocity, etc. upon a time.

1. Displacement-time graph

Activity: 7.1

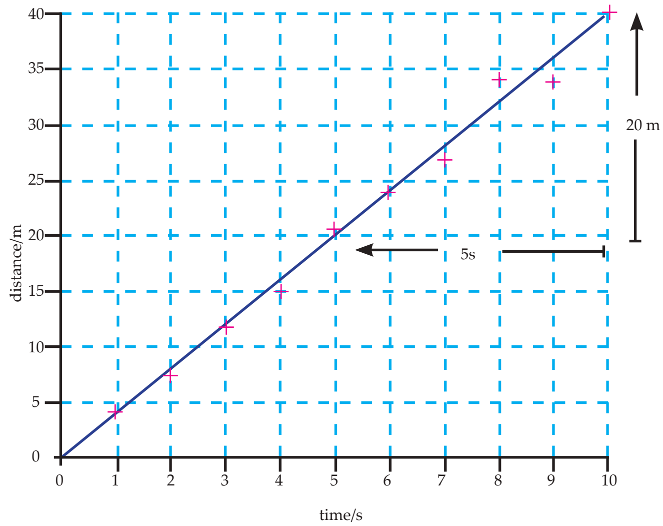
Draw a graph from the given data of displacement and time. Discuss the shape of the graph in the different segments and the corresponding nature of motion.

Time (x-axis) in 's'	1	2	3	4	5	6	7	8	9	10
Velocity (y-axis) in 'm/s'	2	4	6	8	8	8	12	20	12	8

The graphical relationship between the displacement of a body and the time taken is called the displacement-time graph. In the displacement-time graph, displacement is plotted along the y-axis, and the time taken is plotted along the x-axis.

Calculation of slope of displacement-time graph

The slope of the displacement time graph and the velocity are equal. Thus, the calculation of the slope of the displacement-time graph gives the velocity of the object in motion. For example, the calculation of the slope of a displacement-time graph is shown below:



$$Slope\ of\ line\ segment = \frac{rise}{run} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}$$

Where the symbol 'Δ' indicates the change in a quantity.

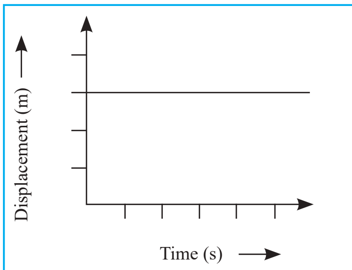
In the case of a displacement-time graph, if 's' denotes displacement

Velocity $= \frac{\Delta s}{\Delta t}$ (Since, the slope of line = velocity of an object)

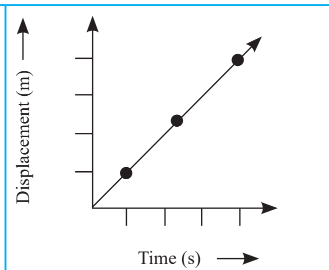
or, velocity $= \frac{s_2 - s_1}{t_2 - t_1} = \frac{40 - 20}{10 - 5} = \frac{20}{5}$

$\therefore\ velocity = 4m/s$

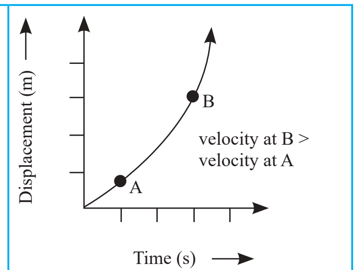
The displacement-time graph for a body depends upon the nature of the motion of the body. They are given below:



a. displacement-time graph of a body at rest



b. displacement-time graph of a body moving with uniform velocity



c. displacement time graph of a body moving with non-uniform velocity

i. **Body at rest:** If the displacement-time graph of a body is a straight line parallel to the time axis, then the body is at rest.

ii. **Body moving with uniform velocity:** If the displacement-time graph of a body is a straight line making an angle with the x-axis, then its speed is uniform. The straight line may or may not pass through the origin.

iii. **Body moving with non-uniform velocity:** If the displacement-time graph of a body is a curved line, then its velocity is non-uniform.

2. Velocity-time graph

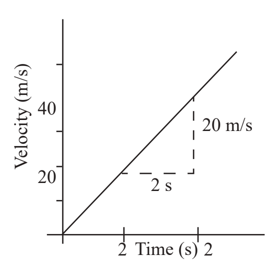
Activity: 7.2

Draw a graph from given data of velocity and time. Discuss the shape of the graph in the different segments and the corresponding nature of motion.

Time (x-axis) in ‘s’	1	2	3	4	5	6	7	8	9	10
velocity (y-axis) in ‘m/s’	2	2	2	4	6	8	10	12	16	22

The graphical relationship between the velocity of a body in motion and the time is called the velocity-time graph. In the velocity-time graph, the velocity of the body in motion is plotted along the y-axis, and the time taken is plotted along the x-axis.

Calculation of slope of the velocity-time graph



The slope of the velocity-time graph and the acceleration are equal. Thus, the calculation of the slope of the velocity-time graph gives an acceleration of the object in motion.

For example, the calculation of the slope of a velocity-time graph is shown below-

Slope of line segment = $\frac{rise}{run} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}$

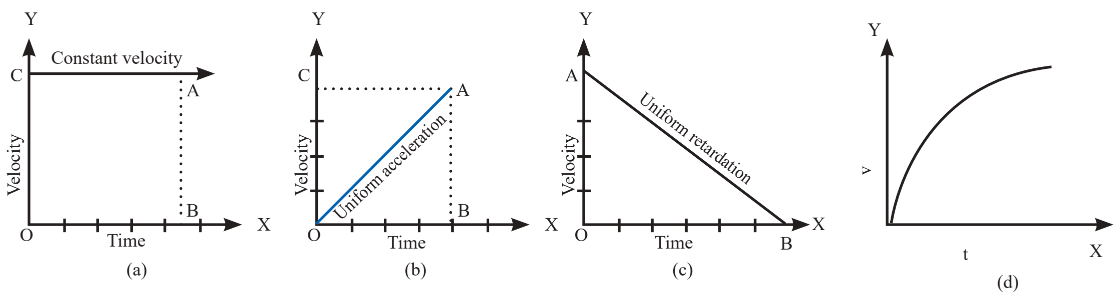
In the case of a velocity-time graph, if 'v' denotes displacement

acceleration = $\frac{\Delta v}{\Delta t}$ (Since, slope of line = acceleration of object)

or, acceleration = $\frac{v_2 - v_1}{t_2 - t_1} = \frac{40 - 20}{4 - 2} = \frac{20}{2}$

$\therefore$ *acceleration = 10m/s²*

The velocity-time graph for a body depends upon the nature of the motion of the body. They are given below:



i. **Uniform velocity:** If the velocity-time graph of a body is a straight line parallel to the time axis, then the body is moving with uniform velocity.

ii. **Uniform acceleration:** If the velocity-time graph of a body is a straight line sloping upward shows uniform acceleration.

iii. **Uniform retardation:** If the velocity-time graph of a body is a straight line sloping downward then it shows uniform retardation.

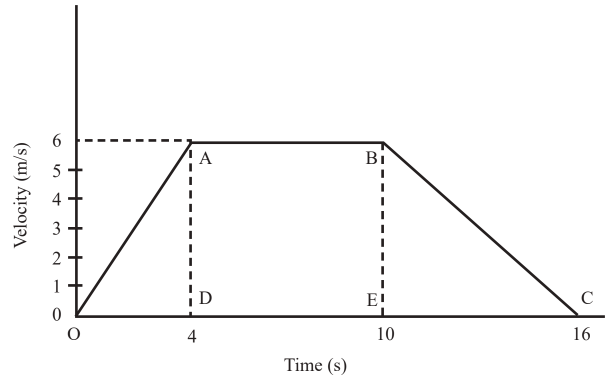
iv. **Non-uniform acceleration:** If the velocity-time graph of a body in motion is a curved line, then it has non-uniform acceleration.

SOLVED NUMERICAL- 7.2

Study the given velocity-time graph of a body and answer the following questions.

i. **Which type of motion is represented by the segments OA, AB, and BC.**

OA is a straight-line graph between velocity and time. It is sloping upward from O to A. Therefore, the graph OA represents uniform acceleration.



AB is a straight-line graph between velocity and time, which is parallel to the time axis. So, AB represents the uniform velocity. There is no acceleration from A to B.

BC is a straight-line graph sloping downward from B to C. Therefore, BC represents uniform retardation.

ii. Calculate the acceleration of the body

Acceleration of the body from O to A is given by the slope of the line.

i.e. Acceleration = slope of OA = $\frac{AD}{OD} = \frac{change\ in\ velocity}{time\ taken} = \frac{6}{4} = 1.5 m/s^2$

iii. Calculate the retardation of the body

Retardation of the body from B to C is given by

Retardation = slope of BC = $\frac{BE}{CE} = \frac{change\ in\ velocity}{time\ taken} = \frac{6}{16-10} = \frac{6}{6} = 1 m/s^2$

Retardation = $1 m/s^2$, i.e. acceleration = $-1 m/s^2$

Equations of Uniformly Accelerated Motion

When a uniformly accelerated body travels in a straight line, then the relationship between the initial velocity (u), final velocity (v), distance travelled (s), acceleration (a), and time taken (t) is called the equation of motion.

Derivation of v = u + at

(Relationship between initial velocity 'u', final velocity 'v', acceleration 'a' and time 't')

Suppose a body has initial velocity 'u', uniform acceleration 'a' for time 't' and final velocity becomes 'v'.

Now, from the definition of acceleration,

$$\text{Acceleration} = \frac{\textit{Final velocity (v) - Initial velocity (u)}}{t}$$

or, $a = \dfrac{v - u}{t}$

or, $at = v - u$

$\therefore$ $\boxed{v = u + at}$.......................(i)

It gives the velocity acquired by a body in time 't'.

Memory note

To solve the numerical problems based on motion, we should remember that:

i. If a body starts from rest, its initial velocity, u = 0

ii. If a body comes to rest, its final velocity, v = 0

iii. If a body moves with uniform velocity, its acceleration, a = 0.

SOLVED NUMERICAL- 7.3

The retardation of a car due to brakes is $2.5m/s^2$. On applying brakes, the car stopped in 10s. Calculate the initial velocity of the car.

Solution

Here, retardation = $2.5m/s^2$, i.e., acceleration (a) = $-2.5m/s^2$

Final velocity (v) = 0 [Since the car comes to rest]

Time taken (t) = 10s

Using the equation of motion

$v = u + at,$

$= u + (-2.5) \times 10$

or, $0 = u - 25$

$\therefore$ $u = 25m/s$

The initial velocity of the car is 25m/s.

Derivation of $s = ut + \frac{1}{2}at^2$

(Relationship between initial velocity 'u', acceleration 'a', distance travelled 's' and time 't')

Suppose a body has an initial velocity 'u' and uniform acceleration 'a' for time 't'. Let the distance travelled by the body in this time be 's'. For a body moving in a straight line under uniform acceleration, the distance travelled 's' in time 't' is given by,

Distance travelled = Average velocity × Time

or, $s = \frac{u + v}{2} \times t$ ....(ii)

Substituting the value of v from the first equation of motion,

$$s = \frac{(u + u + at)}{2} \times t$$

or, $s = \left(\frac{2u + at}{2}\right) \times t$

∴ $\boxed{s = ut + \frac{1}{2}at^2}$ .... (iii)

It gives the distance travelled by a body in time 't'

SOLVED NUMERICAL- 7.4

A body starts from rest. It undergoes an acceleration of 5m/s2. Calculate the distance travelled by the body in 5s.

Solution

Here, initial velocity (u) = 0 [Since the body starts from rest]

Acceleration (a) = $5 m/s^2$

Time taken (t) = 5s

Using the equation of motion

$$s = ut + \frac{1}{2}at^2,$$

or, $s = 0 \times 5 + \frac{1}{2} \times 5 \times 5^2$

∴ s = 62.5m

So, the distance travelled by the body in 5s is 62.5m.

Derivation of $v^2 + u^2 + 2as$

(Relationship between initial velocity 'u', final velocity 'v', acceleration 'a' and distance travelled 's')

Suppose a body has an initial velocity 'u', final velocity 'v', and uniform acceleration 'a' for time 't'. Let the distance travelled by the body in this time be 's'. For a body moving in a straight line under uniform acceleration, the distance travelled 's' in time 't' is given by,

or, $s = \frac{u + v}{2} \times t$ ....(i)

From the definition of acceleration, $a = \frac{v - u}{t}$ or $t = \frac{v - u}{a}$

Substituting the value of 't' in equation (i), we have

$$s = \left(\frac{u + v}{2}\right) \times \left(\frac{v - u}{a}\right)$$

or, $s = \frac{v^2 - u^2}{2a}$

$\therefore$ $\boxed{v^2 = u^2 + 2as}$ ....(iv)

It gives the velocity acquired by a body in travelling a distance 's'.

SOLVED NUMERICAL- 7.5

A bus was moving at a speed of 72km/h. On seeing a child 20m ahead on the road, the driver of the car applied brakes and the bus stopped at a distance of 15m. Calculate the retardation and how long it took for the bus to come to rest.

Solution

Here, Distance travelled (s) = 15m

Initial velocity (u) = $72\frac{km}{h} = \frac{72 \times 1000m}{60 \times 60s}$ = 20m/s

Final velocity (v) = 0

From the equation of motion,

$$v^2 = u^2 + 2as$$

or, $a = \frac{v^2 - u^2}{2s} = \frac{0 - 20^2}{2 \times 15} = \frac{-400}{30} = 13.33\ m/s^2$

The retardation of the bus is $13.33 m/s^2$

Again,

$$v = u + at$$

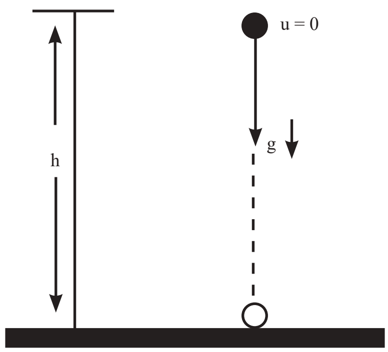
or, $t = \frac{v - u}{a} = \frac{0 - 20}{-13.33} = 1.5s$

The time taken to bring the bus to rest is 1.5s.

Equations of Motion of a Body Dropped from a Certain Height

When a body is freely falling, acceleration is equal to the acceleration due to gravity, i.e. a= g. In such a case, the equations of motion are modified as:

For linear motion	For vertical motion
$v = u + at$	$v = u + gt$
$s = ut + \frac{1}{2} \times at^2$	$s = ut + \frac{1}{2} \times gt^2$
$v^2 = u^2 + 2as$	$v^2 = u^2 + 2gh$
Note: For a body thrown vertically upward, acceleration a= -g.	$v = u - gt$ $s = ut - \frac{1}{2} gt^2$ $v^2 = u^2 - 2gh$



Inertia

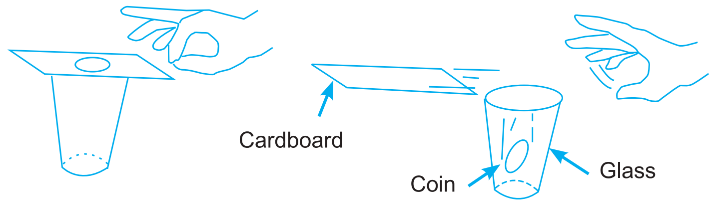
Inertia is the tendency of a body to remain at rest or to continue moving in a straight line. The tendency of a body to remain in its state of rest or of uniform motion along a straight line is called inertia. Based on the state of a body, the inertia is classified into the inertia of motion and the inertia of rest.

Inertia of rest

Activity

i. Take an empty and dry glass tumbler. Place a smooth postcard over the mouth of the glass. Also, place a coin at the centre of the card.

ii. Now, strike the card to flick it horizontally. Do you observe that the card flies away and the coin falls into the glass?



Interia of rest

In the above activity, the postcard comes in motion but the coin maintains its state of rest and falls into the glass tumbler. Thus, the property of a body by which it resists any change in its state of rest is called inertia of rest.

Examples of inertial of rest

i. **When a car or bus starts suddenly, the passengers fall backwards**.

When a car or bus is at rest the passengers inside it are also at rest. If the bus or car comes into motion suddenly, the body of passengers tends to stay at rest even after the vehicle has started moving. So, the passengers fall backwards.

ii. **Dust particles come out of the carpet when it is beaten with a stick.**

When a carpet is beaten with a stick, dust particles on it tend to remain at rest and resist the motion. So, due to the inertia of rest, the dust comes out of the carpet.

iii. **When a branch of a tree is shaken its fruits fall.**

Before shaking the branch of a tree, the fruits are at rest. When the tree is shaken the branches come into motion, but the fruits try to remain at rest due to the inertia of rest. This separates the fruits from branches and they fall.

Inertia of motion

A body in a state of motion tries to remain in its state of motion along the direction of applied force. The property of a body by which it resists any change in its state of uniform motion is called inertia of motion.

Fact and Reason

Your bicycle continues to move forward for some time even after you stop pedalling.

The bicycle continues to move forward for some time even after we stop pedalling it because the bicycle and our body have the inertia of motion. It can travel a little forward until gravity brings us to rest.

Examples of inertia of motion

i. **It is harder to stop a big vehicle, like a bus, than a smaller vehicle, like a motorcycle.**

The inertia of a body is directly proportional to its mass. There is more inertia with a bigger object. A big vehicle has more mass and more inertia of motion than that of a smaller vehicle. So, it is harder to stop a big vehicle.

ii. **When the power supply is switched off, the blades of a fan keep rotating for some time.**

A fan in motion has the inertia of motion. When the power supply is switched off, the inertia of motion tries to keep it in motion.

iii. **When a moving car or bus stops suddenly, the passengers are jerked forward.**

Due to inertia of motion, the body of passengers tries to remain in the state of motion even though the car or bus has come to rest. So, seat belts are provided in cars to prevent any injury that may happen when the passengers are thrown forward violently.

Fact and Reason

It is dangerous to jump out of a bus in motion.

When a bus is in motion, the body of passengers is also in motion. If a passenger jumps out of the bus, the feet come to rest but the upper part of the body tends to remain in motion due to inertia of motion. The person falls forward on the ground. So, it is dangerous to jump out of a bus in motion.

Differences between inertia of motion and inertia of rest

Inertia of motion	Inertia of rest
1. It is the property of a body to resist the change in its state of uniform motion.	1. It is the property of a body to resist the change in its state of rest.
2. Due to inertia of motion, the passengers inside a bus in motion are jerked forward when the bus stops suddenly.	2. Due to inertia of rest, the passengers inside a bus at rest are jerked backwards when the bus moves suddenly.

Fact and Reason

When a bus turns sharply at turnings on the road, the passengers fall aside, why?

Due to inertia of motion, a body continues in its state of uniform motion along a straight line. When a bus turns sharply, the body of passengers inside it tries to remain in motion along the straight line and they fall aside. When a car takes a sharp turn suddenly to the right, the person sitting in the car will be pushed towards the left. When a car takes a sharp turn suddenly to the left, the person sitting in the car will be pushed towards the right.

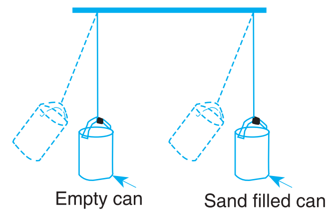
Relation between mass and inertia

Activity

Hang two identical buckets as shown in the given figure and fill one with sand.

Equally, pull and leave them such that they oscillate.

Observe which bucket comes to rest first. Does the empty bucket come to rest first?

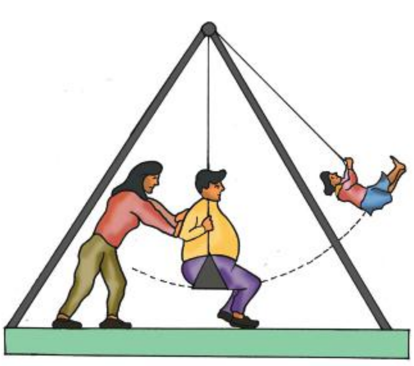


The bucket 'B'; filled with sand has more mass and has more inertia. So, it keeps oscillating for a longer time. But the empty bucket 'A' can have less mass and less inertia. So, it comes to rest first.

A heavier object shows greater resistance to change its state of rest or uniform motion than a lighter object. Mass is a measure of the inertia of a body. A heavier body has more inertia than a lighter body. The inertia of a body is directly proportional to its mass,

Inertia α mass of a body

i.e. An object with a small mass has less inertia and the object with a greater mass has more inertia.



The greater the inertia of a body, the greater will be the force required to bring a change in its state of rest or uniform motion. For example, you push a man and a small child on a swing one after another. It is more difficult to get the adult moving. Once you set them in motion, you would experience difficulty bringing the man into rest. The man has greater inertia and greater resistance to change in his state.

Fact and Reason

The heavier the body, the greater is the force required to change its state.
Mass is the measure of the inertia of a body. A heavier object at rest has more inertia of rest. So, the heavier the body, the greater is the force required to change its state.

Newton's laws of motion

Sir Isaac Newton was an English physicist and mathematician. He put forward three laws of motion in 1686 which are known as Newton's laws of motion. Newton's first law of motion gives a precise definition of force and inertia. The second law of motion describes the relation of acceleration of a body with the force applied and mass of the body. Newton's third law of motion establishes the relationship between 'action' and 'reaction' forces.

Newton's First Law of Motion

Galileo was the first to establish that no force is required to keep a body moving uniformly along a straight line. Unbalanced force is required for changing the state or direction of motion of the body. The equal force acting in the opposite direction, which does not change the state of rest or uniform motion of an object, is known as balanced forces. A body under the action of balanced forces does not change its position of rest or uniform motion. The unequal and opposite forces acting on a body, which change its state of rest or uniform motion are called unbalanced forces. Unbalanced forces acting on a body can change its state of rest or uniform motion.

Statement: Every body continues to be in its state of rest or of uniform motion along a straight line unless it is acted upon by an external force.

Newton's first law of motion consists of three parts.

i. **The first part-** A body at rest remains at rest unless some external force acts on it to change its state of rest. For example, a football on the ground remains in a state of rest unless a player kicks it.

ii. **The second part-** A body in uniform motion continues to move uniformly in a straight line unless some external force acts on it to change its state of motion. For example, to stop a moving car, brakes must be applied.

iii. **The third part-** A body continues to move along the same straight line unless some external force acts on it. For example, to turn a car moving over a straight road, we have to apply a force on the steering wheel of the car.

Fact and Reason

Newton's first law of motion is also called the law of inertia.

Newton's first law of motion states that every body resists the change in its state of rest or that of uniform motion. Such property of a body is known as inertia. Therefore, Newton's first law of motion is also called the law of inertia.

Application of Newton's first law of motion

a. Drivers use the seat belt to prevent forward fall while using emergency break.

b. A person jumping out from a moving bus falls forward and gets injured.

c. A rotating fan continues rotating for a while although the switch is turned off.

d. A book on the table remains in rest until and unless we displace or remove it.

e. When a bullet is fired on a glass pane window, it makes a clean hole without causing cracks in the glass.

Newton's Second Law of Motion

Activity

To observe acceleration and force relation	To observe acceleration and mass relation
Take a football on the ground. Kick it with once with little force. The next time kick it with a greater force. Observe the acceleration in each of the two cases. Do you observe more acceleration when the ball is kicked with a greater force?	Hold a tennis ball and a cricket ball. One after another, throw them on the ground with equal force. Observe the acceleration of each of the two balls. Do you observe more acceleration of tennis balls?

We need more force to move an object faster. It means that the acceleration produced on a body is directly proportional to the force applied to it. A lighter object can be thrown faster but it is difficult to throw a heavier object as fast. A lighter object can be pushed faster than a heavier one. It means that the acceleration produced on a body is inversely proportional to its mass.

Memory note

The second law of motion is the measurement of force.

Acceleration produced on a body is directly proportional to the force applied to it	Acceleration produced on a body is inversely proportional to its mass
We apply more force from our muscles to speed up our motion.	Our speed of running starts to decrease when we are given loads to carry with us.
Vehicles are provided with an accelerator to apply more force by the engine to increase the speed.	Cars can speed up faster on a road sloping upward than heavily loaded trucks.
We need to apply more force to carry a loaded cart.	We need to apply more force to make an adult swing faster than that in the case of a baby in a swing.

Statement: According to Newton's second law of motion, 'the acceleration produced on a body is directly proportional to the applied force and inversely proportional to the mass of the body (m).

Mathematically,

acceleration α *(a) force (F)* ..... *(i)* {When mass (m) remains constant}

acceleration (a) $\alpha \dfrac{1}{mass\ (m)}$ ..... *(ii)* {When the force applied (F) remains constant}

Combining relation (i) and relation (ii), we get

$$a \ \alpha \ \frac{F}{m}$$

or, $F \ \alpha \ ma$

or, $F = k\,ma$ .... *(iii)* Where 'k' is a proportionality constant.

When, m = 1kg, a = $1m/s^2$ then F= 1N

In such a condition, k= 1

Substituting the value of 'k' in equation (iii), we get

$$\boxed{F = ma}$$

Memory note

One newton is the amount of net force that gives an acceleration of $1m/s^2$ to a body with a mass of 1 kilogram.

SOLVED NUMERICAL- 7.6

A car of mass 1000kg (along with passengers) is moving with a velocity of 72km/h and it takes 2.5s to stop it after the brakes are applied. Calculate the force exerted by the brakes on the car.

Solution

Here, initial velocity of the car (u) = 72km/h

$$u = \frac{72 \times 1000}{60 \times 60}\ m/s = 20m/s$$

Final velocity of the car (v) = 0 [since the car comes to rest]

Mass of the car (m) = 1000kg

Time taken to stop the car (t) = 2.5s

According to Newton's second law of motion, force on the car is given by

$$F = m\,a$$

or, $$= \frac{m\,(v-u)}{t}$$

or, $$= \frac{1000\,(0-20)}{2.5} = \frac{-20000}{2.5}$$

$\therefore$ F = – 8000N

The negative sign indicates that the force exerted by the brakes is opposite to the initial direction of acceleration of the car.

SOLVED NUMERICAL- 7.7

A force of 500N acts on a body of mass 1000kg and the body is brought to rest within a distance of 64m. Find the initial velocity and the time taken by the body to come to rest.

Solution

Here, Force (F) = 500N

Mass of the body (m) = 1000kg

Displacement (s) = 64m

According to Newton's second law of motion, if F is the force applied on a body of mass 'm' to accelerate it with 'a'.

$$F = ma$$

$$a = \frac{F}{m} = \frac{500}{1000} = 0.5 m/s^2$$

Since the body comes to rest by applying force on it. i.e. the body is retarding.

So, final velocity (v) = 0

Acceleration (a) = – $0.5 m/s^2$

From the equation of motion,

$v^2 = u^2 + 2as$

or, $0 = u^2 + 2 \times -0.5 \times 64$

or, $u^2 = 64$

or, $u = \sqrt{64} = 8 m/s$

To calculate the time taken, use the equation of motion

$v = u + at$

or, $0 = 8 - 0.5 \times t$

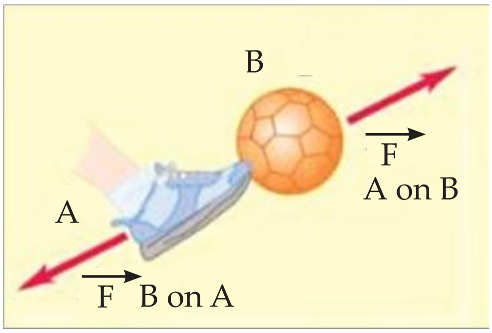
or $0.5 \times t = 8$

$\therefore t = 16s$

$\therefore$ initial velocity (u) = 8m/s, time taken (t)=16s and acceleration (a) = $-0.5 m/s^2$

Newton's Third Law of Motion

Statement: For every action, there is an equal and opposite reaction.



When we kick a football, our foot exerts a forward force on the ball, but we also feel the force the ball exerts back on our foot. Whenever two bodies interact, the forces that they exert on each other are always equal in magnitude and opposite in direction. If a body A exerts a force $\vec{F}$ on a body B (an 'action'), then B exerts a force $-\vec{F}$ on A (a 'reaction'). Mathematically, $\vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A}$

Action and reaction act on two different surfaces. Thus, they do not cancel each other.

Fact and Reason

Action and reaction do not cancel each other even if they have equal magnitudes and opposite directions:

When two equal and opposite forces act on the same body then the resultant force is zero. But action and reaction act on two different surfaces. Thus, they do not cancel each other.

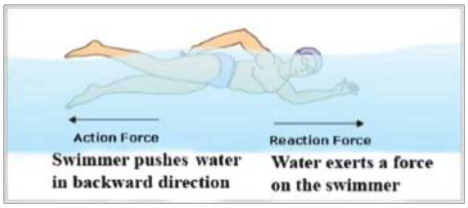
Some examples of newton's third law of motion

1. **We need to press on the ground while walking.**

   To start moving forward, we push backwards on the ground with our feet (action). As a reaction, the ground pushes forward on our foot with a force of the same magnitude. This force accelerates our body forward.

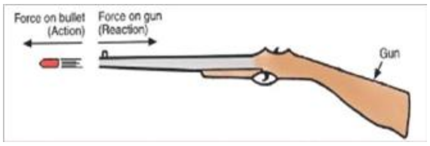
2. **Swimmers push water backward with their hands.**

   While swimming, swimmers push water in a backward direction with their hands (action). Water also pushes the swimmer with equal force in the forward direction (reaction).



3. **A gun recoils while firing a bullet.**

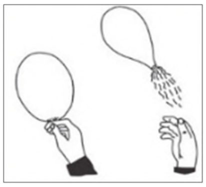
   When a bullet is fired from a gun, the forward force on the bullet (action) is equal to the force backward on the gun (reaction). Due to this backward force gun recoils.



Fact and Reason

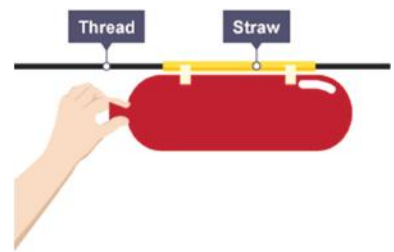
An air-filled balloon goes upward on releasing its mouth, why?

When the mouth of an air-filled balloon, which is in an upside-down position, is released, the air inside rushes out downward (action). According to newton's third law of motion, the air exerts an equal and opposite force on the balloon (reaction). The balloon goes upward (reaction).



Activity

1. **Make a balloon rocket:** Take a longer 'airship' balloon, string, plastic straw, and tape. Insert the string inside a straw pipe and tie both the ends of the string to the rigid supports. Blow up the balloon and pinch its mouth. Tell your friend to tape the balloon to the straw. Finally, let the air come out of the balloon and observe the rocket fly. Discuss the principle behind the balloon rocket. Does the air pressure inside the balloon affect its flight? Discuss your finding in the classroom.



Elasticity and Plasticity

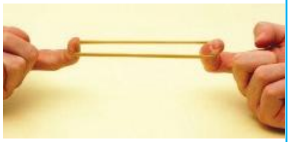
Activity

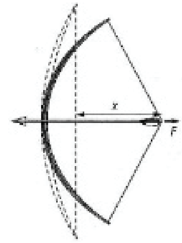
Prepare clay for clay art. Also collect some other substances like toothpaste, eraser, scale, spring, etc. Then do the activities like pressing, twisting, stretching, etc. with each of them. Which substance obtains its original shape after removing force and which doesn't? Categorise them into two groups. Discuss the results of your activity.

Different types of external forces act on several bodies in our surroundings. Such external forces may produce a change in length, volume, and shape of the body. The external force which produces a change in length, volume, and shape of a body is called a deforming force. When a deforming force is applied to a body, which is not free to move, the shape or size of the body changes. A body that experiences a deforming force is called a deformed body.

A relative displacement of particles takes place when an external force is applied to a body, which is not free to move. If the particles are displaced with a certain limit, they regain their original position after removing the deforming force. When the deforming force is removed, the body regains its original state due to the force developed with the body. Such a force developed within a body that restores the body into its original state is called restoring force. The property of a material to regain its original state when the deforming force is removed is called elasticity. The body which possesses the property of elasticity is called an elastic body.

Some Examples of Elasticity






A body that completely regains its original shape and size after the removal of the deforming force is said to be perfectly elastic. There are no perfectly elastic bodies. Quartz fibre and Phosphor bronze are nearly perfectly elastic bodies.

All matters don't tend to regain their shape after removing force deforming them. For example, wet clay does not show any tendency to regain its original configuration after deformation. Bodies that do not exhibit the property of elasticity are called plastic. Perfectly wet clay is highly plastic. Bodies that do not exhibit the property to return to their own shape and size after removing a deforming force is called perfectly plastic. Putty, semi-solid coal tar, wax, etc. are examples of nearly plastic bodies. Such bodies retain their deformed shape and size. The property of a body by which it tends to retain the altered shape and size on the removal of deforming force is called plasticity.

Memory note

The bodies which partially regain their original form after removing a deforming force are called partially elastic. Actual bodies have elasticity in between the limits of perfect elasticity and perfect plasticity.

Fact and Reason

Why are steel rods preferred for strong construction works?

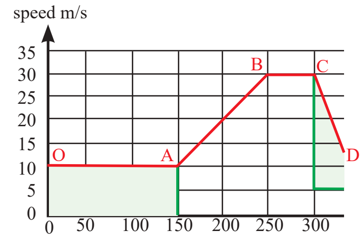
Steel is highly elastic. It has a high capacity to resist the deforming force. So, steel rods are used in the construction of strong buildings, bridges, etc.

Answer writing skill

1. **Define inertia.**

   Inertia of a body is its property due to which it resists any change in its state of rest or motion.

2. **Study the given graph and identify the segment with uniform velocity, uniform acceleration, and retardation.**



The segment with uniform velocity	The segment with uniform acceleration	Segment with retardation
OA, BC	AB	CD

3. **Newton's first law of motion is also called the law of inertia. Give reason.**

Newton's first law states that if a body is at rest or is moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless it is acted upon by an unbalanced force. It is called the law of inertia because it tells that every material body has a property by which it resists the change in its state of rest or its state of motion. This property is called inertia.

4. **Differentiate between elasticity and plasticity.**

The differences between elasticity and plasticity are:

S.N	Elasticity	S.N	Plasticity
1.	Substances with elasticity regain their shape or size after removing deforming force.	1.	Substances with plasticity retain their shape or size after removing deforming force.
2.	There is an internal restoring force set up inside the elastic body.	2.	There is no internal restoring force set up inside the plastic body.

5. **A ball of mass 1kg is thrown with a force of 10N. Calculate the acceleration and the final velocity of the ball after 2 seconds.**

Solution:

Mass of the ball (m) = 1kg

Force applied (F) = 10N

Initial velocity (u) = 0m/s

Time (t) = 2 seconds

Acceleration (a) =?

Final velocity (v) =?

Using formula,

$$F = ma$$

$$or,\ a = \frac{F}{m} = \frac{10}{1}$$

$$a = 10 m/s^2$$

Again,

$$v = u + at$$
$$= 0 + 10 \times 2$$
$$= 20 m/s$$

6. Mention the role of elasticity in engineering designs.

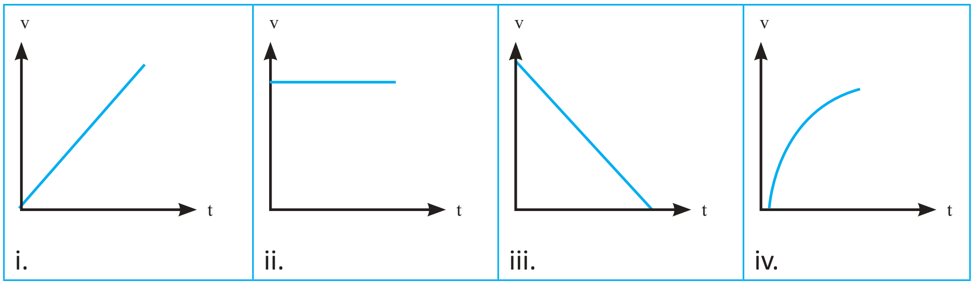
The elastic behaviour of materials plays an especially important role in engineering design. For example, while designing a building, bridge, automobiles, etc. the knowledge of elastic properties of materials like steel, concrete, etc. is very essential.

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. Which of the following graphs is representing uniform acceleration?



b. When a car is moving in a circular track and covering equal distances in an equal interval of time, what kind of velocity is present in it?

i. uniform velocity
ii. variable velocity
iii. variable speed
iv. constant velocity

c. Why does a passenger fall backwards, when a car or bus starts to move suddenly?

i. inertia of motion   ii. inertia of rest
iii. state of motion   iv. state of rest

d. Which law of motion is applicable while launching a rocket?
   i. Newton's first law of motion
   ii. Newton's second law of motion
   iii. Newton's third law of motion
   iv. Newton's law of inertia

e. Which of the given substances shows the property of plasticity?
   i. silk   ii. quartz
   iii. copper   iv. rubber

2. Define the following with required examples.

a. Force   b. Inertia   c. One newton force
d. Elasticity   e. Plasticity   f. Balanced force
g. Unbalanced force

3. Short Answer Questions

a. Write the relationship between the SI unit and the CGS unit of force.
b. Give two examples of non-uniform velocity.
c. Give an application of Newton's first law of motion.
d. Give an example of Newton's third law of motion.
e. What is an equation of motion?
f. What type of motion a particle has if its velocity-time graph is as mentioned below?
   i) Graph is parallel to the time axis
   ii) Graph is a straight line passing through the origin and having a constant slope.
g. On what factors does the inertia of a body depend?
h. Name the type of inertia in each of the following cases.
   i) A passenger jumping out of a moving bus falls forward.
   ii) On taking a sharp turn the driver feels a sideway jerk.
   iii) Dust particles are removed when a carpet is beaten with a stick.

iv) When a bus is stopped suddenly, a passenger experiences a forward jerk.

i. Identify the action-reaction forces in the following cases

   i) A boy walking on the ground

   ii) Firing a bullet from the gun

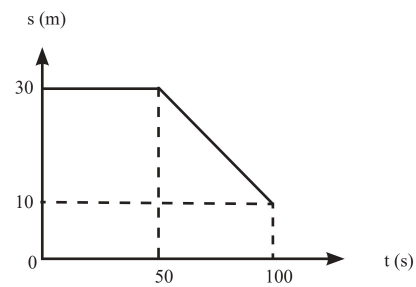
   iii) A book lying on a table

   iv) A boy swimming in a swimming pool

   v) Launching of a rocket from the earth surface

j. Give one example each of elastic and plastic substances.

k. Study the given displacement time graph. What is the velocity of the object in the last 50 seconds?



Step 2

4. Give reason.

a. A passenger falls backwards when the bus suddenly starts moving.
b. Passengers experience a forward push when a running bus stops suddenly.
c. It is dangerous to jump out of a fast-moving train.
d. A tree is shaken to get its fruits down.
e. Dust comes out of a carpet when we hit it with a stick.
f. Swimmers push water backwards while swimming.
g. A gun recoils on firing. Would the user suffer greater or smaller jerks if the gun is heavy?
h. A rubber ball rebounds when it hits a wall.
i. We should not stretch a spring extensively.
j. Steel rods are preferred in construction works.

5. **Differentiate between the following.**

a. Speed and velocity

b. Acceleration and retardation

c. The inertia of rest and inertia of motion

d. Elasticity and Plasticity

Step 3

6. **Answer the following questions.**

a. A body is moving with a uniform acceleration of $2m/s^2$. What does it mean?

b. Under what conditions does a body travel a certain distance but the net displacement be zero. Explain with an example.

c. A satellite goes around the earth with constant speed in a circular orbit. Does it have acceleration? Explain.

d. A student kept a school bag in the floor of bus. When s/he was getting off the bus the bag was not their but few foots away. What might be the reasons?

e. How is inertia related to mass?

f. Two similar vehicles are moving with the same velocity on the roads such that one of them is loaded and the other one is empty. Which of the two vehicles will require larger force to stop it? Give reason.

g. How are newton's laws of motion applicable in our daily life? Give two examples related to the first law of motion, the second law of motion, and the third law of motion.

h. 'Newton's first law of motion is also called the law of inertia.' Explain this statement.

i. Give an example of an application each of elasticity and plasticity in our daily life.

7. **Numerical**

a. When the brake is applied in a vehicle travelling with a velocity of 25m/s the retardation becomes $0.5m/s^2$, how far will it travel in 15 seconds? [Ans: 318.75m]

b. A bus is moving with a velocity of 72km/hr. On seeing the red signal of traffic 27m ahead on the road, the driver applies brakes and the bus stops at a distance of 25m. Calculate the time taken by the car to come to rest? [Ans: 2.5s]

c. A bus is running with a velocity of 60km/hr. On seeing a child 11m ahead on the road, the driver of the bus applies brakes and the bus stops at a distance of 10 metres. Calculate its retardation.

[Ans: $-13.89m/s^2$]

d. A vehicle that starts to move from rest gets an acceleration of $5m/s^2$ within 2 seconds. Calculate the velocity and distance covered by the vehicle within the given time. [Ans: 10m/s, 10m]

e. A force of 10N acts on a body of mass 2kg. If the body was initially at rest, calculate the velocity acquired by it in 5s. [Ans: 25m/s]

f. The mass of a car along with its rider is 1000kg. It is moving with a velocity of 72km/h and takes 5s to stop after the brakes are applied. Calculate the retardation and retarding force exerted by the brakes on the car. [Ans: $-4m/s^2$, 4000N]

g. A bullet of mass 10g is fired from a gun. The bullet takes 0.003s to move through its barrel and leaves it with a velocity of 300m/s. Find the force exerted on the bullet by the gun? [Ans: 1000N]

h. Find the force required to produce an acceleration of $2m/s^2$ on a body of mass 10kg. What would be its acceleration if the force was doubled? [Ans: 20N, $4m/s^2$]

i. A stone dropped from the top of a building reaches the ground with a velocity of $49ms^{-1}$. If the acceleration due to gravity is $9.8ms^{-2}$, calculate the time for which the stone is falling freely. [Ans: 5s]

j. A ball is thrown vertically upward at the velocity of 20m/s. Calculate

i. how high it goes?

ii. the time taken to reach the maximum height.

(Taking acceleration due to gravity g= $9.8m/s^2$) [Ans: a. 20.4m, b. 2.04s]

Step 4

8. Long question answers.

a. Derive the following equations of motion

i. $v = u + at$

ii. $s = ut + \frac{1}{2}at^2$

iii. $v^2 = u^2 + 2as$

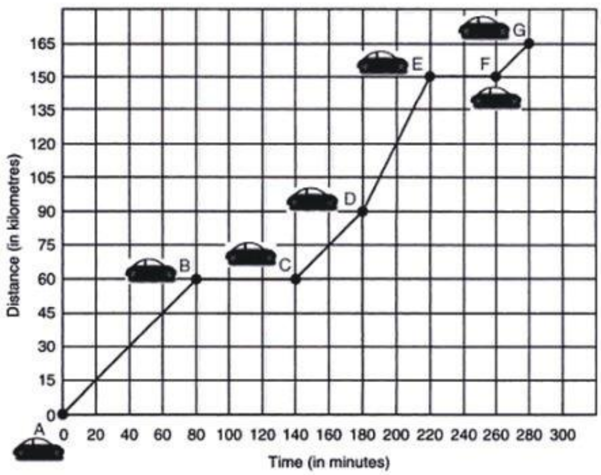
b. State Newton's second law of motion and prove F= ma.

c. Discuss the role of inertia of motion and inertia of rest in our daily life.

d. Explain the role of Newton's laws of motion in launching a rocket.

e. Explain a role each of elasticity and plasticity in our daily life.

f. Look at the distance-time graph of a car and answer the questions



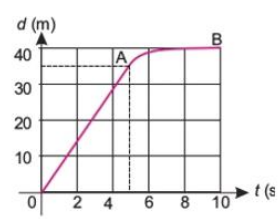
i. Which parts of the graph represent the position of the car when it was at rest?

ii. Which part of the graph represents the fastest speed?

iii. Find the speed of the car between the regions AB and FG.

g. Study the given velocity-time graph depicting the motion of a bus. Find

- Distance travelled by bus.
- The velocity of the bus in the first seconds.
- The average velocity of the bus.



Ans: 40m, 7m/s, 4m/s

UNIT

8

SIMPLE MACHINE

ESTIMATED TEACHING PERIODS

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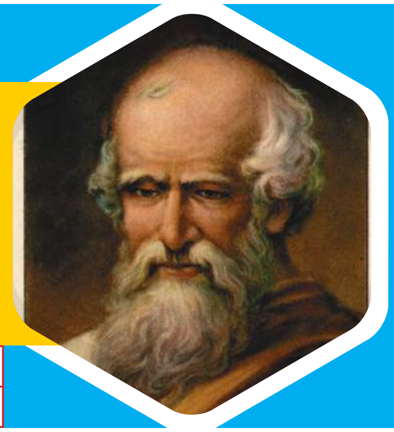


Archimedes
(287BC-212BC)

Curriculum issued by CDC

- Introduction to simple machine
- Incline plane (wedge and screw), pulley, wheel and axle (Introduction, MA, VR and efficiency)
- Relation between effort and effort distance
- Introduction to complex machine

Learning outcomes

After completion of this unit, students will be able to:

- explain MA, VR and efficiency of incline plane, pulley, wheel and axle.
- solve numerical problems related to MA, VR and efficiency of inclined plane, pulley and wheel and axle.
- introduce complex machine.

Terms and terminologies

1. Simple machine: The device which makes our work easier, faster, and more convenient is called a simple machine.
2. Compound machine: A complex structured machine with two or more simple machines working together is called a compound machine.
3. Load: Load is the resistance to be overcome or the weight being lifted by a simple machine.
4. Load distance: The distance moved by the load in a simple machine is called load distance.
5. Effort: Effort is the force applied directly to a simple machine to move the load or to do work.

6. Effort distance:	The distance moved by effort applied in a simple machine is called effort distance.
7. Mechanical advantage (M.A.):	The ratio of the load lifted to the effort applied in a simple machine is called mechanical advantage.
8. Velocity Ratio (V.R.):	The ratio of the distance moved by the effort to the distance moved by the load in a simple machine is called velocity ratio.
9. Input work:	Work done on a simple machine by a given effort is called input work.
10. Output work:	Work done by a simple machine on the load is called output work.
11. Efficiency:	The ratio of output work to input work in a simple machine expressed as a percentage is called efficiency.
12. Practical machine:	The machine which is useful in our daily life is called a real or practical machine.
13. Perfect simple machine:	A hypothetical frictionless machine in which total input work is converted into output work without wastage of energy is called an ideal or a perfect simple machine.
14. Pulley:	The metallic or wooden circular disc having a groove along its rim and capable of rotating about an axis passing through its centre is called a pulley.
15. Single fixed pulley:	A pulley that doesn't move up and down with load is called a single fixed pulley.
16. Single movable pulley:	A pulley that moves up and down with load is called a single movable pulley.
17. Block and tackle:	The arrangement of pair of blocks consisting of one or more pulleys is called a block and tackle system.
18. Wheel and axle:	A system of two co-axial cylinders of different diameters which rotate together is called wheel and axle.
19. Inclined plane:	The sloped flat supporting surface with one end higher than the other, used for raising or lowering a load is called an inclined plane.
20. Wedge:	A wedge is a simple machine that consists of two inclined planes, giving it a thin end and a thick end.
21. Screw:	A screw is a simple machine with an inclined plane wrapped around a cylinder.
22. Pitch:	The distance between adjacent threads is called pitch.

Introduction

A variety of tools are used in daily life to do our work. For example, sharp objects are used for cutting things, the pulley is used to lift loads, wheel and axle multiply effort or speed up our work, the slanted surface is used to multiply effort, etc. Such devices give us an advantage by changing the amount, speed, or direction of forces. The device which makes our work easier, faster, and more convenient is called a simple machine. For example, scissors, knife, nutcracker, bottle opener, spoon, pulley, screw, etc. These machines use muscular energy to work.

Some simple machines

Activity

Make a list of different types of simple machines used in our daily life. Classify them and fill in a table as shown below:

Name	Type of the simple machine	Use

Make a list of compound machines. Identify the simple machines used in that machine and fill in a table as shown below:

Compound machine	Simple machines in use	Use

Terms Related to Simple Machines

Load and Load Distance

Load is the resistance to be overcome or the weight being lifted by a simple machine. SI unit of the load is newton (N). It is represented by 'L'. The distance moved by the load in a simple machine is called load distance or load arm. Its SI unit is meter (m). It is represented by 'Ld'.

Effort and Effort Distance

The effort is the force applied directly to a simple machine to move the load or to do work. SI unit of effort is newton (N). It is represented by 'E'. The distance moved by effort applied in a simple machine is called effort distance or effort arm. Its SI unit is meter (m). It is represented by 'Ed'.

Mechanical Advantage (M.A)

Mechanical advantage is a measure of the force amplification achieved by using a simple machine. The ratio of the load lifted to the effort applied in a simple machine is called mechanical advantage, i.e.

$$\boxed{MA = \frac{\text{Load (L)}}{\text{Effort (E)}}}$$

Memory Tips

A simple machine that multiplies force has a mechanical advantage greater than 1, (MA>1).

MA doesn't have units as it is a simple ratio of two forces.

If the load lifted by the crowbar is 3 times greater than the effort applied, the mechanical advantage of a crowbar will be 3. It means that the crowbar multiplies the effort applied by 3 times.

Fact and Reason

Friction should be reduced to increase the mechanical advantage of a machine, why?

Weight and friction are the two factors that affect mechanical advantage. In a simple machine, the friction causes wastage of energy and reduces its MA. So, friction should be reduced to increase the mechanical advantage of a machine.

Velocity Ratio (VR)

Velocity ratio is the ratio of the velocity at which effort is applied on a machine to the velocity at which load moves. Velocity ratio is a measure that shows how many times the effort distance is longer than the load distance. Simply, the ratio of the distance moved by the effort to the distance moved by the load in a simple machine is called velocity ratio, i.e.

$$\boxed{VR = \frac{\text{distance moved by effort (Ed)}}{\text{distance moved by load (Ld)}}}$$

VR doesn't have units as it is a simple ratio of two distances.

If the distance moved by effort is 4 times longer than the distance moved by load, velocity ratio of the simple machine will be 4. It means that the effort applied moves 4 times longer distance than the distance moved by load.

Memory Tips

Work done on a simple machine by a given effort is called input work.
Input work=Effort (E)×Effort distance (Ed)
Work done by a simple machine on the load iscalled output work.
Output work=Load (L)×Load distance (Ld)

Memory Tips

Friction doesn't affect effort distance and load distances. So, the velocity ratio is independent of friction.

Efficiency (η)

The ratio of output work to input work in a simple machine expressed as a percentage is called efficiency. i.e.

$$\boxed{\text{Efficiency } (\eta) = \frac{\text{Output work}}{\text{Input work}} \times 100\%}$$

Efficiency doesn't have a unit as it is a simple ratio of two works. If out of total effort applied in the crowbar, 75% is utilised to lift the load and 25% is wasted to overcome friction, then efficiency of a simple machine will be 75%.

Fact and Reason

Friction should be reduced to increase the efficiency of a machine, why?

Frictional force converts the applied energy in the simple machine into other forms of energy like heat. The efficiency of a machine decreases as the frictional force increases. Friction should be reduced to increase the efficiency of a machine.

Relation Between MA, VR and Efficiency

The efficiency of a simple machine is given by,

$$\text{Efficiency} = \frac{\text{Output work}}{\text{Input work}} \times 100\%$$

or, $$\text{Efficiency} = \frac{\text{Load} \times \text{Load distance}}{\text{Effort} \times \text{Effort distance}} \times 100\%$$

or, $$\text{Efficiency} = \frac{\dfrac{\text{Load}}{\text{Effort}}}{\dfrac{\text{Effort distance}}{\text{Load distance}}} \times 100\%$$

∴ $$\boxed{\text{Efficiency} = \frac{\text{MA}}{\text{VR}} \times 100\%.}$$

Real or Practical Machine

The machine which is useful in our daily life is called a real or practical machine.

A real simple machine is never 100 % efficient because of the following reasons:

i. Friction affects the efficiency of a simple machine.

ii. No machine is weightless and weight affects its efficiency.

Ideal or Perfect Simple Machine

In the case of an ideal simple machine, Input work = Output work, So, an ideal simple machine has 100% efficiency. A hypothetical frictionless machine in which total input work is converted into output work without wastage of energy is called an ideal or a perfect simple machine.

Fact and Reason

An ideal simple machine is a hypothetical concept.

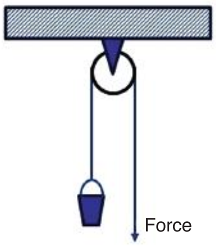
No machine can be weightless and frictionless, and total input work cannot be converted into output work without some wastage of energy. So an ideal simple machine is only a hypothetical concept.

Types of Simple Machines

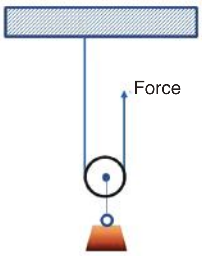
1. Lever
2. Pulley
3. Wheel and axle
4. Inclined plane
5. Wedge
6. Screw

Pulley

Pulley consists of a grooved disc with a rod passing through its centre to facilitate free rotation of the disc. A thread or cable over the groove is used to rotate the disc. The metallic or wooden circular disc having a groove along its rim and capable of rotating about an axis passing through its centre is called a pulley. Pulleys are an age-old simple machine and still of wide use in daily life. A common traditional use of pulleys is to lift buckets of water from the well. Nowadays several electrical devices, vehicles, cranes, etc. are installed with pulleys.



Single fixed pulley



Single movable pulley

Block and tackle system

Types of Pulleys

1. Single Fixed Pulley

A pulley that doesn't move up and down with load is called a single fixed pulley. It doesn't multiply the effort applied but it is widely used because it changes the direction of effort applied to make our work easier.

Fact and Reason

The velocity ratio of a single fixed pulley is always one.

In the case of a single fixed pulley, the distance moved downward by the effort is equal to the distance moved upward by the load (i.e. Ed= Ld). So,

Mathematically,

$$VR = \frac{\text{distance moved by effort (Ed)}}{\text{distance moved by load (Ld)}} = \frac{LD}{LD} = 1$$

2. Single movable pulley

A pulley that moves up and down with load is called a single movable pulley. A single movable pulley is used to multiply force in modern elevators, weight lifting machines, etc.

Fact and Reason

The velocity ratio of a single movable pulley is always two.

In the case of a single movable pulley, the distance moved by the effort is twice the distance moved by the load (i.e. Ed= 2Ld). So, the velocity ratio of a single movable pulley is always two.

Mathematically,

$$VR = \frac{\text{distance moved by effort (Ed)}}{\text{distance moved by load (Ld)}} = \frac{2LD}{LD} = 2$$

Memory note

The velocity ratio of single movable pulley = number of rope segments to support the load = two

Differences between a single fixed pulley and a single movable pulley

Single fixed pulley	Single movable pulley
1. It doesn't move up and down with a load.	1. It moves up and down with a load.
2. It changes the direction of effort applied.	2. It multiplies the effort applied.
3. Its velocity ratio (VR) is one.	3. Its velocity ratio (VR) is two.
4. It works like a first class lever.	4. It works like a second class lever.

Activity

Measure the weight of a 1kg mass (i.e. Load) by a spring balance. Use the spring balance at one end of the rope to lift the load with the help of a single fixed pulley, single movable pulley, and block and tackle system as shown in the given figures. Fill the data in the given table after your measurements and calculate the corresponding efficiencies of different types of pulleys. Analyse the data and write the conclusion that you draw from your results in different cases.

S.N.	Type of pulley	VR	Load(L)	Effort(E)	MA	Efficiency (η)
1.	Single Fixed Pulley					
2.	Single Movable Pulley					
3.	Block and Tackle System					

SOLVED NUMERICAL- 8.1

How much is the distance moved by the effort to lift the load by 2m in the pulley shown in the given figure? Calculate the efficiency of the pulley.

Solution,

Here,

Load (L) = 300N

Effort (E) = 200N

Load distance (Ld.) = 2m

In the case of a single movable pulley,

Distance moved by effort (Ed) = 2 × Ld

∴ Distance moved by effort (Ed) = 2 × 2 = 4m

According to the formula,

$$\text{Efficiency } (\eta) = \frac{\text{Output work}}{\text{Input work}} \times 100\%$$

$$= \frac{\text{Load x Load distance}}{\text{Effort x Effort distance}} \times 100\%$$

or, $$\text{Efficiency } (\eta) = \frac{300 \times 2}{200 \times 4} \times 100\%$$

or, $$\text{Efficiency } (\eta) = \frac{6}{8} \times 100\%$$

∴ Efficiency (η) = 75%.

The efficiency of the pulley shown in the given figure is 75 %.

Also, $$(\eta) = \frac{MA}{VR} \times 100\%$$

$$\eta = \frac{\frac{L}{E}}{2} \times 100\%$$

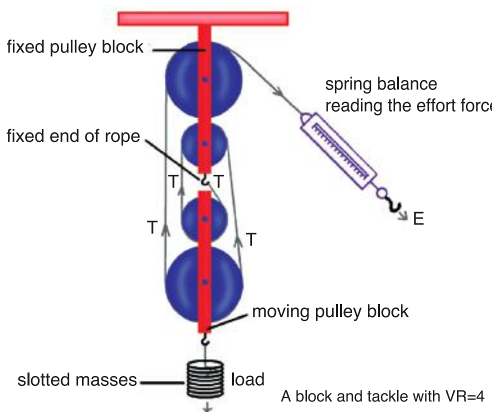
$$\eta = \frac{\frac{300}{200}}{2} \times 100\%$$

Since, VR of single movable pulley is 2.

η = 75%.

3. Block and Tackle System

A combination of pulleys is called block. The arrangement of pair of blocks consisting of one or more pulleys is called a block and tackle system. It can multiply force as well as change the direction of force.



Block and tackle system

Fact and Reason

A block and tackle system is usually used to lift or pull heavy loads in the easiest way.

The block and tackle change the direction and multiply force at the same time. The fixed block changes the direction and the movable block magnifies the force. So, a block and tackle system is usually used to lift or pull heavy loads in the easiest way.

Memory note

The velocity ratio of block and tackle system = the number of rope segments to support the load = number of the pulley. For the block and tackle system with two pulleys in the block and one pulley in the tackle, velocity ratio = number of pulleys = 3.

SOLVED NUMERICAL - 8.2

How much is the distance moved by the effort to lift the load by 2m in the block and tackle system having 5 pulleys? If the efficiency of the pulley system is 75% then calculate the effort applied to lift the 3000N load.

Solution,

Here, Load (L) = 3000N

Load distance (Ld.) = 2m

In the case of a block and tackle system with 5 pulleys,

Velocity ratio = number of pulleys = 5

or, Velocity Ration = 5

or, $VR = \dfrac{\text{Distance moved by effort (Ed)}}{\text{Distance moved by load (Ld)}} = 5$

or, $Ed = 5 \times 2$

$\therefore$ $Ed = 10m$

The efficiency of the block and tackle system (η) = 75%

According to the formula,

or, $\text{Efficiency } (\eta) = \dfrac{MA}{VR} \times 100\%$

or, $75\% = \dfrac{\frac{L}{E}}{5} \times 100\%$

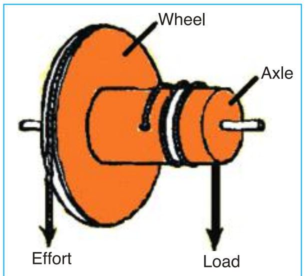
or, $75 = \dfrac{3000}{E \times 5} \times 100$

or, $E = \dfrac{3000}{75 \times 5} \times 100$

$\therefore$ $E = 800N$

The effort required to lift the load by the given block and tackle system is 800N.

Wheel and Axle



Wheel and axle

A system of two co-axial cylinders of different diameters which rotate together is called wheel and axle. The larger-diameter cylinder is called a wheel and the smaller-diameter cylinder is called an axle. There is frequent use of wheel and axle in our daily life. For example, door knob, tap knobs, screwdriver, etc. Wheel and axle can't increase both the force and the speed at the same time. It can work either like a force or a speed multiplier.

Fact and Reason

The truck steering wheel is larger than a car steering wheel.

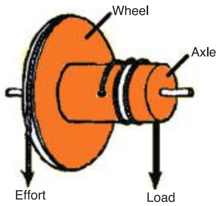
A larger-diameter steering wheel in trucks multiplies force by more amount than a smaller-diameter steering wheel in cars. This makes it easy to control the movement of the front wheels of a heavily loaded truck through the steering linkage. So, the truck steering wheel is larger than a car steering wheel.

Fact and Reason

Wheel and axle can't increase both the force and the speed at the same time.

A wheel and axle multiplies force when the force applied is on its wheel. On the other hand, if the force applied is on the axle of a wheel and axle then it increases the speed of work. So, the wheel and axle can't increase both the force and the speed at the same time.

MA, VR, and Efficiency of Wheel and Axle

Simple Machine	MA	VR	Efficiency
Wheel and Axle 	$MA = \frac{L}{E}$	$VR = \frac{\text{Effort distance}}{\text{Load distance}}$ When effort is applied from wheel, $VR = \frac{(\text{Circumference of wheel}(2\pi R)}{(\text{Circumference of axle}(2\pi r))}$ $VR = \frac{\text{Radius of wheel (R)}}{\text{Radius of axle (r)}}$	$\eta = \frac{MA}{VR} \times 100\%$ or, $\eta = \frac{\frac{L}{E}}{\frac{R}{r}} \times 100\%$ or, $\eta = \frac{L \times r}{E \times R} \times 100\%$

SOLVED NUMERICAL- 8.3

In a wheel and axle, the radius of the wheel is 30cm and that of the axle is 10cm. If a load of 600N is lifted by applying an effort of 250N, then calculate its MA, VR, and efficiency.

Solution

Here,

Load (L) = 600N

Effort (E) = 250N

Radius of wheel (R) = 30cm

Radius of axle (r) = 10cm

Now,

i. $MA = \frac{L}{E} = \frac{600}{250} = 2.4$

ii. In the case of a wheel and axle,

$$VR = \frac{R}{r} = \frac{30}{10} = 3$$

iii. According to the formula,

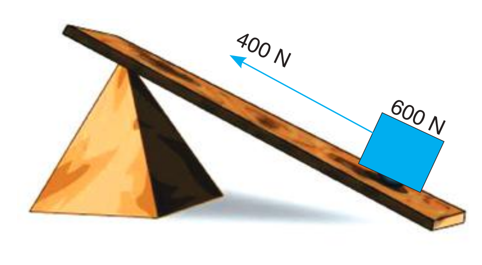
Efficiency (η) = $\frac{MA}{VR} \times 100\%$

or, $\eta = \frac{2.4}{3} \times 100\%$

$\eta = 80\%$

The efficiency of the wheel and axle is 80 %.

3.2 Inclined Plane



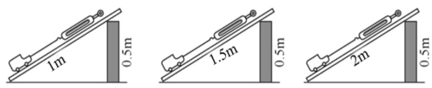
An inclined plane is a simple machine with a sloped surface. The sloped flat supporting surface with one end higher than the other, used for raising or lowering a load is called an inclined plane. It is also known as a ramp. For example, a staircase, a ramp used to load goods into trucks, a road winding uphill.

Memory note

Inclined planes are very useful to make disabled friendly hospitals and houses.

Activity 8.2

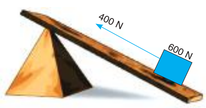
Measure the weight (i.e., load, L) of a heavy toy car by a spring balance. Attach it to the spring balance and pull it over the inclined planes as shown in the given figures to calculate the values of effort applied (E). Fill the data in the given table after your measurements and calculate the corresponding efficiencies of the inclined planes. Analyse the data and write the conclusion that you draw from your results in different cases.



S.N.	Length of Inclined Plane	Height of Inclined Plane	VR	Load(L)	Effort(E)	MA	Efficiency (η)
1.							
2.							
3.							

The length of an inclined plane is always greater than its height so it can multiply effort.

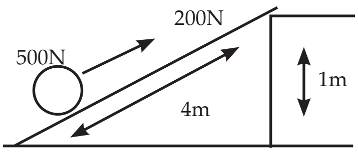
MA, VR, and Efficiency of Inclined Plane

Simple Machine	MA	VR	Efficiency
Inclined Plane 	$MA = \frac{L}{E}$	$VR = \frac{\text{Effort distance}}{\text{Load distance}}$ $VR = \frac{\text{Length of inclined plane (l)}}{\text{Height of inclined plane (h)}}$ $VR = \frac{l}{h}$	$\eta = \frac{MA}{VR} \times 100\%$ or, $\eta = \frac{\frac{L}{E}}{\frac{l}{h}} \times 100\%$ or, $\eta = \frac{L \times h}{E \times l} \times 100\%$

SOLVED NUMERICAL - 8.4

Study the given figure and calculate.

i. MA ii. VR iii. Efficiency



Solution

Here,

Load (L) = 500N

Effort (E) = 200N

Load distance (Ld) = 1m

Effort distance (Ed) = 4m

Using formula

i. $MA = \frac{L}{E} = \frac{500}{200} = 2.5$

ii. $VR = \frac{\text{Effort distance}}{\text{Load distance}} = \frac{4}{1} = 4$

According to the formula,

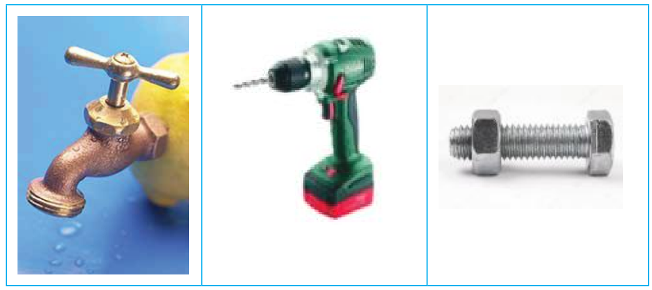
iii. Also, $(\eta) = \frac{MA}{VR} \times 100\%$

$\eta = \frac{2.5}{4} \times 100\%$,

or, $\eta = 62.5\%$.

The efficiency of the pulley shown in the given figure is 62.5 %.

Screw



The figures shown alongside are showing the application of screws in our daily life. A screw is a simple machine with an inclined plane wrapped around a cylinder. It has a structure like a winding inclined plane. The line formed by the inclined plane is called a thread. The distance between adjacent threads is called pitch.

Memory note

P.L. Robertson invented the screw.

The velocity ratio of the screw

While using a screw, when effort makes one complete turn, the resistance force moves a distance equal to the pitch. If 'r' is the length of the lever arm or that the top of the screw over which screw driver is fixed to rotate it, then effort distance is equal to the circumference.

i.e. effort distance = $2\pi r$

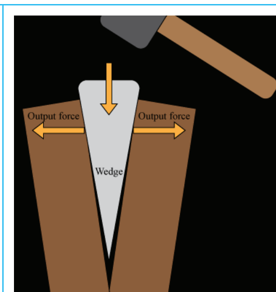
If, 'd' is the length of the pitch, then

i.e. Load distance = d

The velocity ratio of the screw is given by

$$\boxed{\text{V.R.} = \frac{\text{effort distance}}{\text{load distance}} = \frac{2\pi r}{d}}$$

Wedge



A knife is an example of a wedge. It has a sharp cutting edge that looks like two slanted surfaces meeting at the edge to form a sharp structure. In the given figure, a knife is being used to cut potatoes. Cutting becomes easy with the knife because of the wedge shape of the blade. The very thin edge of the blade easily enters and cuts through the potato.

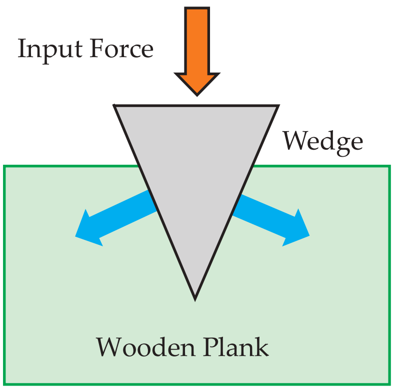
A wedge is a simple machine that consists of two inclined planes, giving it a thin end and a thick end. It is used to cut or split apart objects. It makes work easier by increasing the force applied to the object. Force is applied to the thick end of the wedge, and the sloping sides of the wedge apply force to the object for cutting it or splitting it apart.

Fact and Reason

The mechanical advantage of a wedge is greater than 1.

A wedge applies more force to the object (output force) than the user applies to the wedge (input force), so the mechanical advantage of a wedge is greater than 1.

The velocity ratio of wedge



In the given figure, input force is applied to the head of the wedge. The sharp edge penetrates deep inside the substance to be cut. If 'W' is the width of the head of the wedge and 'L' is its length, then distance moved by effort is the length of the wedge, and distance moved by the load is the width of the head of the wedge. i. e.,

effort distance = L

load distance = W

The velocity ratio of the wedge is given by

$$\text{Velocity ratio} = \frac{\text{effort distance}}{\text{load distance}} = \frac{L}{W}$$

SOLVED NUMERICAL- 8.5

Find the velocity ratio of the wedge shown in the given figure.

Solution:

Given,

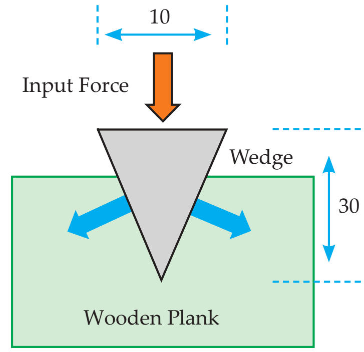
Width of the inclined plane (W) = 10cm

Length of the inclined plane (L) = 30cm

The velocity ratio of the wedge is given by

$$\text{Velocity ratio} = \frac{\text{effort distance}}{\text{load distance}} = \frac{L}{W}$$

Or, $$\text{Velocity ratio} = \frac{30}{10} = 3$$



Compound Machine

Activity 8.3

Look at the given pictures of different machines. Discuss about the simple machines used in their construction and their role in performing work with the use of that machine.

 *scissors*	 *stapler*	 *wheelbarrow*
 *Sewing machine*	 *bicycle*	 *Fishing rod*

Most of the machines we use nowadays are compound in structure. A complex structured machine with two or more simple machines working together is called a compound machine. For example, clocks, bicycles, motorbikes, sewing machines, etc. Compound machines use different types of energy like electrical energy, chemical energy, etc. to work.

Answer writing skill

1. **What is a screw?**
   A screw is a simple machine that is a modified inclined plane that winds around a cylindrical core to form a spiral.
2. **Identify the two simple machines working together in a bicycle.**
   Wheel and axle, and lever are the two simple machines working together in a bicycle.
3. **The single fixed pulley cannot multiply force but it is widely used by people in a well and many other places, why?**
   The single fixed pulley cannot multiply force but it is widely used because it changes the direction of the force. As a result, the work becomes easier.
4. **Write differences between wheel and axle and pulley.**
   Following are the differences between wheel and axle and pulley

Wheel and axle	Pulley
1. It consists of two cylinders of different diameters.	1. It consists of a grooved disc with an axis through its centre.
2. In a wheel and axle, both the cylinders rotate together.	2. In a pulley, the disc rotates about the fixed axis.

5. **VR of a simple machine is always greater than its mechanical advantage, why?**

   Mechanical advantage of a simple machine is decreased by the friction and weight of moving parts of the simple machine but the velocity ratio remains constant. So, the velocity ratio of a simple machine is always greater than its mechanical advantage.

6. **'Mechanical advantage of a simple machine is 3.' What does it mean?**
   The mechanical advantage of a simple machine is 3. It means the machine can overcome the load three times more than the effort.

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

a. Why is the mechanical advantage of a simple machine always less than its velocity ratio?
   i. M.A. is affected by friction
   ii. M.A. is the ratio of load and effort
   iii. V.R. is the ratio of effort distance and load distance
   iv. V.R. is affected by friction

b. Under what condition mechanical advantage of a machine will be less than one?
   i. The applied force is less than the resistance force.
   ii. The effort distance is greater than the resistance distance.
   iii. The effort distance is less than the resistance distance.
   iv. The applied force and resistance forces are the same.

c. How would you increase the mechanical advantage of a doorknob?
   i. increase the radius of the outer knob
   ii. increase the radius of the inner cylinder
   iii. decrease the radius of the outer knob
   iv. increase the radius of both the inner cylinder and outer knob in proportion

d. What is the formula of the efficiency of an inclined plane?
   i. $\eta = \frac{L \times h}{E \times l} \times 100\%$ ii. $\eta = \frac{h \times E}{L \times l} \times 100\%$
   iii. $\eta = \frac{L \times l}{E \times h} \times 100\%$ iv. $\eta = \frac{l \times h}{E \times L} \times 100\%$

e. What is the velocity ratio of a single fixed pulley?
   i. 1 ii. >1
   iii. <1 iv. 2

2. Define the following, with examples.

a. Mechanical advantage (MA) b. Velocity ration (VR)
c. Efficiency d. Pulley
e. Inclined plane f. Wheel and axle
g. Screw h. Wedge

3. Short question answers.

a. Write the principle of a simple machine.
b. Write an expression to show the relationship between mechanical advantage, velocity ratio, and efficiency for a simple machine.

c. Write the condition for the following:
   i. to multiply effort with the help of a simple machine.
   ii. to make work easier by using an inclined plane.
   iii. to make our work easier by using a wedge.

d. What change can be brought in the inclined plane to increase its mechanical advantage?

e. What is the relation between the mechanical advantage and velocity ratio of the given machines?
   i. an ideal simple machine ii. a practical machine

f. Write down the velocity ratio of the different types of pulley.

g. Write the formula to calculate the velocity ratio of the following:
   i. Pulley ii. Wheel and axle
   iii. Inclined plane iv. Screw
   v. Wedge

Step 2

4. Give reason.

a. The efficiency of a practical simple machine can never be 100 %.
b. A single fixed pulley does not multiply effort though it is widely used.
c. The velocity ratio of a single fixed pulley is one.
d. The velocity ratio of a single movable pulley is two.
e. The use of lubricants increases the efficiency of a machine.

5. Differentiate between the following.

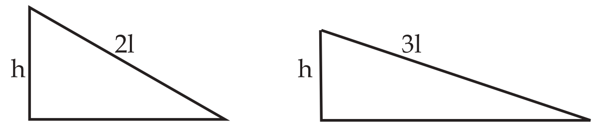
a. Simple machine and compound machine
b. Single fixed pulley and single movable pulley
c. Pulley and wheel and axle
d. Screw and wedge

Step 3

6. Answer the following questions.

a. Write the purpose of using simple machines.
b. How does a single fixed pulley help us to draw water from a well?
c. 'Wheel and axle' is called a continuous lever. Explain this statement.

d. The adjacent figures show two inclined planes of the same height 'h'. However, the lengths of the two planes are '2 l' and '3 l' respectively. Which inclined plane makes our work easier while lifting a load? Write with reason.



e. Have you seen any machine with 100% efficiency? Why are we not able to design one? Discuss.

7. Numerical

a. A load of 80N is lifted up with the help of 100N effort using single fixed pulley. Calculate.

- i. MA of the pulley
- ii. Efficiency
- iii. How much percentage of the energy is wasted while lifting the load? [Ans: MA = 0.8, 80%, 20 %]

b. A block and a tackle system has five pulleys. If an effort of 1000N is required to lift a load of 4500N, find

i. MA   b. VR   c. Efficiency

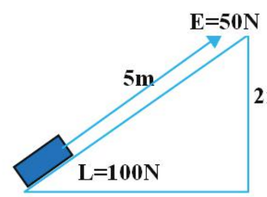
[Ans: a. 4.5 b. 5 c. 90%]

c. A worker uses a pulley system to raise a 250N carton by 16.5m. A force of 150N is exerted and the rope is pulled 33m. Find

- i. Mechanical advantage (MA)
- ii. Velocity ratio
- iii. Efficiency of the pulley system

[Ans: a. 1.667 b. 2 c.83.35 %]

d. A load is lifted by using an inclined plane as shown in the given figure.



- i. Calculate MA, VR, and efficiency.
- ii. What should be the length of the plane to pull the same load with the effort of 25N with the efficiency remaining constant?

[Ans: 2, 2.5, 80%, 10m]

e. A wedge having a thickness of 6cm and a length of 20cm is used to split a wooden log. If the amount of force applied is 500N and the resistance overcome is 1400N then find the value of MA, VR, and efficiency. [Ans: 2.8, 3.33, 84%]

Step 4

8. Long question answers

a. Derive a formula to show the relationship between mechanical advantage, velocity ratio, and efficiency.

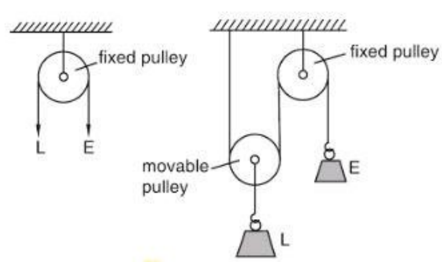
b. Explain the role of each block and tackle in a combined pulley to make our work easier.

c. Draw the diagram

  i. to show a single fixed pulley and a single movable pulley.

  ii. to show a block and tackle system of pulleys having a velocity ratio of 5. Also indicate the position of load and effort.

d. Study the given diagram and answer the following questions.

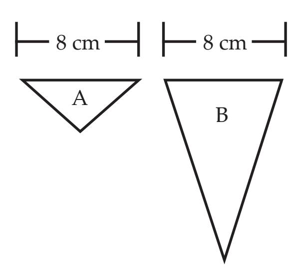


  i. What is the velocity ratio of the single pulley system shown? Write with reason.

  ii. What is the velocity ratio of the two-pulley system? Write with reason.

  iii. If the efficiency of the two-pulley system is 75 %, find the effort required to lift a load of 500N with its help.

e. Among the two wedges shown alongside, which one would require the least amount of force while splitting wood by using them? Write with a reason.



UNIT

9 ENERGY

ESTIMATED TEACHING PERIODS

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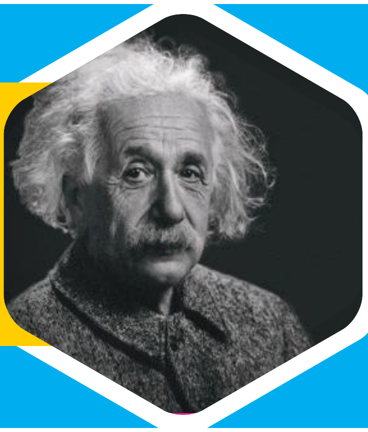


Einstein
(1879-1955)

Curriculum issued by CDC

- Introduction to solar energy, thermonuclear fusion reaction and conditions required for it
- Introduction to the technology that harnesses solar energy (solar lamp, street lights, solar heater, solar panel)
- Model preparation of solar heater
- The concept and importance of biomass
- The production, importance and use of biogas and briquette
- Alternative sources of energy used in Nepal and their potential

Learning outcomes

After completion of this unit, students will be able to:

- explain the thermonuclear fusion which is the source of solar energy.
- introduce the technology of solar energy and prepare a simple model based on it.
- introduce biofuel and discuss its usefulness.
- explain the making of briquette and biogas and use them.
- identify the best alternative sources of energy for different parts of Nepal and discuss their potential.

Terms and terminologies

1. Energy: Energy is the ability to do work.
2. Non-renewable energy sources: Sources of energy that occur in limited and exhaustible amounts are called non-renewable energy sources.

3. Renewable energy sources:	Sources of energy that are being produced continuously in nature and are inexhaustible are called renewable energy sources.
4. Thermonuclear fusion:	The process of formation of heavier atoms in presence of high temperature and pressure in the stars like the sun is called thermonuclear fusion.
5. Einstein's mass-energy relation:	The energy released from the mass lost in a nuclear reaction is given by Einstein's mass-energy relation; $E = mc^2$.
6. Solar energy harvesting:	Solar energy harvesting is the process of capturing and storing solar energy which is radiated from the sun.
7. Photovoltaic cell:	A solar cell or photovoltaic (PV) cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect.
8. Solar panel:	Solar panel is an assembly of photovoltaic cells mounted in a framework for installation.
9. Solar cooker:	A solar cooker is a device that uses the energy of direct sunlight to heat, cook or pasteurize drinks and other food materials.
10. Solar water heater:	A solar water heater is a device that captures sunlight to heat water.
11. Solar dryer:	Solar dryer is a device that uses solar energy to dry substances, especially vegetables, fruits, herbal products, spices etc.
12. Biomass:	Biomass is the material that comes from living organisms such as plants and animals.
13. Biomass energy:	Energy released from biomass through combustion or other chemical process is called biomass energy.
14. Biogas:	Biogas is a mixture of gases like methane (CH_4), carbon dioxide (CO_2), hydrogen (H_2) and hydrogen sulphide (H_2S).
15. Briquette:	A briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire.
16. Charcoal briquette:	A charcoal briquette is a compressed block of charcoal.
17. Biomass briquette:	A biomass briquette is compressed biomass which is made by using a moulder and compressor.
18. Hydroelectricity:	The electrical energy generated by rotating turbines connected to the generators with the help of moving water is called hydroelectricity.

19. Alternative sources of energy:	The sources of energy that are available in nature and can be used instead of non-renewable energy sources are called alternative energy sources.
20. Wind energy:	The energy received from the blowing air across the earth is called wind energy.

Introduction

'Energy is the ability to do work.' Whatever work is done, some energy has to be spent. Living beings as well as machines need the energy to perform work. There is no work accomplished without energy. When we walk, our muscular energy is used up. To run vehicles, fossil fuel is used as a source of energy. There is increased use of energy sources that can replace fossil fuels to prevent the future scarcity of energy resources. For example, biogas is a biofuel to cook food. The use of biomass briquettes can replace the use of coal for heating purposes. While performing a work by using energy, the energy does not vanish rather it changes into some other forms of energy. Energy can neither be created nor destroyed, but it can be transformed from one form to another. This is called the principle of conservation of energy.

Source of energy

Activity

What sources of energy do people use in your locality? Make a list of energy sources and classify them into two categories as the source that can provide energy continuously for a long time and the source that have limited reserve on the earth which gets depleted on its continuous use.

Energy resources on the earth can be classified as non-renewable sources and renewable sources.

Non-renewable sources of energy

Some energy sources cannot be generated in a short period. They cannot be used again and again. The energy sources which occur in limited and exhaustible amounts are called non-renewable energy sources. For example, coal, petroleum, natural gas, nuclear sources, etc. Such sources are if once used up, can not be renewed for millions of years. But some non-renewable resources such as metals can be used again and again. i.e., they can be recycled.

Renewable Energy Sources

Some of the energy sources can be replenished in a short period. The sources of energy, which are being produced continuously in nature and are inexhaustible are called renewable energy sources. For example, hydropower, wind energy, wood, charcoal, biomass, etc. Oxygen is a renewable source of energy because it is replaced in the atmosphere as plants release oxygen during photosynthesis. But if we use some renewable sources of energy faster than they are renewed, they are exhaustible too. For example, nowadays the groundwater is being exhausted from some locations due to its excessive use.

Solar energy

The sun is the closest star to the earth. Its average distance from the earth is 1.5×10^{8} km. Its mass is about 2×10^{30} kg. The core temperature of the sun is about 15,000,000 °K. Whereas the surface temperature is about 5778 °K. It provides an adequate amount of heat and light energy for life to exist on the earth. 3.8×10^{26} J/s energy gets released from the sun. More than half of the incident energy from the sun is either reflected back to space or absorbed in the atmosphere. As solar energy passes through the atmosphere, most of the ultraviolet and gamma rays are absorbed by the atmosphere. Such energy does not fall equally in all parts of the earth. On average, 1.4 kW of solar energy falls per square meter on the earth surface. A part of this solar energy is absorbed by the landmass, the water bodies and plants. Such energy consumed causes the phenomena like wind, storms, rainfall, snowfall, etc.

Thermonuclear Fusion: Source of the Solar Energy

The sun obtains its energy through a process of nuclear fusion. It is composed mostly of the gases like hydrogen and helium. The core of the sun is at a high temperature of about 15 million degrees Celsius. Hydrogen ions (H^+) are found at such a high temperature when the electrons of hydrogen atoms separate from the atom. There is high repulsion between hydrogen ions i.e. protons. The extremely high pressure caused by the gravitational pull brings them closer forming helium atoms. The process of formation of helium atoms from hydrogen atoms in presence of high temperature and pressure in the stars like the sun is called thermonuclear fusion. During this process, a huge amount of energy gets released in the form of heat and light. It occurs in the following three different steps.

i. Two protons combine to form a deuterium ($_1H^2$) along with a positron i.e. positive electron ($_1e^0$)

$$_1H^1 + {_1H^1} \longrightarrow {_1H^2} + {_1e^0} + \text{energy}$$

ii. The deuterium thus formed combines with another proton to form a light helium atom ($_2He^3$).

$$_1H^2 + {_1H^1} \longrightarrow {_2He^3} + \gamma\text{–radiation}$$

iii. Finally the two light helium atoms combine together to form a stable helium atom ($_2He^4$) along with two protons.

$$_2He^3 + {_2He^3} \longrightarrow {_2He^4} + {_1H^1} + {_1H^1} + \text{energy}$$

In short

$$\boxed{4\,{_1H^1} \longrightarrow {_2He^4} + 2\,{_1e^0} + \text{energy}}$$

Memory note

Isotopes are the atoms of an element having the same number of protons but a different number of neutrons. Thus, the isotopes have the same atomic number but a different mass number. For example, Protium ($_1H^1$), Deuterium ($_1H^2$) and tritium ($_1H^3$) are the isotopes of hydrogen. In the notation $_1H^2$, 1 stand for the atomic number and 2 stands for atomic mass (1 proton +1 neutron).

Conditions Suitable for Thermonuclear Fusion in the Sun

i. Abundant hydrogen: There is a sufficient amount of hydrogen in the sun which continues the thermonuclear fusion.

ii. High temperature: The high temperature in the sun forms free protons in the plasma state.

iii. High pressure: Pressure squeezes the atoms together for their combination.

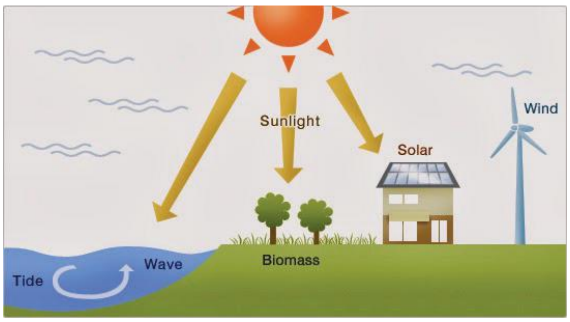
Einstein's mass-energy relation

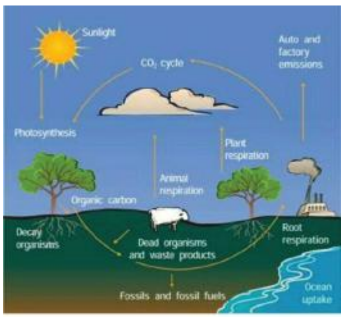
Einstein's mass-energy relation is used to calculate the energy released from the fraction of mass that gets lost in each step of the thermonuclear fusion. The energy released from the mass lost in a nuclear reaction is given by Einstein's mass-energy relation; $E = mc^2$. Where 'm' stands for the mass lost and 'c' is the speed of light (i.e. 3×10^8 m/s).

For example, if 0.5 g of mass is lost during the nuclear reaction, the energy released is given by $E = mc^2 = 5\times10^{-4} \times (3 \times 10^8)^2 = 5\times10^{-4} \times 9\times 10^{16} = 4.5 \times 10^{13}$ J. Thus, a huge amount of energy gets released from a nuclear reaction.

The sun as an ultimate source of energy

The sun is the main source of all forms of energy. It gives us heat and light energy. The sun is considered the ultimate source of energy because the different forms of energy are directly or indirectly obtained from the sun. Following are some examples:





i. The water cycle is also known as the hydrological cycle. This cycle includes precipitation, evaporation, condensation, etc. This happens due to the Sun's heat. The heat from the sun melts snow and ice blocks and water fills in rivers. Water molecules from lakes, rivers, streams, reservoirs and the sea get heated up by the sun and change into a vapour that rises into the air. Condensation of such water vapours forms cloud and rainfall occurs. If the water vapours are frozen, they become snow. Finally, the water in rivers is collected in big dams to generate electricity. Thus, hydroelectricity is indirectly derived from the sun.

ii. A small portion of the sun's energy reaching the earth is absorbed by green plants through the process of photosynthesis. In this process, carbon dioxide and water are converted into carbohydrates. The sun's energy is then converted into chemical energy and stored in various parts of the plants. The carbohydrates are consumed as food by the animals. Thus, the energy which we obtain from food is derived from the sun.

iii. The energy in fossils fuels like coal, petrol, diesel, natural gas, etc. originally comes from the sun. They are formed by the fossilization of ancient plants and animals which captured solar energy through photosynthesis. We burn fossil fuels to release the energy that ancient plants captured from the sun. Thus, fossil fuel energy is derived from the sun.

iv. Biomass fuels are obtained from once-living sources. Wood, vegetation, crop residues, garbage, etc. are examples of biomass. Plants store solar energy during the process of photosynthesis. The energy from the plants is transferred to the animals. Thus, the energy which we obtain from biomass is actually derived from the sun.

v. Sun's rays heat the air around the earth. But the energy from the sun does not fall uniformly at all parts of the earth. Air gets heated unequally and air pressure variation occurs. Then air blows from the region of high pressure to the region of low pressure. Thus, wind energy is also an outcome of solar energy.

Solar energy harvesting technologies

Activity

Look at the pictures showing the traditional method of solar energy harvesting and the corresponding modern method.

drying gundruk in the open air

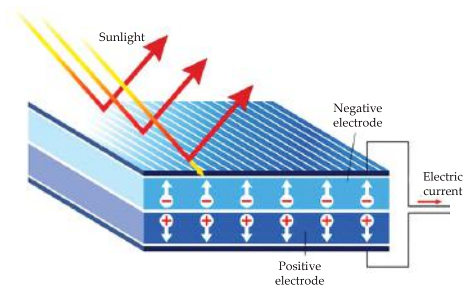
drying gundruk in the solar dryer

What other kind of solar energy harvesting methods have you seen in your locality?

We can see solar panels fixed on some of the residential rooftops in our locality. People use solar panels, solar water heaters, solar dryers, etc. The use of such tools is solar energy harvesting technology. Solar energy harvesting is the process of capturing and storing solar energy which is radiated from the sun. Following are some of the solar energy harvesting technologies.

1. Photovoltaic Solar Panels

A solar cell or photovoltaic (PV) cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Several photovoltaic cells are connected together to make a solar panel. The solar panel is an assembly of photovoltaic cells mounted in a framework for installation. Solar panels use the sun's power to create a flow of electricity. The size of a solar panel ranges in size from a few square centimetres to a few square metres. The use of solar panels is the most widely adopted method of harvesting solar energy.



photovoltaic cell

Solar panel fixed on the rooftop

Each PV solar cell is made up of semiconductor material. The structure's two thin semiconductor wafers are placed on top of each other. When light falls upon such a structure then it creates a flow of electricity through two terminals. The electricity is compounded into a whole panel of solar cells and then into a vast PV panel array. PV solar arrays produce direct current (DC).

Fact and Reason

We need an inverter to run devices connected to our domestic circuit through electricity generated from the solar panel, why?

The devices connected in our domestic circuit run from alternating current (AC). However, the electricity generated from the solar panel is DC. An inverter converts DC into AC. So, the DC from the solar panel must be converted to AC by using an inverter to run appliances connected to our domestic circuit.

Photovoltaic cells are used in different devices like solar lamps, solar street lamps, etc.

Solar Lamp


Solar Lamp

A solar lamp or solar lantern is a lighting system composed of a LED lamp, solar panels, battery and charge controller. There may also be an inverter in a solar lamp if it runs from both AC and DC. The lamp operates on electricity from batteries, charged through the use of solar panels i.e., solar photovoltaic panels. Solar-powered lamps help in achieving energy independence by utilizing the power of the sun.

Solar street lamps


Solar street lamps

Solar street lights are raised light sources which are powered by solar panels integrated into the pole. The solar panels charge a rechargeable battery, which powers a fluorescent lamp or Light Emitting Diode (LED) lamp during the night. Solar street lights consist of four main parts: solar panel, lighting fixture, rechargeable battery, and pole.

The solar panel converts solar energy into electricity. This electricity generated is used to charge batteries and to power the lamps. Charge controllers are used to control the charging of the batteries. The main functions of charge controllers are to prevent over-charging of batteries from solar panels, over-discharging of batteries to the load and to control the functionalities of the load. LEDs are usually used as the lighting source of modern solar street lights. A rechargeable battery stores the electricity generated by the solar panel during the day and provides energy to the fixture during the night. A strong pole is necessary to support all components fixtures, panels, and sometimes batteries. In the case of newer designs, PV panels and all electronics are integrated with the pole itself.

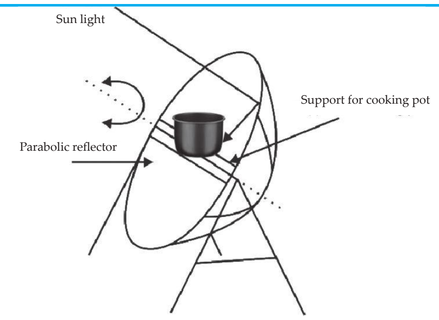
Memory note

LEDs used in modern solar street lights provide much higher luminosity with lower energy consumption.

Solar cooker

A solar cooker is a device that uses the energy of direct sunlight to heat, cook or pasteurize drinks and other food materials. It has a curved mirror to converge solar radiation at the pot used for cooking. The cooking pot used in the solar cooker has a black outer surface that absorbs heat radiations.

Solar cooker



Working principle of solar cooker

Fact and Reason

The outer surface of the cooking pot used in solar cookers is made black, why?

Black colour effectively absorbs infrared radiations. So, the outer surface of the cooking pot in the solar cooker is made black to absorb solar radiation for effective heating.

Solar water heater

A solar water heater is a device that captures sunlight to heat water. Commonly solar water heater is used to heat water for bathroom purposes. The simplest version of a solar water heater system uses a pump to circulate cool water through a black body panel. The water is continually circulated through a loop. Some systems do not have a pump system. In such a system, the warmer water 'floats' and the colder water sinks that creates a thermosiphon. These systems require the storage tank to be above the solar absorption source as in the case of a vacuum tube solar water heater.

Solar water heater

Fact and Reason

Vacuum tube solar water heaters are good for water heating purposes in winter, why?

The solar radiation intensity is low in winter. In a vacuum tube solar water heater, minimal amounts of thermal energy escape the vacuum tube. It allows nearly all radiant energy to be converted into thermal energy. So, vacuum tube solar water heaters are significantly more efficient at heating water during cold months.

Solar dryer

Traditionally, food grains, vegetables, etc. are kept in the sun to make them dry. This takes more time. The use of a solar dryer to make foods dry saves time. A solar dryer is a device that uses solar energy to dry substances, especially vegetables, fruits, herbal products, spices etc. The temperature of the air inside the drier is more than that of the air outside it. It can replace the traditional method of drying foods in the sun. Food is protected from flies, other insects, rain and dust. The quality of food remains high in terms of colour, health, and nutrition. So, the use of a solar dryer avoids the possibility of contamination when drying food in the external environment.


Solar dryer

Activity

Use locally available resources to make models of each solar cooker, solar water heater and solar dryer.

Biomass energy

Biomass is the material that comes from living organisms such as plants and animals. The most common biomass materials used for energy are plants, wood, straw, sawdust, agricultural waste, etc. The energy from biomass can be transformed into usable energy through direct and indirect means. Biomass can be burned to create heat directly. Sometimes biomass is processed into biofuel indirectly like alcohol. The energy released from biomass through combustion or other chemical process is called biomass energy.

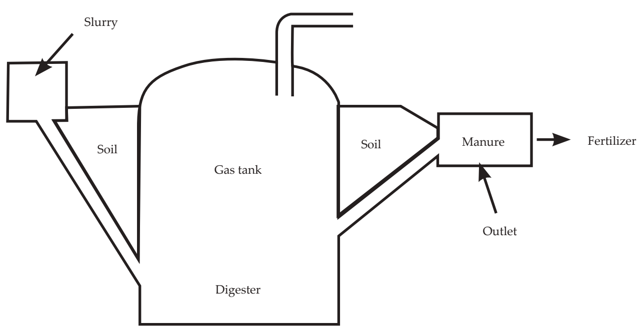
Fact and Reason

Biomass is a renewable source of energy.

Plants and animals will always exist as long as the conditions are suitable for life on the earth. As long as we plant trees and crops, we will have resources. Biomass supplies are not limited. It can be obtained continuously on the earth. So, biomass is a renewable energy source.

Biogas

The biomass can be converted into combustible gas i.e. biogas in a biogas plant. Biogas is a mixture of gases like methane (CH_4), carbon dioxide (CO_2), hydrogen (H_2) and hydrogen sulphide (H_2S). The major constituent of biogas is methane. A biogas plant is a physical installation to produce biogas from biomass. It is built either of cement-concrete or brick-walled.



Fixed dome type biogas plant

In a biogas plant, the feed is fed into the system from the mixing tank. It has a mixing fan to make a slurry from animal dung and water. There is a pipe from the mixing tank to the digestive tank to send the feed into the digestive tank. A digestive tank is a brick-walled underground tank with a dome-shaped roof. It is an airtight tank, where the feed and water will stay for some time and anaerobic decomposition generates gas. The biogas generated gets stored in a dome. With an increase in pressure of the gas inside the dome, it pushes the digested material out of the tank into the outlet chamber. There is a pipe with a valve at the top of the dome as a gas outlet. Gas generated is supplied through an outlet valve. Biogas from the biogas plant can be supplied through pipes for cooking and lighting. The outlet chamber is for taking out the spent slurry after completion of gas generation from it.

Memory note

Biogas can be used as cooking fuel, lighting fuel, to generate electricity, and fuel for the combustion engine.

Organic matter rich substances are used as input material for biogas production. Animal wastes like cattle dung, urine, goat and poultry droppings, etc. Similarly, human wastes and kitchen wastes, agricultural wastes, etc. can be used as input material for biogas production. In the village area of our country, the main input material for biogas production is cattle dung.

Fact and Reason

Biogas is one of the suitable sources of energy for village areas in Nepal.

In the village area, many people are engaged in farming.

i. The raw materials like animal dung, plant wastages, etc. are easily available.

ii. Bulbs can glow from the electricity generated from biogas for lighting purposes.

So biogas is one of the suitable sources of energy for village areas in Nepal.

Advantages of Biogas

i. It produces more heat when burnt.

ii. The use of biogas as cooking fuel replaces the use of firewood. So, it helps to control deforestation.

iii. It is a non-polluting fuel as it does not produce smoke. So, it helps in controlling air pollution.

iv. The spent dung slurry, left after the extraction of biogas, is rich in nitrogen and phosphorus compounds. It provides nutrient-rich manure for plants.

v. Biogas can also be used to produce electricity for lighting purposes.

Memory note

The spent dung slurry, left after the extraction of biogas, is rich in nitrogen and phosphorus compounds and hence forms good manure.

Limitation of biogas

There are some limitations associated with the biogas plant. The initial cost of installation of the plant is high but it's a cheap energy source for long term use. In winter, the rate of gas production slows down. In the case of a smaller number of cattle owned by a farmer, animal dung is insufficient to feed a biogas plant. Biogas plant construction occupies more space. So, it is not possible to construct biogas plants anywhere in cities.

Biomass briquette

Briquettes are solid fuels often used for domestic purposes in developing countries. They are used for heating purposes in industries too. Briquettes are formed by the compaction of solid material. A briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire.

Memory note

Compaction or densification of briquettes increases the heating value per unit volume.

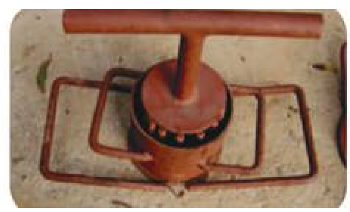
Types of biomass briquettes

Carbonized or charcoal briquettes and noncarbonized biomass briquettes are the two types of biomass briquettes.

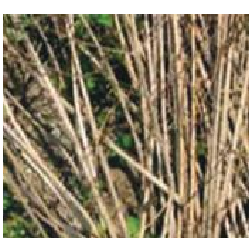
Charcoal briquettes


powdered charcoal


powdered clay


mould

Collect powdered charcoal, powdered clay (sticky soil), and a mould as shown in the given figure. Measure each powdered charcoal and sticky clay to mix them in a ratio of 3:1 to make a paste. Press that paste in the mould. Take it out and let it become dry for 2 to 4 days.


carbon rich material


burning in low oxygen


sticky clay


briquette

A charcoal briquette is a compressed block of charcoal. It is produced by burning a carbon-rich material such as wood in a low-oxygen atmosphere and then mixing it with another binder. Commonly sticky clay is used as a binder while making charcoal briquettes. They are not actual charcoal lumps, but a combination of charcoal and other ingredients moulded into easy-to-light lumps.

We need to collect raw materials to make carbonized briquettes at first. Raw materials like litter, fallen branches of trees, straw, etc. Then we need to let them dry. Dry matter is then burnt in a drum or a pit to make charcoal. Powdered charcoal is mixed with fine clay in a ratio of 3:1. This mixture is converted into a paste by adding water. That paste is pressed in a mould to give the shape of a briquette. Finally, the briquette becomes ready for packing after drying for 2 to 4 days.

Beehive charcoal briquette

banana peel briquettes

coconut charcoal briquettes

Biomass briquettes

Memory note

Animal Dung Briquettes (Guitha)

Manually, in the village area of our country, farmers press animal dung by their hand and let that dry in the sun to make animal dung briquettes.

Biomass briquettes are a biofuel substitute for coal and charcoal. A biomass briquette is compressed biomass by using a moulder and compressor. It is prepared by densification of woody biomass, leafy biomass, and agricultural residues etc. The agricultural waste like groundnut shells, castor seed shells, almond shells, coconut shells, rice husk, cotton stalks, sunflower stalk, pine needles, coffee husk, and other waste from forestry like fallen leaves, tree bark, sawdust, jute waste etc. can be used to make biomass briquettes. Biomass briquettes are given different shapes by using moulders.

sawdust briquettes

rice husk briquettes

paper briquettes

Memory note

In Nepal, the first commercial production plant 'Nepal Bio-Extruder Industry Pvt. Ltd.' was established in 1982 in Thapathali, Kathmandu with an annual production capacity of 900 metric tons. It used the rice husk pyrolyzing technology to produce charcoal briquettes (brand name Jwala briquettes) from rice husk.

There are different technologies for pressing the biomass briquettes.

piston press briquetting technology

screw press briquetting technology

roller press briquetting technology

Use of biomass briquette

The use of biomass briquettes can replace fuels like diesel, kerosene, lignite, coal, firewood, etc. In our country where a huge amount of agro-residues is available, this technology can handle a wide range of biomass to give good quality briquettes. Biomass briquettes can be used for the following purposes:

i. It is used for room heating purposes.
ii. It is used as fuel for cooking purposes in the kitchen, picnic spots, etc.
iii. People use briquettes for warming the children and newly delivered mothers.
iv. It can be used instead of wood and loose biomass in small scale industries like rubber industries, leather processing units, brick kilns, etc.

How to use a briquette?

To use a briquette, we need to ignite one end of a briquette until it turns red.

Then it is transferred into its stove which is made up of ceramic, iron or steel. The burnt part of the briquette is kept downward.

Advantages of Biomass briquette

The use of firewood can be replaced with the use of biomass briquettes. So, the use of biomass reduces deforestation.

Simple skills and low expenditure need for briquette production. It can be a good source of income by commercial production. It reduces the energy crisis problem. There are several advantages associated with the use of biomass briquettes:

i. It is a cheap and readily available renewable source of energy
ii. It is much cleaner to handle than charcoal or coal.
iii. It reduces air pollution and helps to conserve the environment.
iv. It replaces the use of fossil fuels like kerosene, LPG, etc. and traditional sources of energy like firewood, coal, and dung-cake.
v. Ash after complete combustion of a briquette can be used in gardens and fields.
vi. Loose biomass causes a problem in handling, transportation and storage. Briquettes are easy to handle and eliminate problems of transportation and storage of loose biomass.

Limitation of biomass briquette

There are some limitations associated with the use of biomass briquettes. It requires a huge investment for its initial production. There is a high energy requirement for the production of biomass briquettes. In the rainy season, the drying process needs another heat source other than the sun. Biomass briquettes must be stored in a waterproof storage area otherwise the briquettes will not burn when lit. The quality of the raw materials and wear of the die, piston, and screw are frequent operational problems associated with briquetting technology. Doors and windows must be open while using the briquette otherwise, it may suffocate us.

Use of alternative sources of energy in Nepal

The present rate of fossil fuel consumption is high. This will bring energy crisis in the near future. To avoid this, we need to find sources of energy that replace fossil fuels. The sources of energy that are available in nature and can be used instead of non-renewable energy sources are called alternative energy sources. Renewable sources of energy are also called alternative sources of energy.

Nepal has a great potential for renewable energy resources. Hydropower, solar energy, biomass, biogas, and wind energy are all sources of renewable energy in Nepal. Traditionally, people have been using biomass energy resources. To work in the field of alternative sources of energy, Nepal established a semi-autonomous agency called the Alternative Energy Promotion Centre (AEPC) in 1996. It worked in the field of solar energy, mini/micro hydropower projects, biogas plants, improvement of cooking stoves, biomass energy etc.

Solar PV technologies, solar thermal energy technologies (solar dryer, solar cooker, solar heater), biomass technologies, wind energy technology, biogas technologies (household biogas, urban household biogas, large biogas), mini/micro hydropower technologies are in the implementation phase in Nepal. Several solar power stations like Nuwakot solar power stations have got installed in different parts of Nepal.

1.5 MW Nuwakot solar power station

wind-solar hybrid power station at Hariharpur, sindhuli

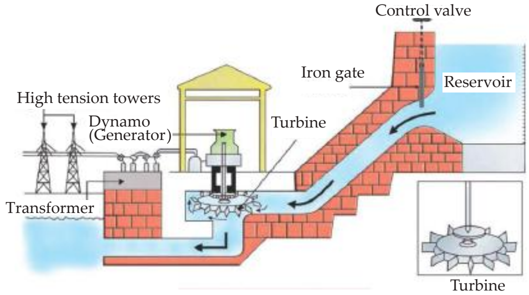
Wind energy in Nepal

The energy received from the blowing air across the earth is called wind energy. Strong wind regions of Nepal have a high potential for the generation of electricity from windmills. A wind power station is established in Hariharpur of Sindhuli district.

Solar and biogas in Nepal

Farmers in Nepal use solar dryers to store vegetables and fruits during the harvest season. If such products are not stored properly, they are more likely to rot without consumption. Many people in the village area have installed biogas plants. In city areas, a modified biogas plant made from plastic tanks is in use to generate biogas from biodegradable kitchen wastage. Use of solar water heater is also common in city areas as well as in some of the village areas too.

Hydroelectricity in Nepal



Hydroelectricity is the best alternative source of energy in Nepal. To generate hydroelectricity at a hydropower plant, water collected in a dam is allowed to pass through a tunnel. It converts the potential energy of water stored in a dam into kinetic energy. This energy can be used to rotate turbines connected with a generator. The kinetic energy of the flowing water is converted into the kinetic energy of the armature of a generator connected to the turbine. The electrical energy generated by rotating turbines connected to the generators with the help of moving water is called hydroelectricity. A hydroelectricity generating station that utilizes the potential energy of water at a high level is known as a hydroelectric power plant.

Fact and Reason

Hydroelectricity is the most suitable source of energy in the context of our country.

In Nepal, there are so many fast-flowing perennial rivers. These rivers flow on the north to south sloppy land. Such a sloppy land structure is suitable for the storage of water in dams. So, hydroelectricity is the most suitable source of energy in the context of our country.

Advantages of hydroelectricity for Nepal

i. Hydroelectricity does not cause air pollution.

ii. It can be transmitted over long distances in extremely small time.

iii. It can be converted into different forms of energy like heat, light, etc. by passing through suitable devices.

iv. Water used to generate hydroelectricity can be reused for other purposes like irrigation.

v. It is cheaper in long term use though the installation cost of a hydropower plant is very high.

Answer writing skill

1. **Write the name of two devices that are used for solar energy harvesting.**

   Two devices that are used for solar energy harvesting are a solar cooker and a solar water heater.

2. **Write two advantages of biomass briquette over loose biomass.**

   Following are two advantages of biomass briquette over loose biomass:

   i. The direct burning of loose biomass in a conventional way gives less heat and creates more air pollution.

   ii. Loose biomass causes a problem in handling, transportation and storage.

3. **Differentiate between a renewable source of energy and a non-renewable source of energy.**

   The differences between a renewable source of energy and a non-renewable source of energy are:

SN	Renewable source of energy	SN	Non-renewable source of energy
1	The sources of energy, which are being produced continuously in nature and are inexhaustible are called renewable sources of energy.	1	The sources of energy which occur in limited and exhaustible amounts are called non-renewable energy sources.
2	It does not pollute the environment.	2	It pollutes the environment.

4. **Why is solar energy called a useful alternative source of energy for Nepal?**

   Geographically Nepal is located in suitable latitudes. There are more than 300 sunshine days per year in Nepal. So, solar energy harvesting technologies can be used in different parts of Nepal.

5. **Fossil fuels are called non-renewable energy sources, why?**

   It takes millions of years for the formation of fossil fuels. Coal, Crude oil and natural gas are formed from the fossilized remains of prehistoric plants and animals. They are limited in amount and cannot be regenerated in a short period.

6. **Suggest two alternative sources of energy in the context of rural areas in our country. Support your suggestions.**

Solar energy and biogas would be the best alternative sources of energy in the context of rural areas of our country.

i. Solar energy: Solar energy is harnessed from the sunlight by the use of solar panels. These are cheaper, portable and easy to install. Solar panels can provide electricity in places where there are no hydropower transmission lines yet.

ii. Biogas: It is a suitable fuel for the people in the village area of our country. The raw materials to produce biogas are easily available in the village area.

EXERCISE

Step 1

1. Choose the best answer from the given alternative.

a. Which of the following is a renewable source of energy?

i. wood	ii. petroleum
iii. natural gas	iv. uranium

b. What are solar cells made of?

i. calcium	ii. silicon
iii. silver	iv. aluminium

c. What is the main possible source of energy in the context of our country?

i. hydroelectricity	ii. nuclear energy
iii. tidal energy	iv. biomass

d. What is the main constituent of biogas?

i. methane	ii. carbon dioxide
iii. hydrogen	iv. hydrogen sulphide

e. Which product is formed after the process of carbonization?

i. charcoal	ii. coal tar
iii. coke	iv. coal

2. **Define the following with required examples.**

a. Energy
b. thermonuclear fusion
c. biomass
d. biofuel
e. alternative sources of energy
f. wind energy
g. briquette
h. hydroelectricity

3. **Short question answers.**

a. Give an example of any two suitable places in our country to generate electricity from wind.

b. Name two alternative sources of energy that are suitable in the context of our country.

c. Write two examples of biomass energy sources.

d. Write two advantages of using biogas as a fuel.

e. Write two advantages of biomass briquette over loose biomass

f. 'The ultimate source of energy is the sun.' Justify this statement with an example.

g. How does enormous energy get released from the sun?

h. Write two conditions for the thermonuclear fusion in the sun.

i. What alternative sources of energy do people in your locality use? Write the purpose of that source.

Step 2

4. **Give reason.**

a. Hydroelectricity is a suitable source of energy in the context of Nepal.

b. Biomass is a renewable energy source.

c. Biogas is one of the suitable sources of energy for village areas in Nepal.

d. The spent dung slurry, left after the extraction of biogas is used as manure.

e. Burning a wood briquette is far more efficient than burning firewood.

5. Differentiate between the following.

a. Renewable source of energy and non-renewable source of energy

b. Solar energy and wind energy

c. Charcoal briquette and biomass briquette

d. Natural gas and biogas

e. Solar cell and solar heater

Step 3

6. Answer the following questions.

a. Name the type of biomass briquette shown in the given figure. Write their raw materials.

(a)	(b)
	

b. Write three advantages of each of the following:

i. hydroelectricity ii. biogas iii. biomass briquettes

c. Draw the diagram to show the construction of a biogas plant.

d. Justify the given sources of energy as an outcome of solar energy.

i. Hydroelectricity ii. fossil fuel

iii. wind energy iv. biomass energy

e. Identify the devices that are used for solar energy harvesting purposes. Write its working principle.

(a) (b) (c)

Step 4

7. Long question answers.

a. How are charcoal briquettes made? Explain with steps involved in the process of briquetting.

b. Lets suppose the energy crisis hit your city. How would you produce gas for kitchen from an animal dung? Describe briefly.

c. Tons of biodegradable solid waste are produced each day in cities. Suggest some ways to change waste into energy.

d. "Charcoal briquette manufacturing can be a good source of income from low investment". Justify this statement based on raw materials, the technology used, and its uses.

e. Lets suppose you have lots of waste organic materials such as old newspapers or saw dust. How would you use it as a source of energy? Discuss the technology.

f. Nepal is heavily dependent upon fossil fuel. Suggest any three most probable alternative source of energy and their probability in Nepal.

UNIT

10 WAVES

ESTIMATED TEACHING PERIODS

TH	PR
13	3

W.C. Röntgen
(1845-1923)

Curriculum issued by CDC

- Introduction and types of waves
- Introduction and differences between longitudinal waves and transverse waves
- Differences between mechanical waves and electromagnetic waves
- Introduction to electromagnetic spectrum.
- Introduction and application to radio waves, infrared rays, visible rays, uv-rays, X-rays and gamma rays.
- X-ray photography method (introduction, method of taking photo and reason to observing bones)
- CT scan (introduction and working mechanism)
- Reflection of sound (introduction and application in our daily life)
- Ultrasonography (introduction and working mechanism)

Learning outcomes

After completion of this unit, students will be able to:

- identify as well as differentiate between mechanical waves and electromagnetic waves.
- identify electromagnetic spectrum and give the application of their components.
- introduce the method of X-ray photography and CT scan.
- demonstrate the reflection of sound and investigate their application in our daily life.
- explain working mechanism of ultrasonography in health checkup.

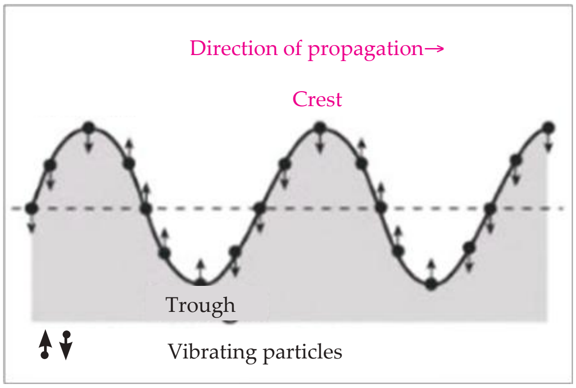
Terms and terminologies

1. Wave:	Wave is the periodic disturbance in a medium that carries energy from one place to another.
2. Mechanical wave:	The wave which requires a material medium for its propagation is called a mechanical wave.
3. Electromagnetic waves:	The waves which do not need a material medium for their propagation and can travel even through vacuum are called electromagnetic waves.
4. Transverse wave:	If the direction of the vibration of the particles of the medium is perpendicular to the direction of the propagation of the wave, the wave is called a transverse wave.
5. Longitudinal wave:	If the direction of the vibration of a particle of the medium is parallel to the direction of the wave propagation, the wave is called a longitudinal wave.
6. Electromagnetic spectrum:	The orderly classification of electromagnetic waves according to their wavelength or frequency is called the electromagnetic spectrum.
7. Visible spectrum:	The spectrum within the range of 400 nm to 750 nm which strikes the retina is called visible spectrum.
8. Invisible spectrum:	The region of the spectrum which does not strike the retina is called an invisible spectrum.
9. Ultrasound:	Sound above the frequency of 20,000 Hz is called ultrasound.
10. Reflection of sound:	The phenomenon in which the sound bounces off a solid or a liquid is called reflection of sound.
11. Echo:	The repetition of sound because of the reflection of sound waves is called echo.
12. Echolocation:	Echolocation is the process of locating an object in its surrounding with the help of reflected sound.
13. SONAR:	The method to measure the depth of sea bed, locate scraps, wrecks, submarines of enemies, etc. in the water by producing ultrasound is called SONAR.
14. Noise pollution:	The disturbance produced in the environment by undesirable, loud, and harsh sounds from various sources is called noise pollution.
15. Acoustic protection:	The technique or method used to absorb undesirable sound by soft and porous surfaces is called acoustic protection.
16. Medical imaging:	Medical imaging is the process of imaging the interior of a body for clinical analysis and medical intervention.
17. Radiography:	Radiography is an imaging technique using X-rays, gamma rays, or similar ionizing radiation and non-ionizing radiation to view the internal form of an object.

18. X-ray imaging:	X-ray imaging is a process of creating pictures of our internal body parts by detection of x-rays that pass through the body.
19. CT Scan:	A CT scan is an x-ray procedure of diagnostic test that creates cross-sectional images with the help of computer processing.
20. Ultrasonography:	Ultrasonography is a procedure that uses ultrasound waves to look at tissues and organs inside the body.
21. Sonogram:	The computer picture of the area inside the body created by echoes of ultrasound waves is called a sonogram.

Introduction

On dropping a stone in water, we see ripples forming on the surface. When ripples move through water, the molecules of water vibrate just up and down at their respective position. The ripples carry energy from the stone to all parts without the actual movement of the water from one point to another. Sound waves propagate through the air by 'to and fro' motion of air molecules. Wave motion transfers energy from one point to another. Wave is the periodic disturbance in a medium that carries energy from one place to another.



propagation of energy in a wave without transmission of matter

Fact and Reason

Waves transport energy but do not transfer matter from one region to another.

When a stone is dropped in water, its kinetic energy displaces the water molecules around it. Each molecule of water displaces the next molecule near it. This process continues till all energy gets transferred. So, waves transport energy but do not transfer matter from one region to another.

Memory Note

The loudest natural sound wave on earth is caused by an erupting volcano.

Activity

What do you see on a still water surface when a stone is dropped in it?
How does your voice reach a friend sitting next to you?

Types of waves

Waves can be classified as mechanical waves and electromagnetic waves

Waves

- **Mechanical Waves** — Requires a medium
  - **Longitudinal Waves** — e.g. Sound waves
  - **Transverse Waves** — e.g. Water waves
- **Electromagnetic Waves** — Do not require a medium — e.g. light waves, microwaves, infrared waves, uv rays, radio waves

A. Mechanical Wave

The wave which requires a material medium for its propagation is called a mechanical wave. Such waves are also called elastic waves because it depends on the elastic nature of the medium. For example, sound waves etc.

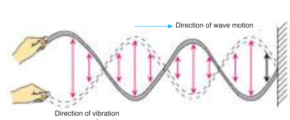
Classification of mechanical waves

a. Transverse Wave

Activity

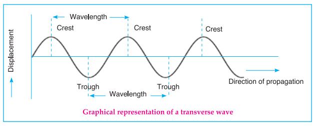
1. Attach a rope to a doorknob as shown in the given figure.
2. Shake the rope up and down.
3. Observe the up-and-down motion of the rope creating high points and low points.

   The periodic motion set in the rope is a wave with crest and trough and called a transverse wave.



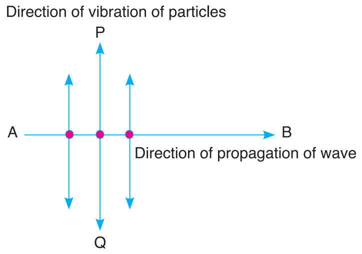
If the direction of the vibration of the particles of the medium is perpendicular to the direction of the propagation of the wave, the wave is called a transverse wave. For example, ripples on the water surface, light waves, a wave pattern set in a stretched string.

Terms Used in Transverse Wave



Graphical representation of a transverse wave

(1) Crest: In a transverse wave, the position of the maximum upward displacement of a vibrating particle from the mean position is called a crest.



Vibration of medium particle in a transverse wave

(2) Trough: In a transverse wave, the position of the maximum downward displacement of a vibrating particle from the mean position is called a trough.

(3) Amplitude: In a transverse wave, the maximum displacement of a vibrating particle from the mean position (either upward or downward) is called amplitude. It is measured in metres or centimetres.

(4) Wavelength: In a transverse wave, the distance between two consecutive crests or troughs is called wavelength. The wavelength is represented by Greek letter lambda. Its SI unit is metre (m).

(5) Frequency: The number of waves produced per second is called frequency. The frequency is represented by ' f '. Its SI unit is hertz (Hz). A wave with one complete cycle in one second has a frequency of 1 Hz. The bigger units of hertz are-

1 kilohertz (kHz) = 10^3 Hertz (Hz)

1 Megahertz (MHz) = 10^6 Hertz (Hz)

If a wave has a frequency of 100Hz, this means that 100 complete cycles are made in 1 second.

Memory Note

The frequency of audible sound is 20 hertz to 20,000 hertz.

(6) Time Period : The amount of time required to complete one full cycle of the wave is called the time period. It is represented by 'T'. Its SI unit is second. Mathematically, $\boxed{T = \frac{1}{f}}$

Fact and Reason

A sound wave is a mechanical wave.

The sound wave carries energy by sharing of the vibration of molecules or particles in a medium like air, water, steel, etc. Sound needs a material medium for its propagation. It cannot travel through a vacuum. So sound wave is a mechanical wave.

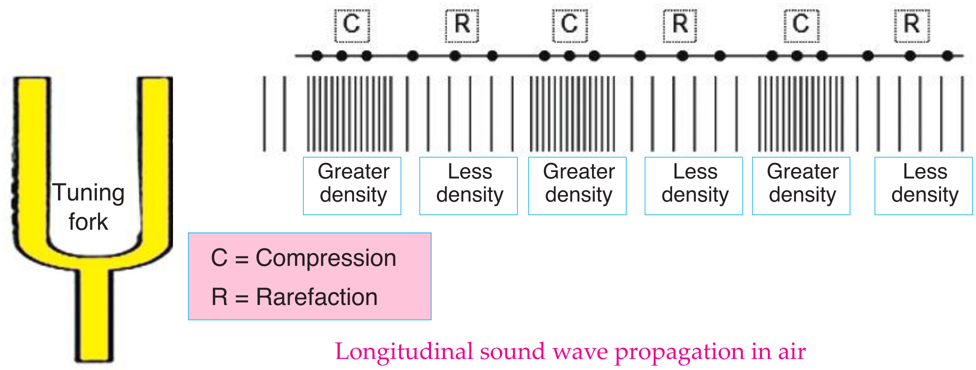
b. Longitudinal Wave

Activity

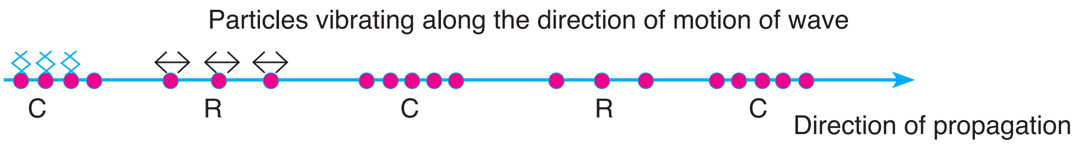
Stretch a 'slinky' spring along the floor and give it a quick wiggle to and fro along the length of the spring. What do you observe?

If you mark a dot on the slinky, you will observe that the dot on the slinky will move back and forth parallel to the direction of the propagation of the disturbance.

If the direction of the vibration of a particle of the medium is parallel to the direction of the wave propagation, the wave is called a longitudinal wave. For example, sound wave, a wave pattern set in a stretched spring, etc.



Longitudinal sound wave propagation in air



Particles of medium vibrating in a longitudinal wave

Terms Used in Longitudinal Wave

1) **Compressions:**

   In a longitudinal wave, compressions are the regions where density, as well as pressure, is high.

2) **Rarefactions:**

   In a longitudinal wave, rarefactions are the regions of low pressure where particles are spread apart.

Fact and Reason

The sound waves which we listen are longitudinal waves.

Vibrations in air consist of areas of high pressure called compressions and areas of low pressure called rarefactions. So, the sound waves which we listen are longitudinal waves.

3) **Amplitude**

   Amplitude is the maximum distance the particles in a wave vibrate from their mean position.

4) **Wavelength**

   The distance between two consecutive compressions (C) or two consecutive rarefactions (R) is called the wavelength.

Relationship among Frequency, Wavelength, and Velocity or Wave Equation

The speed of propagation equals the product of wavelength (λ) and frequency (*f*).

Mathematically, Wave velocity(v)= frequency(f) × wavelength (λ)

$$\boxed{v = f \times \lambda.}$$

Fact and Reason

Sound waves of all frequencies propagate with the same speed through a medium.

When the frequency of a wave increases, its wavelength decreases, and vice versa. The product $v = f \times \lambda$ remains the same. So sound waves of all frequencies propagate with the same speed through a medium.

Frequency (in Hz)	Wavelength (in m)	The velocity of sound (in m/s)
256	1.34	343
512	0.67	343

Differences between transverse wave and longitudinal wave

Transverse Waves	Longitudinal Waves
1. The direction of the vibration of the particle of the medium is perpendicular to the direction of the wave propagation.	1. The direction of the vibration of the particle of the medium is parallel to the direction of the wave propagation.
2. These waves can be generated in solids and liquids.	2. These waves can be generated in solids, liquids, and gases.
3. A complete transverse wave consists of a crest and a trough.	3. A complete longitudinal wave consists of compression and rarefaction.
4. It travels at high speed.	4. It travels at low speed.
5. It can travel through a vacuum.	5. It cannot travel through a vacuum.

B. Electromagnetic Wave

Electromagnetic waves consist of oscillating electric and magnetic fields. Waves which do not need a material medium for their propagation and can travel even through vacuum are called electromagnetic waves. The gamma-ray, X-ray, ultraviolet ray, infrared radiation, microwaves, and radio waves are all electromagnetic waves.

Fact and Reason

A light wave is an electromagnetic wave.

A light wave consists of both electric and magnetic fields. It doesn't need a material medium for its propagation. It can travel through a vacuum. So light wave is an electromagnetic wave.

Properties of Electromagnetic (EM) Waves

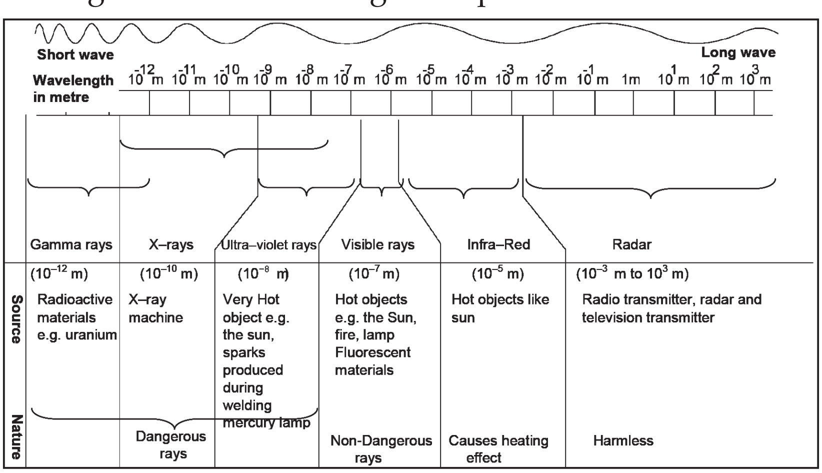
1. Electromagnetic waves are transverse waves in nature.
2. They travel with the speed of light but differ in frequency or wavelength.
3. They obey the laws of reflection and refraction.
4. They are not affected by electric and magnetic fields.

Electromagnetic Spectrum

Activity 10.2

Make a list of different kinds of devices or methods that work based on waves. Classify them based on their common features and the nature of the wave used. Discuss characteristics of the waves used.

The orderly classification of electromagnetic waves according to their wavelength or frequency is called the electromagnetic spectrum. It is the range of all types of electromagnetic waves. We see only the small region of visible light in the electromagnetic spectrum.



Electromagnetic waves

Memory Note

Visible Spectrum and Invisible Spectrum- The spectrum within the range of 400nm to 750nm which strikes the retina is called visible spectrum and the region of the spectrum which does not strike the retina is called an invisible spectrum.

a. Gamma Rays

Gamma rays have a wavelength ranging from 10^{-13} m to 10^{-11} m. These rays are produced by radioactive elements. Gamma rays have the highest frequency as well as highest penetrating power.

Uses

i. Gamma rays are used in the treatment of cancer.

ii. Gamma rays can kill harmful bacteria. So, they are used for sterilising medical equipment.

iii. They are used to produce a photo-electric effect.

b. X- rays

X-rays have a wavelength ranging from 10^{-11}m to 10^{-9}m. These rays are produced when a high-speed electron is blocked by a target. X-rays of a longer wavelength are called soft X-rays. They can pass through flesh but not bones because bones absorb X-rays more than flesh.

Uses

i. X-rays are used in radiography.

ii. 'CAT scan' detective agencies use to detect gold, silver, revolver, etc. sealed in bags.

Fact and Reason

X-ray is used in radiography.

Soft X-rays can penetrate flesh but they are absorbed more by bones. So, they are used in radiography.

c. Ultraviolet rays

Electromagnetic waves whose wavelength is just shorter than violet light is called ultraviolet rays. The wavelength of ultraviolet rays ranges from 5×10^{-9}m to 5×10^{-7}m. These rays are produced from the sun, mercury vapour lamps, etc.

Uses

i. The ultraviolet rays absorbed by the human body produces vitamin D. It helps in the growth of strong bones and teeth.

ii. They are used to detect original gems from fake ones.

iii. Ultraviolet rays kill germs and microorganisms. Hence, they are used to sterilise surgical instruments and drinking water.

d. Visible rays

The wavelength of visible light ranges from 4×10^{-7}m to 8×10^{-7}m ($4000A^o$ to $8000A^o$) and the corresponding frequency is 7.5×10^{14}Hz to 3.75×10^{14}Hz. Our eyes detect visible light. Fireflies, light bulbs, and stars all emit visible light.

Uses

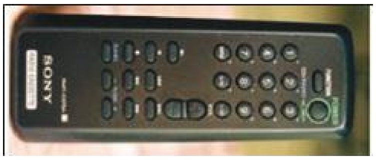
i. It is used for seeing objects

ii. It is used for photography

e. Infrared Rays

Electromagnetic waves whose wavelength is just longer than red light is called infrared rays. The wavelength of infrared rays varies from 8×10^{-7}m to 8×10^{-5}m. Sun, lamp, burning gases, etc. are the sources of infrared rays.

Uses



i. Infrared rays are used in infrared photography.

ii. Any disease in crops changes their heat radiation. So infrared rays are used to detect diseases in crops.

iii. Infrared radiation is commonly used in wireless remote-control units for televisions and short-distance wireless data transfer.

Memory Note

Infrared rays have a long wavelength and they can travel long distances in fog without much scattering. So infrared rays are used in infrared photography.

Memory Note

William Herschel discovered infrared rays.

f. Microwaves

The wavelength of microwaves ranges from 10^{-5}m to 10^{-3}m. These waves are produced by electromagnetic oscillators of high frequency in an electric circuit.

Uses

i. They are used in satellite communications.

ii. Microwaves in microwave oven cook our food.

g. Radio waves

The wavelength of radio waves ranges from 10^{-3}m to 10^{3}m. Radio waves are produced by electromagnetic oscillators of low frequencies. Radio waves of short wavelengths are used in communication including satellite, RADAR, and TV. Longer wavelengths are used in radio broadcasting.

Uses

It is used mainly for communications- radio, television, telephone links, RADAR, etc.

Electromagnetic waves and their sources, nature, and use

Memory note

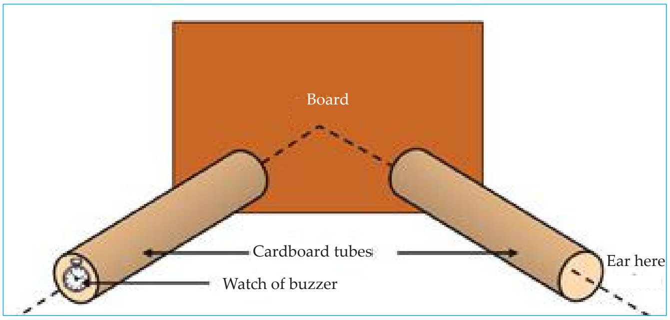
The shorter the wavelength, the higher the frequency. Higher frequencies can deliver more energy, which makes the electromagnetic waves more dangerous.

S.N.	Electromagnetic wave and frequency	Source	Nature	Use
1.	Gamma rays 10^{19}Hz above	Radioactive materials, nuclear reactions	Harmful	Radiography, treating cancer, measuring thickness
2.	X- rays 10^{17}–10^{19}Hz	X-ray tube, stars	Harmful	Taking X-ray-radiography, treating cancer tumours, etc.

3.	Ultraviolet rays $10^{15} – 10^{17}$Hz	The sun, mercury vapour lamp, electric arc	Harmful	Sterilising food, detecting invisible writing or forge
4.	Visible rays $10^{14} – 10^{15}$Hz	The sun, hot objects	Non-dangerous	Seeing, photography, photosynthesis
5.	Infrared rays $10^{11} – 10^{14}$Hz	Very hot objects, especially the sun	Non-dangerous	Night-vision devices, treat muscular strain
6.	Microwaves $10^{9} – 10^{11}$Hz	microwave oven	Harmless	Used in microwave ovens for cooking, radar, etc.
7.	Radio waves $10^{3} – 10^{9}$Hz	radio and TV transmitters, etc.	Harmless	Communications- radio, television, RADAR

Reflection of Sound

Activity 10.4



Take two cardboards and roll them to make tubes as shown in the given figure. Place them on a table facing toward a board by making an angle as shown in the given figure. Put a watch or timer in one tube and put your ear against the open end of the other tube. When the two tubes are making an equal angle with the board then we should hear a loud sound. Sound waves also follow the laws of reflection i.e., angle of incidence of sound = angle of reflection of sound.

Sound wave gets reflected at the surface of a solid or liquid and follows the same laws of reflection of light. The phenomenon in which the sound bounces off a solid or a liquid is called a reflection of sound.

Application of reflection of sound

1. Echolocation or Sound Navigation and Ranging (SONAR)

   On shouting loudly, the same sound reaches the ears after reflecting from the surface of the walls. The repetition of sound because of the reflection of sound waves is called echo. Echolocation is the process of locating an object in its surrounding with the help of reflected sound. The reflection property of sound is used in SONAR (sound navigation and ranging) to measure the depth of the sea and to locate the positions in the sea.

echolocation

Fathometer on ship generates ultrasound waves. Let the downward distance travelled up to the bed of the ocean by the waves be 'd'. When these waves reflect back from the bed of the ocean and are received by the fathometer, the upward distance travelled is also 'd'. Hence the total distance travelled is equal to '2d'. If 'v' be the velocity of waves in water and 't' be the total time taken for the waves to reach back to the fathometer, from the definition of speed,

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Total time taken}}$$

or, $$v = \frac{2d}{t}$$

$\therefore$ $\boxed{d = \frac{v \times t}{2}}$, which gives the depth of the ocean bed.

Activity

Go out of your building and shout in a loud voice. Press the button of the stopwatch when you shout and stop your stopwatch when you listen to the echo. Note the time taken to listen to the echo. Calculate the rough estimate of the distance between you and the reflecting surface.

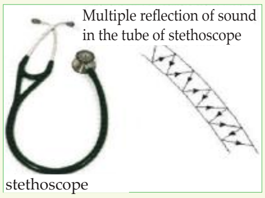
Memory note

Animals like dolphins and bats use echolocation to hunt food and to find objects in their path. Bats can move easily in darkness with the help of reflected ultrasound.

2. The velocity of sound in the air can be calculated with the help of an echo.

Memory note

In a stethoscope, the sound is received by a chest piece and sent to the earpieces by multiple reflections of sound in the tube of the stethoscope.



3 Reflection of sound is used in SONAR to a find the depth of ocean beds.

4. The stethoscope is used to hear the sounds of internal organs. It works on the low of reflection of sound.

Reduction of sound reflection (Acoustic protection)

Some buildings, e.g., concert halls, radio and TV studios, auditoriums, conference halls, etc. require special acoustical design and treatments to transmit clear sound. Sound recorded or transmitted should be free from any kind of listening defects and effects of internal and external noises. The recording studios have porous walls made to reduce reflected sound. In an auditorium or a big hall, excessive reverberation is highly undesirable. The walls and roofs are covered with sound-absorbing materials like rough plaster to reduce reverberation. Sound absorbing material is used as a carpet on the floor. Heavy curtains are used at the entrance, exit, and door. Sound absorbing panels are kept near the stage. The technique or method used to absorb undesirable sound by soft and porous surfaces is called acoustic protection.

wooden planks in the wall of film halls

heavy thick curtains in the auditorium

Fact and Reason

The walls and roofs of an auditorium or a big hall, are covered with sound-absorbing materials.

In an auditorium or a big hall without a good absorber of sound, due to multiple reflections, the observer can hear the sound even after the source has stopped producing it. Sound becomes too blurred and distorted to be heard. So, in an auditorium or a big hall, the walls and roofs are covered with sound-absorbing materials.

Medical imaging

Complete the given activity to learn about medical imaging that is done to reveal internal structures hidden by the skin and bones.

Activity 10.5

Visit a nearby hospital and consult the respective technician related to different medical imaging technologies. If it is not possible to visit hospitals, then watch an audio-video resource related to medical imaging technology. Collect information about different medical imaging technologies that are mentioned below in the given table.

Medical imaging technology	How is the image made?	What type of diagnosis can be done?	Safety directives
X-ray	…………….	……………..	………………
CT Scan	…………….	……………..	………………
Ultrasonography	…………….	……………..	………………

X-ray imaging

Memory note

X-rays were first discovered in 1895 by the German physicist Wilhelm Roentgen. He won the first Nobel Prize in Physics in 1901 for his discovery.

X-rays are the oldest and most frequently used form of medical imaging. X-ray imaging is a process of creating pictures of our internal body parts by detection of x-rays that pass through the body. Such images show the parts of our body in different shades of black and white.

In an X-ray imaging procedure, a machine sends X-ray beams through the body of a person to be diagnosed. The resulting images are recorded either on film or by a digital recorder. In the case of film, the image is developed in the form of a negative through chemical processing. In the case of a digital recorder, the image is developed through computer processing.

Fact and Reason

X-ray images show the parts of our body in different shades of black and white.

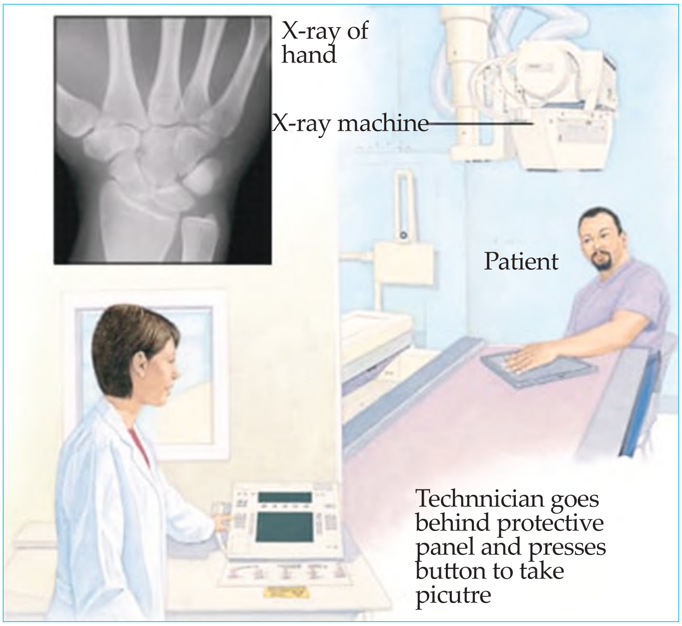
Different tissues absorb different amounts of radiation. Calcium in bones absorbs x-rays the most, so bones look white. Fat and other soft tissues absorb less and look grey. Air absorbs the least, so lungs look black.

Uses of X-ray imaging

The most familiar use of x-rays is checking for fractures (broken bones) or joint dislocation.

i. A bone x-ray makes images of any bone in the body, including the hand, wrist, arm, elbow, shoulder, spine, pelvis, leg, ankle, etc.

ii. It is used to guide orthopaedic surgery, such as spine repair, joint replacement, and fracture reductions.



X-ray machine

iii. To look for injury, infection, arthritis, abnormal bone growths, and bony changes seen in metabolic conditions. For example, chest x-rays can spot pneumonia.

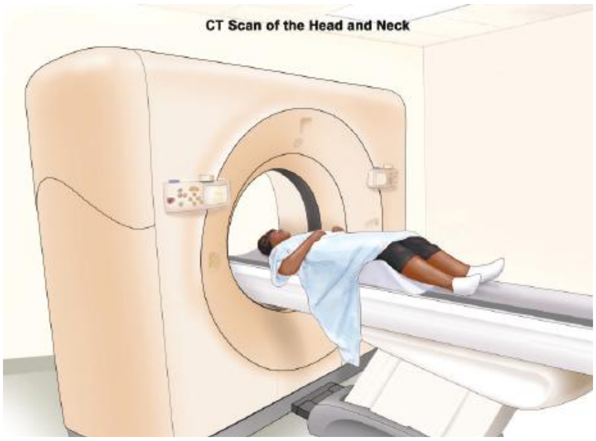
iv. To assist in the detection and diagnosis of bone cancer.

Risks and safety precautions of X-ray imaging

X-rays have enough energy to potentially cause damage to DNA. A person exposed to high-dose X-rays will develop cancer later in life. High levels of radiation exposure can have effects such as cataracts, skin reddening, and hair loss, etc. There are some safety precautions while doing X-ray imaging. The amount of radiation from the X-ray machine for imaging should be well controlled within the safety range. We need to wear a lead apron to protect sensitive parts of our bodies.

CT Scan

A CT scan also known as a CAT scan or computerised axial tomography is a painless diagnostic test. It uses x-rays and computers to create cross-sectional images of bones and tissues inside our bodies. A CT scan is an x-ray procedure of diagnostic test that creates cross-sectional images with the help of computer processing. CT images are more detailed than conventional x-ray images and can reveal bones as well as soft tissue and organs.



CT scan

A CT scanner is a large square or round x-ray machine with a tunnel through the centre. During CT scan patient will have to lie on a table that slowly passes through the tunnel. While doing a CT scan, a giant ring called a gantry rotates around the body of the patient. The x-ray beams will be focused to capture many views of the body at a regular gap of 45° from different angles throughout 360° rotation. When the gantry spins the detectors will send data to a computer that will create cross-sectional images of the bones and soft tissues inside the body of the person. Image slices developed from computer data processing can either be displayed individually in two-dimensional (2D) form, or stacked together to generate a three-dimensional (3D) image. The 3D image can reveal abnormal structures, or help the physician to plan and monitor treatments.

Fact and Reason

CT is being used widely to assess trauma patients in emergency departments. Why?

A CT scan can image complicated fractures, subtle fractures, or dislocations. Any kind of abnormal structures can be clearly seen on a CT scan.

Uses

The doctor may recommend a CT scan to examine the body of a person for identification of blood clots, broken bones, cancerous tumours, infections, internal injuries, and bleeding, and signs of heart and vascular disease.

Ultrasonography

Memory note

Sound above the frequency of 20,000Hz is called ultrasound. Humans cannot hear the ultrasound. Sound below the frequency of 20Hz is called infrasound. The audible sound ranges from frequency of 20Hz - 20Khz.

Ultrasonography is a procedure that uses ultrasound waves to look at tissues and organs inside the body. In this technology, a beam of ultrasound is focused inside the body through a transducer or an ultrasound probe. For this purpose, a transducer is placed on the body surface like the abdomen and slowly moved from one area to another. The transducer receives sound waves bouncing back from the abdomen and projects the image onto the monitor. The ultrasound technician saves these images on the computer.

The ultrasound waves make echoes in ultrasonography that form pictures of the tissues and organs on a computer screen. The computer picture of the area inside the body created by echoes of ultrasound waves is called a sonogram. A sonogram is given to us to share with the doctor for diagnosis and treatment plan.

Activity

Use the locally available resource to make models of technology involved in X-ray imaging, CT scan, and Ultrasonography.

Medical applications of ultrasonography

ultrasonography to check status of foetus

Ultrasound is widely used in medical applications, both as a diagnostic tool and in certain treatments. Following are some of the applications of ultrasonography.

i. To locate the position of the tumour with the help of ultrasound.

ii. An ultrasound scan of the womb helps to obtain an image of a human foetus in the womb.

iii. A concentrated beam of ultrasound can be used to break up kidney stones without surgery.

Answer writing skill

1. Define wave.

A wave is a periodic oscillation by which energy is transmitted through space.

2. What is the application of ultrasound in the medical field?

In the medical field, ultrasonic waves are used as a diagnostic tool and in certain treatments.

3. We cannot see an x-ray. Why?

We cannot see an X-ray because its frequency is not in a visible range.

4. Write differences between X-ray and CT scan

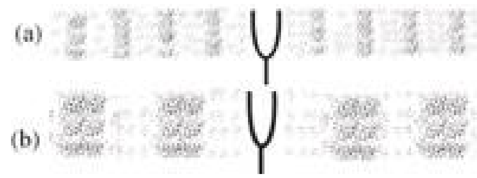
Following are the differences between X-ray and CT scan

S.N	X-ray	S.N	CT scan
1.	It creates two-dimensional images of diagnosed organs.	1.	It creates three-dimensional images of diagnosed organs.
2.	It is used primarily to see bones and to detect cancers and pneumonia.	2.	It is used primarily to diagnose conditions in organs and soft tissues.

5. **Study the given diagram and answer the following.**

   i. **Which wave has a longer wavelength?**

   B has a longer wavelength.



   ii. **Which figure indicates high pitch?**

   Figure A indicates high pitch because it has a shorter wavelength and higher frequency.

6. **CT scans are preferred over x-ray imaging for diagnosis during critical accidents. Discuss the advantages of using CT scan over x-ray imaging.**

   There is a probability of damage to internal organs, blood vessels, soft tissues, brain, etc during critical accidents. A x-ray imaging produces a 2D image only however a CT scan produces detailed images of organs, bones, soft tissue, and blood vessels. So, a CT scan is preferred over x-ray imaging for diagnosis in critical accident cases.

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

   a. What types of waves are produced when a stone is dropped in water?

   i. longitudinal wave ii. electromagnetic wave
   iii. transverse wave iv. both i and ii

   b. What type of wave is a sound wave?

   i. longitudinal wave ii. mechanical wave
   iii. transverse wave iv. both i. and ii.

   c. What is the frequency of ultrasonic waves?

   i. below 20Hz ii. above 20Hz
   iii. below 20kHz iv. above 20kHz

   d. Which of the following electromagnetic radiation has the highest frequency?

   i. X-rays ii. Gamma rays
   iii. Ultraviolet rays iv. Infrared rays

   e. Which of the following technology takes a 360^o image of the internal organ?

i. X-ray
iii. CT scan
ii. ultrasonography
iv. endoscopy

2. Define the following, with examples.

a. Wave
b. Crest
c. Trough
d. Amplitude
e. Wavelength
f. Frequency
g. Time period
h. Medical imaging
i. X-ray imaging
j. CT Scan
k. Ultrasonography

3. Short Answer Questions.

a. Give two examples each of longitudinal wave and transverse wave.
b. The frequency of a wave is 100Hz, what does it mean?
c. Write SI unit of following:
i. amplitude ii. wavelength iii. frequency
d. What is a wave equation?
e. What is the frequency of ultrasound?
f. What is an echo?
g. What is SONAR?
h. What is the electromagnetic spectrum?
i. Write the name of electromagnetic waves at either end of the electromagnetic spectrum.

Step 2

4. Give reason.

a. Sound waves are longitudinal waves.
b. A light wave is an electromagnetic wave.
c. X-rays are harmful but radio waves are not harmful
d. In an auditorium or a big hall, the walls and roofs are covered with sound-absorbing materials.
e. X-ray images show the parts of our body in different shades of black and white.
f. CT is being used widely to assess trauma patients in emergency departments.

5. Differentiate between the following.

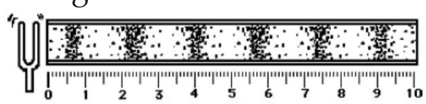
a. Mechanical wave and electromagnetic wave
b. Longitudinal wave and transverse wave
c. X-rays and infrared rays
d. X-ray imaging and CT scan

Step 3

6. Answer the following questions.

a. If the wavelength of a sound wave is reduced to half, what happens to the wave frequency and speed of the wave?

b. Study the given diagram and answer the following.

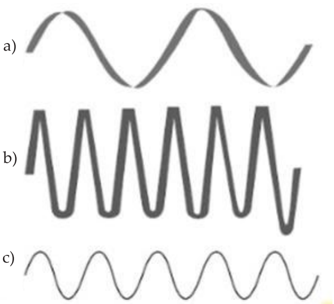


i. What is its wavelength?

ii. If the vibrations are made in one second, what is its frequency?

iii. Find its speed.

c. Three waveforms are shown in the given figure. Observe them and answer the following.



i. Which wave has maximum amplitude?

ii. Identify the waves of the longest wavelength and the shortest wavelength.

iii. If all the waves occur in one second then which has the highest frequency.

d. Write two uses of each of the following waves in electromagnetic spectrum

i. Gamma-ray　ii. X-rays　iii. Ultraviolet rays

iv. Visible light　v. Infrared rays　vi. Microwaves

vii. Radio waves

e. Lets suppose your house is in a busy street of a city and you really need a nice sleep. How can you get rid of noises from the traffic, people and horns?

f. Despite the fact that excessive exposure to x-ray can cause cancer, it is widely used in hospitals. Discuss the reasons for its use. Also enlist some uses of x-ray imaging.

g. X-rays are harmful waves for it can cause cancer. Doctors are bound to be exposed to x-rays frequently. How do they avoid x-ray exposure? Discuss the safety measures they follow.

h. CT scan is actually a huge X-ray machine that pierce us from multiple angles. Discuss how this technology can be used in medical fields?

i. Ultrasonography is simply a burst of higher frequency soundwaves. How can we use it in medical fields?

7. Numerical

a. The frequency of a wave is 50Hz. Find out the time period.

[Ans: 0.02 s]

b. Find the frequency of the wave whose time period is 0.01s.

[Ans: 100 Hz]

c. The speed of sound in air is 332m/s. Find the wavelength of a sound wave having a frequency of 10Hz. [Ans: 33.2 m]

d. A person standing near a cliff shouts and hears the echo after 2s. If the velocity of sound in air is 332 m/s, find the distance between him and the cliff. [Ans: 332 m]

e. A radar signal is reflected by an aeroplane and received 2×10^{-5}s after it was sent. If the speed of the wave is 3×10^{8}m/s, how far is the aeroplane? [Ans: 3×10^{3}m]

Step 4

8. Long question answers.

a. Derive a relation between frequency (f) and time period (T) of a wave.

b. Have you ever been to hospital for x-ray? How does x-ray imaging work?

c. CT scan is a complex machine that uses a rotating x-ray tube and rows of detectors. How does it actually produce detailed internal images of the body? Describe the technology.

d. Ultrasonography is an act of passing a beam of ultrasound through our body. How does it makes images of our internal organs? Discuss the physics behind it.

e. Three imaging technologies are, namely, X-ray, CT scan, and Ultrasonography. Which imaging technology will you suggest to individuals with different kinds of diagnostic and treatment problems? Make a list for each of the three technologies.

f. How has electromagnetic waves affected modern life style? Research and make a short report.

UNIT

11 ELECTRICITY

ESTIMATED TEACHING PERIODS

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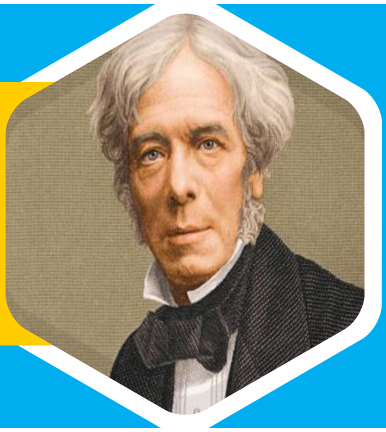


Michael Faraday
(1791-1867)

Curriculum issued by CDC

- Introduction to current electricity
- Introduction and differences between electromotive force and potential difference
- Introduction to electric resistance
- Relation among voltage, current and resistance
- Numerical problems related to V=IR
- Series and parallel combination of loads (introduction, characteristics and numerical)
- Introduction to lighting and heating effects of current electricity
- Introduction to electric power and numerical problems related to it.
- Electricity consumption and electric bill
- Control measures of load shedding and loss of electricity

Learning outcomes

After completion of this unit, students will be able to:

- introduce current electricity and solve numerical problems related to it.
- introduce and differentiate between electromotive force and potential difference.
- introduce resistance and solve numerical problems related to it.
- introduce types of combination of loads, explain their characteristics and solve related numerical problems.
- introduce lighting and heating effects of current electricity.
- introduce electric power and solve related numerical problems.
- solve the numerical problems related to electricity consumption and electric bill.
- explain the control measures of load shedding and loss of electricity.

Terms and terminologies

1. Current electricity:	The form of energy produced due to the continuous flow of electrons through a conductor is called current electricity.
2. Source of electricity:	A device that continuously generates electricity is called a source of electricity.
3. Conductor:	The substances which allow the electrons to flow through them are called conductors.
4. Insulator:	The substances which do not allow the electrons to flow through them are called insulators.
5. Charge:	The electric property of electrons and protons is called charge.
6. Electric current:	The rate of flow of charge through a conductor is called electric current.
7. One ampere current:	When 1 coulomb of charge flows through a conductor in 1 second, then the current flowing through it is said to be 1 ampere.
8. Resistance:	The property of a conductor by which it opposes the flow of electrons through it is called its resistance.
9. Electric circuit:	A continuous path made by connecting an electric source, electric load, switch, etc. with the help of a conducting wire is called an electric circuit.
10. Conventional current:	Conventionally, in an electric circuit the direction of electric current is taken from the positive terminal to the negative terminal, which is opposite to the direction of the flow of electrons.
11. Electromotive force (e.m.f.):	Electromotive force of a cell is defined as the energy supplied by the cell to drive a unit charge around the whole circuit.
12. Potential difference (p.d.):	The potential difference between any two points in an electric circuit is defined as the amount of work done in moving unit charge from one point to the other point.
13. Ammeter:	An ammeter is a device to measure the electric current flowing in a circuit.
14. Voltmeter:	The instrument which measures the potential difference across any two points in a circuit is called a voltmeter.
15. One volt:	If 1 joule of work is done in moving a unit charge from one point to the other point, then the potential is called 1 volt.
16. Ohm's law:	According to Ohm's law, "When the physical conditions like temperature, length of wire, etc. remain constant, then the

	electric current (I) flowing through a conductor is directly proportional to the potential difference across its ends, provided that the physical conditions like temperature, length of wire, etc. do not change.
17. One ohm:	When a current of 1 ampere flows through a conductor by applying a potential difference of 1 volt then the resistance of a conductor is one ohm.
18. Heating effect:	The process in which wire heats up when current flows through it is called heating effect.
19. Heating element:	The wire of high resistance and high melting point which converts electrical energy into heat energy is called a heating element.
20. Series connection of resistors:	When two or more resistors in a circuit are connected from end to end then the resistors are said to be connected in a series connection.
21. Parallel connection of resistors:	When two or more resistors in a circuit are connected between two common points then the resistors are said to be connected in parallel connection.
22. Electric power:	Electric power is the rate that determines electrical energy which is transferred into other forms of energy per unit of time.
23. One kilowatt-hour:	One Kilowatt-hour (kW h) is the commercial unit to measure the electric energy consumed when electric appliances of power 1 kW run for an hour in a domestic circuit.

Introduction

Elements are made up of atoms. Each atom has electrons revolving around its nucleus. In the case of metals like silver, copper, aluminium, etc., electrons in them can flow continuously when connected to a source of electricity. The form of energy produced due to the continuous flow of electrons through a conductor is called current electricity. A device that continuously generates electricity is called a source of electricity. For example, a dry cell, generator and dynamo.

Memory Note

Lightning is a natural source of static electricity.

Charge

The electric property of electrons and protons is called charge. The SI unit of charge is coulomb (C). The charge of an electron is 1.6×10^{-19}C.

One coulomb charge

1.6×10^{-19}C = Charge of 1 electron

$1C = \frac{1}{1.6 \times 10^{-19}}$ electrons charge = about 6.24×10^{18} electrons

Current

The rate of flow of charge through a conductor is called an electric current. Current is denoted by the letter 'I'. It is a scalar quantity. If Q is the charge which is flowing through a conductor in time t, then the current I is given by

$$\boxed{I = \frac{Q}{t}}$$

The SI unit of current is ampere. It is denoted by 'A'. Current can be measured by connecting ammeter in series in electric circuit.

Multiple units of current	Submultiple units of electric current
1 kiloampere (kA) = 10^3A	1 milliampere (mA) = 10^{-3}A
1 Megaampere (MA) = 10^6A	1 microampere = 10^{-6}A

Fact and Reason

Current is a scalar quantity, why?

Electric current has a magnitude and a direction in a closed circuit. It may seem that current is a vector. A vector always obeys the laws of the addition of vectors. But current doesn't obey it and ordinary laws of algebra are used to add currents. So current is a scalar quantity.

1A current

$$\boxed{1 \text{ ampere (A)} = \frac{1 \text{ coulomb (C)}}{1 \text{ second (s)}}}$$

When 1 coulomb of charge flows through a conductor in 1 second, then the current flowing through it is said to be 1 ampere (A).

SOLVED NUMERICAL-11.1

A current of 0.5A is drawn by a filament of an electric bulb for 10 minutes. Calculate the amount of electric charge that flows through the circuit.

Solution

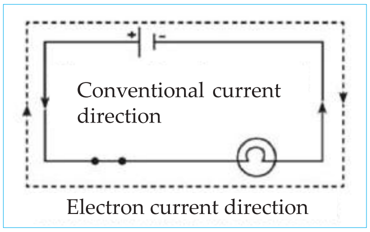
Here, current drawn by a filament (I) = 0.5A time (t) = 10 min = 10 × 60s = 600s

Electric current through a conductor is given by

$$I = \frac{Q}{t}$$

$$\text{or,} \quad Q = I\,t = 0.5 \times 600 = 300C$$

Direction of current in a closed circuit



In an electric circuit, there is a flow of electrons. However, electrons were not known at the time when the phenomenon of electricity was first observed. So, electric current was considered to be the flow of positive charges and the direction of flow of positive charges was taken to be the direction of electric current. Conventionally, in an electric circuit, the direction of the electric current is taken from the positive terminal to the negative terminal, which is opposite to the direction of the flow of electrons.

Electromotive force (e.m.f.) and potential difference (p.d.)

Activity

Discuss and find the answer to the given questions.

1. What makes it possible for the flow of water from the water tank on top of the roof to the tap in your home?
2. What is the role of a water-lifting pump for the flow of water through pipes in the water supply system of your home?

Water flows from the tank at top of the roof with a certain amount of potential energy, just as charges in a circuit start with high electrical potential at the battery. As the water begins to flow down through pipes, its potential energy drops, just as the electrical potential of charges drops as they travel through the circuit. At the bottom of the water pipe, the potential energy is minimum, and work must be performed to pump it to the water tank to travel through the pipe again. Similarly, in an electrical circuit, the electromotive force (e.m.f.) of a source performs work on the charges to bring them to a higher potential after their trip through the circuit.

1. **Electromotive force (e.m.f.)**

A cell in a circuit does some work for the continuous flow of electrons. To do work, the cell utilises the chemical energy present in it. Electromotive force is the energy transformed into electrical energy per coulomb of charge flowing in a circuit.

$$\text{e.m.f.} = \frac{\text{energy converted}}{\text{charge}}$$

The SI unit of e.m.f. is JC^{-1} or volt (V).

Memory note

E.m.f. of a cell is defined as the energy supplied by the cell to drive a unit charge around the whole circuit. There is 1.5V written on a dry cell. It means that 1.5 joule of work is to be done by the cell when a charge of one coulomb moves from the positive terminal to its negative terminal through the circuit.

2. **Potential difference (p.d.)**

The potential difference between any two points in an electric circuit is defined as the amount of work done in moving unit charge from one point to the other point. Potential difference is abbreviated as p.d. It is a scalar quantity.

$$\boxed{\text{e.m.f.} = \frac{\text{Work done}}{\text{Charge}} = \frac{W}{Q}}$$

SI unit of potential difference

The SI unit of electric potential is JC^{-1}, called volt (V).Voltage can be measured by connecting volt metre in parallel in electric circuit.

Memory note

Alessandro Volta (1745-1827), an Italian physicist, is best known for the development of the voltaic battery. SI unit of voltage, the volt is named after him.

1 volt

$$1 \text{ volt (V)} = \frac{1\text{J Work done}}{1\text{C Charge}}$$

Thus, if 1 joule of work is done in moving a unit charge from one point to the other point, then the potential is called 1 volt.

Fact and Reason

An electric load is connected with two wires for its working

Electric current flows through an electric circuit when there is a potential difference. Out of the two wires connected to the load, one is at a high potential and another is at a low potential. If the two wires are at the same potential, the electric current does not flow through the load and the load does not work.

SOLVED NUMERICAL- 11.2

Calculate the work done in a circuit in which an electric charge of 12 coulombs passes when a potential difference of 15V is applied.

Solution,

Here, potential difference (V) = 15V

Electric charge (Q) = 12C

According to the formula,

$$\text{Electric potential (V)} = \frac{\text{Work done (W)}}{\text{Charge (Q)}}$$

or, $W = VQ$

or, $W = VQ$

or, $W = 15 \times 12 = 180\text{J}$

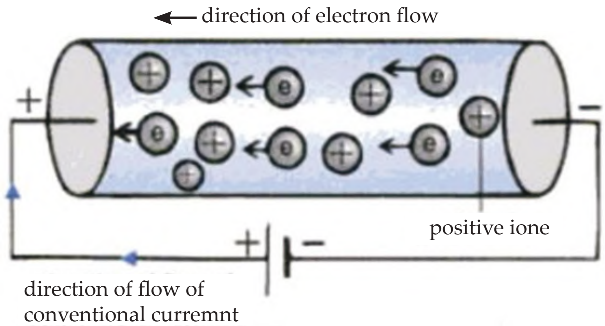
Thus, the work done is 180J.

Fact and Reason

The potential difference of a source of electric current is always less than its e.m.f., why?

A source of current like a cell has internal resistance. Some energy from an electric source is wasted in overcoming this internal resistance. The rest of the energy is used to move the charge through the external resistance. i.e., the available energy is less than the energy generated. So, the potential difference of a source of electric current is always less than its e.m.f.

Electrical Resistance



When electrons move from one part to the other, they collide with other electrons and with the positive ions present in the conductor. Due to these collisions, there is some obstruction to the flow of electrons through the conductor. These collisions are responsible for the slowdown of the speed of the electrons. Thus, even as the conductor conducts electricity, at the same time it offers some obstructions to the flow of electrons. The property of a conductor by virtue of which it opposes the flow of electrons through it is called its resistance. The SI unit of resistance is Ohm (Ω). Resistance is denoted by R. It is a scalar quantity.

Fact and Reason

The resistance depends on the arrangement of atoms and the configuration of electrons around the nucleus of an atom of the conductor.

When the collisions suffered by drifting electrons in a conductor increase then the resistance offered by the conductor also increases. So, the resistance depends on the arrangement of atoms and the configuration of electrons around the nucleus of an atom of the conductor.

Higher units of resistance

kilo-ohm (kΩ) = 10^3 Ω

mega-ohm (mΩ) = 10^6 Ω

giga-ohm (GΩ) = 10^9 Ω

Memory note

George Simon Ohm (1789-1854), a German Physicist, gave the Ohm's law. SI unit of resistance, the ohm is named after him.

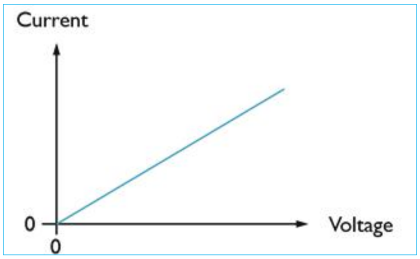
Ohm's law

Activity

Make a circuit by connecting dry cells, a bulb, ammeter, and a voltmeter. Change the number of dry cells and measure corresponding readings on voltmeter and ammeter. Fill your data in a table as shown below.

Number of batteries	Voltage	Current
1	.....	....
2	.....	....

Plot the value of voltage and corresponding current in a graph. What result do you obtain from this activity?



In the above activity, adding dry cells increases the current in a circuit, too. The brightness of the bulb also increases with an increase in current passing through the circuit. When we plot a graph between I and V, the graph becomes a straight line. This activity shows that as the voltage increases, the current also increases. According to Ohm's law, "When the physical conditions like temperature, length of wire, etc. remain constant, then the electric current (I) flowing through a conductor is directly proportional to the potential difference across its ends."

i.e., $I \propto V$ (At constant physical conditions)

or, $V \propto I$

$\therefore$ $\boxed{V = IR}$

Where R is a constant called resistance of the conductor. The value of resistance depends on the nature, length, temperature, and area of the cross-section of the conductor.

Memory note

In 1826, a German physicist George Simon Ohm, by his experiments, established a relationship between electric current (I) and potential difference (V) in an electric circuit.

1 Ohm resistance

According to Ohm's law

$$\text{Resistance (R)} = \frac{\text{Potential difference (V)}}{\text{Current (I)}}$$

When the potential difference (V) = 1 volt, the current (I) = 1 ampere then the resistance of conductor (R) = 1 ohm

i.e. $\boxed{1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ ampere}} \quad \text{or } 1\ \Omega = \frac{1\ \text{V}}{1\ \text{A}}}$

When a current of 1 ampere flows through a conductor by applying a potential difference of 1 volt then the resistance of a conductor is one ohm.

SOLVED NUMERICAL- 11.4

A current of 4A flows through a car headlamp when it is connected to the car battery, providing a voltage of 12V across the lamp. Find the resistance of the lamp.

Solution,

Here, Potential difference across the lamp (V) = 12V

Electric current (I) = 4A

According to the formula, $R = \frac{V}{I} = \frac{12V}{4A} = 3\Omega$

The resistance of the lamp is 3Ω

Factors affecting the resistance of a conductor

1. **Length of the conductor**

It is found that the resistance of a wire increases with an increase in its length.

i.e., $\boxed{R \propto l}$

2. **The cross-sectional area of the conductor**

The resistance of a conductor is inversely proportional to its area of cross-section.

i.e., $\boxed{R \propto \frac{1}{A}}$ Where R is the resistance and A is the area of cross-section of the conductor.

Memory note

If the area of cross-section of the conductor is doubled, the resistance gets halved. If the area of cross-section of a conductor is halved, its resistance also gets doubled.

Fact and Reason

The filament of a lamp is made of very fine wire.

The resistance of a conductor is inversely proportional to its cross-sectional area. i.e., $R \propto \frac{1}{A}$. The fine filament of a lamp has a very small cross-sectional area. It offers high resistance to convert electric energy into heat and light energy. So, the filament of a lamp is made of very fine wire.

3. **Temperature**

   The resistance of all pure metals increases with a rise in temperature and decreases with a decrease in temperature.

4. **Nature of materials in circuit**

   Metals like copper, silver, aluminium, etc. have very low resistance at room temperature. Whereas Nichrome, constantan, tungsten, etc. have very high resistance.

Heating Effect

When electric current flows through a wire, the wire heats up. This is called the heating effect of an electric current. The heating effect depends upon the resistance of a conductor. The greater the resistance of the wire, the greater the amount of heat produced. The wire of high resistance and high melting point which converts electrical energy into heat energy is called a heating element. For example, nichrome.


Iron


Electric kettle


Geyser


Immersion rod


Room heater

Memory note

Fuse works on the principle of heating effect of electric current.

Application of heating effect of electric current

Electric heater, electric stove, immersion rod, water heater, iron, etc. are examples of applications of heating effect of electric current.

Electric heater

An electric heater has a coil of the nichrome alloy. Nichrome is an alloy made of 80 % nickel and 20% chromium. It is silvery-grey in colour, corrosion-resistant, and has a high melting point of about 1,400°C. When an electric current is passed through the two ends of the wire, it produces heat and the temperature reaches up to 800°C to 1000°C. It does not oxidise easily at high temperatures.

Fact and Reason

A nichrome coil is used in an electric heater, why?

A nichrome wire offers high resistance to the current passing through it. It gets heated to a high temperature in a short time to convert electrical energy into heat energy. During such conversion at a high temperature of about 900°C, it does not get oxidised. So, a nichrome coil is used in an electric heater.

Connection of Resistors (Electrical devices)

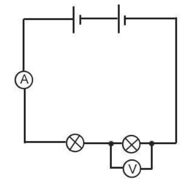
In our domestic circuit, there are several electric loads like bulbs, TV, fan, refrigerator, electric motor, etc. Such loads also offer resistance to the flow of electrons. They are connected to the same main power supply to our home. There are two ways to connect two or more resistors or electrical devices together in a circuit. They are series connections and parallel connections.

1. Series Connection

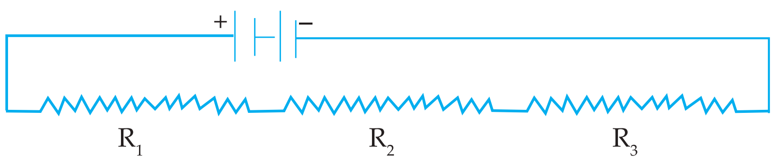
In a series circuit, two or more appliances are connected to provide a single conducting path for current. When two or more resistors in a circuit are connected from end to end to get the same current flowing through each of them in succession then the resistors are said to be connected in a series connection. For example, the decorative lights used in DEEPAWALI, Christmas lights, etc.

Activity

Connect two bulbs in series as shown in the given circuit diagram and measure the electric current flowing in the circuit and potential difference across each resistor by using a multimeter.



Expression of the equivalent resistance in a series connection of resistors



Series combination of resistances

In the given circuit diagram, there are three resistors of resistance R_1, R_2, and R_3 that are connected in series with a source of potential difference 'V'. Let, a current 'I' flow through the circuit.

From Ohm's law, the potential differences across the three resistances are given by

$V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$

If R be the equivalent resistance of the series connection, then on applying a voltage 'V' across it, the same current 'I' must flow through it.

So, $V = IR$

But $V = V_1 + V_2 + V_3$

or $IR = IR_1 + IR_2 + IR_3$

$\therefore$ $\boxed{R = R_1 + R_2 + R_3}$

Characteristics of series connection of resistors

i. There is a single conducting path for all resistors in a series circuit.

ii. Current through different resistors is the same but voltage is divided.

iii. The total resistance in a series circuit is equal to the sum of the separate resistances in the circuit.

Fact and Reason

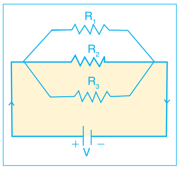
The series arrangement of the load is not used for the domestic circuit.

There are several electric loads like light, fan, TV, refrigerator, etc. in a domestic circuit. If they are connected in series, they cannot be switched 'on' or 'off' separately and cannot be used independently as per the requirement. So, a series arrangement of the load is not used for the domestic circuit.

2. Parallel Connection

Activity

Connect three resistors in parallel as shown in the given figure and measure the electric current flowing through each bulb and the potential difference across them by using a multimeter.

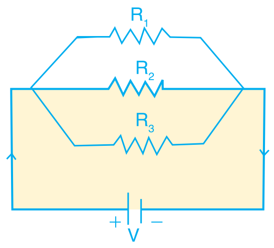


Memory Note

Parallel connection of loads is used in the domestic circuit.

In a parallel circuit, two or more appliances are directly connected to a source of electricity. Each resistor has an individual path for the flow of current. Thus, electric current divides in a parallel connection of resistors. When two or more resistors in a circuit are connected between two common points then the resistors are said to be connected in parallel connection.

Expression of the equivalent resistance in a parallel connection of resistors



Parallel combination of resistances

In the given figure, three resistances R_1, R_2 and R_3 are connected in parallel with a source of potential difference 'V'. Let a current 'I' flow through the circuit. The current 'I' at point 'A' is divided into three currents as I_1 along with R_1, I_2 along with R_2 and I_3 along with R_3.

Now, from Ohm's law, the individual current through each resistor is given by

$I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$, $I_3 = \frac{V}{R_3}$ $(\because I = \frac{V}{R})$

These three currents recombine at point 'B' to give the same current 'I'.

i.e., $I = I_1 + I_2 + I_3$

If R be the equivalent resistance of the parallel connection, then

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\therefore \boxed{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Characteristics of parallel connection of resistors

i. There is a separate conducting path for all resistors in a parallel circuit.

ii. The potential difference across the individual resistor is the same.

iii. The current through different resistors is different.

Fact and Reason

Bulbs can be used separately in parallel connection of loads.

Electric loads are connected in parallel in a domestic circuit. Each bulb has a separate conducting path for current. So, in our domestic circuit, when one bulb breaks, the other bulbs in the circuit remain lit. Each bulb can be used separately.

Activity

Use a dry cell, bulb switch, and conducting wires to make an electric circuit. Connect an ammeter and a voltmeter in the circuit to measure electric current and the corresponding potential difference. Change the number of dry cells and note the values of electric current and potential difference.

SOLVED NUMERICAL- 11.4.

The resistors are first connected in series and then in parallel. Calculate their equivalent resistances in both cases.

Solution:

Here, Resistance of the first resistance (R_1) = 10Ω

Resistance of the second resistance (R_2) = 15Ω

Resistance of the third resistance (R_3) = 20Ω

In series circuit, the equivalent resistance is given by

$R = R_1 + R_2 + R_3$ Substituting the value of R_1, R_2 and R_3

$R = 10 + 15 + 20 = 45$

In a parallel circuit, the equivalent resistance is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

or, $\frac{1}{R} = \frac{1}{10} + \frac{1}{15} + \frac{1}{20} = \frac{6+4+3}{60} = \frac{13}{60}$

$\therefore \quad R = \frac{13}{60} = 0.216\Omega$

Electric Power

Electric power is the rate that determines electrical energy which is transferred into other forms of energy per unit time. The SI unit of power is the watt. For example, the power of a bulb is 20W, the power of a fan is 150W, etc. Power can be determined by the formula as

$$\text{Electric power (P)} = \frac{\text{electric energy}}{\text{time taken}} = \frac{W}{t} \quad \text{....................i}$$

From the definition of potential difference,

$$\text{Potential difference (V)} = \frac{W}{Q}$$

or, $W=VQ$

Now putting the value in equation (i),

$$\text{Electric power } P = \frac{VQ}{t}$$

$\therefore \quad \boxed{P = IV} \qquad \text{since } I = \frac{Q}{t}$

SOLVED NUMERICAL-11.5

There is a potential difference of 12V across a bulb and a current of 3A flows through it. Find the power of the bulb.

Solution:

The potential difference across the bulb (V) = 12 V

Current through the bulb (I) = 3 A

Using formula to calculate the power of an electric load

$P = IV$

or, $P = 3 \times 12$

$\therefore \quad P = 36W$

The power of the electric bulb is 36W.

Calculation of the Cost of Electric Energy Consumed

A metre that measures the electric energy consumed by various electric appliances in the unit of a kilowatt-hour is called a kilowatt-hour metre. It is simply called an electric metre. The electric metre is connected before the main switch box. The total current drawn by all the appliances in the house passes through the metre and it gives the reading of energy consumed.

kilowatt-hour meter

Kilowatt-hour (kW h) is the commercial unit to measure the electric energy consumed when electric appliances of power 1kW run for an hour in a domestic circuit.

1 kilowatt hour = 1000 watt×1 hour

$1kWh = 1000W \times 3600s$

$= \quad 3.6 \times 10^6 Ws$

$= \quad 3.6 \times 10^6 J$

$= \quad 3.6MJ$

Electrical appliances convert electric energy into other forms of energy. The amount of electric energy converted depends on the power of the appliances and the time for which they are switched on.

$$\text{Power of an appliance} = \frac{\text{electric energy}}{\text{time}}$$

$$\boxed{\text{Energy converted} = \text{power of an appliance} \times \text{time}}$$

We pay for the electric energy consumed by the electrical appliances in our homes. For this, the electric metre readings at the beginning and end of a month are noted to calculate the electric energy consumed in a month. The difference in the reading gives the value of electric energy consumed in that month in units (kW h). The number of units is multiplied by the rate per unit to calculate the cost of a month. The electric energy consumed by the electric appliances in a house is given by using a formula.

$\boxed{\text{Electric energy consumed} = P \times n \times t}$ units (kW h)

Where 'P' is the power of an electric appliance expressed in kilowatt (kW).

'n' is the number of a particular appliance

't' is the time of use the appliance expressed in an hour (h)

Cost = number of units (kW h) × rate per unit

Memory Note

Things to remember while solving the problems related to electric power consumption.

i. The power of the appliances must be expressed in kilowatt (kW).

ii. The time of use of different devices must be expressed in hours.

SOLVED NUMERICAL- 11.6.

In a house, there is a daily use of 10 CFL each of 20W for 5 hours, a rice cooker of 900W for 1 hour, and a LED TV of 50W for 4 hours. Calculate the monthly bill if the rate is Rs. 10 per unit.

Solution

Energy consumed by CFL

Given, Power of a CFL (P) = 20W = $\frac{20}{1000}$kW = $\frac{2}{100}$ kW = 0.02 Kw

Number of CFLs (n) = 10

Time of use (t) = 5 hours

Now, the electric energy consumed by CFL in a day = $P \times n \times t$

= 0.02x10x5

= 1 units (kWh)

Energy consumed by rice cooker

Given, Power of the rice cooker = 900W = $\frac{900}{1000}$ kW = $\frac{9}{10}$ kW

Number of rice cookers (n) = 1

Time of use (t) = 1 hours

Now, the electric energy consumed by rice cooker in a day = $P \times n \times t$

$= \frac{9}{10} \times 1 \times 1 = 0.9$ units (kW h)

Energy consumed by TV

Given, Power of TV (P) = 50W = $\frac{50}{1000}$ kW = $\frac{5}{100}$ kW

Number of TVs (n) = 1

Time of use (t) = 4 hours

Now, the electric energy consumed by TV in a day = = $P \times n \times t$

$= \frac{5}{100} \times 1 \times 4 = 0.2$ units (kW h)

Total electric energy consumed in a day = 1+ 0.9 + 0.2 = 2.1 units

Therefore, Total electric energy consumed in a month = 30 × 2.1 = 63 units

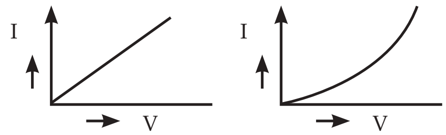
The bill of a month = Total units × rate = 63 × 10 = Rs. 630

Answer writing skill

1. **Define the electric resistance of a conductor.**

   Electric resistance is the property of a conductor due to which it opposes the flow of current through it.

2. **Identify the V-I graph for ohmic and non-ohmic material.**



   The first graph is for the ohmic conductor.

3. **Why are domestic circuit appliances connected in parallel with voltage sources?**

   The domestic circuit appliances are connected in parallel with voltage sources to supply the same voltage to each device and to use them separately.

4. **Differences between emf and pd.**

Differences between e.m.f. and p.d. are:

S .N.	e.m.f.	S .N.	p.d.
1.	e.m.f. is the energy supplied by a cell or a source to send a unit charge once round the complete circuit.	1.	p.d. is the energy spent in sending a unit charge through the external resistance of the circuit.
2.	It includes the energy required to overcome the internal resistance of the cell.	2.	It does not include the energy required to overcome the internal resistance of the cell.
3.	It is independent of the resistance of the circuit.	3.	It is proportional to the resistance between the given points.

5. **How much energy is given to each coulomb of charge passing through a 12V battery?**

Solution

Here, potential difference (V) = 12V

Charge (Q) = 1C

Work done (W) =?

Now, Electric potential = $\frac{\text{Work done}}{\text{Charge}}$

or, $V = \frac{W}{Q}$

or, $12 = \frac{W}{1}$

$\therefore$ W = 12J

Thus, the work done in moving each coulomb charge is 12J.

6. **There are three bulbs each having the same power. They are connected in series in an electric circuit. In another circuit, there is another set of three bulbs of the same power connected in parallel to the same source. Will the bulbs in both circuits glow with the same brightness? Justify your answer.**

When a set of three identical bulbs are connected in series to a source and another set of identical bulbs to the first set is connected in parallel, then the bulbs in parallel will glow with more brightness. This is because each bulb gets the same voltage in parallel connection whereas voltage is distributed among three bulbs in series connection.

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. How many electrons produce one coulomb charge?

i. about 6.24×10^{19} iii. about 6.42×10^{18}

ii. about 6.24×10^{18} iv. about 6.42×10^{19}

b. Which of the following is the characteristic of a series connection of resistors?

i. The current through different resistors is same

ii. The potential difference through the different resistors is same

iii. The potential difference across the resistor increases

iv. The current through the resistor decreases

c. What is the resistance of an iron that draws a 4A current when connected to 220V mains?

i. 5.5 Ω   ii. 55 Ω

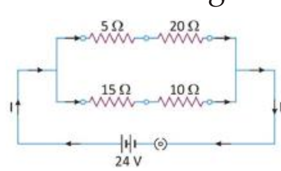
iii. 550 Ω   iv. 55.5 Ω

d. What is the power rating of a rice cooker connected to a 220 V domestic circuit when it carries 4.1A?

i. 90.2 W   ii. 53.6 W

iii. 536 W   iv. 902 W

e. What is the value of total current flowing in the circuit given alongside?



i. 0.48 A   iii. 1.92 A

ii. 0.96 A   iv. 0.52 A

2. Define the following, with examples.

a. Charge   b. 1 coulomb charge

c. Electric current   d. 1 A current

e. 1 volt   f. Resistance

g. 1 ohm

h. Heating effect

i. Heating element

j. 1 kWh

3. Short Answer Questions

a. Write SI unit of the following:

i. electric charge

ii. e.m.f.

iii. p.d.

iv. current

v. electrical resistance

b. What is an electric circuit?

c. What is the conventional direction of electric current?

d. Name two metals that have low resistance.

e. On what factors does the resistance of a conductor depend?

f. State the law which relates the current in a conductor to the potential difference across its ends.

g. What is electric power?

h. Give an example each of a series connection and parallel connection of resistors.

i. Electromotive force of a dry cell is 1.5 Volt. What does it mean?

Step 2

4. Give reason

a. An electric load is connected with two wires for its working.

b. Terminal voltage is less than the e.m.f. of a cell.

c. Nichrome wire is used as a heating element in an electric heater.

d. The filament of a lamp is made of very fine wire.

e. Electric loads are connected in parallel in the domestic circuit.

f. In our domestic circuit, when one bulb burns out, the other bulbs in the circuit remain lit.

5. Differentiate between the following.

a. Series connection of resistor and parallel connection of resistor

b. e.m.f. and p.d

Step 3

6. Answer the following questions.

a. What will happen to the resistance of a conductor if

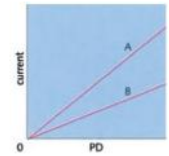
   i. the length of the wire is halved?

   ii. the area of cross-section of the conductor is doubled?

   iii. the temperature of the conductor is increased?

b. Let's suppose you have two bulbs of same power and two cells of same voltage and resistance. How can we connect them for maximum brightness? How should it be connected to make them glow for longer? Draw an electric circuit to show it.

c. The graph line A and B on the given figure are for two different conductors. Which conductor has more resistance? Write with a reason.



d. We do not use series connection of loads in our house but we use it in decoration lights. What might be the reasons for not using series connection in house but in decoration lights?

e. Bulbs are connected parallelly in house but not in street lights. There must be some advantages of connecting bulbs parallely in house and some disadvantages of connecting street light parallelly. What might be those advantages and disadvantages? Discuss.

f. Look at the given figure. Why doesn't it get an electric shock? In which condition do birds sitting on a cable get an electric shock?

g. Explain in short about the factors that affect the resistance of conductors.

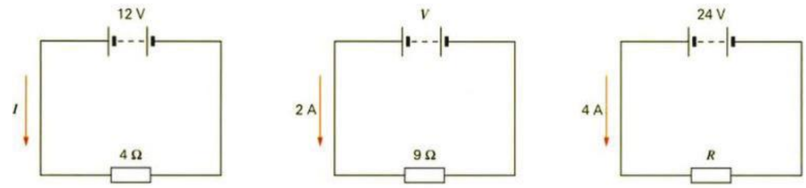
h. If we add more salt in a salt solution the brightness of bulb connected to the solution keeps increasing. What might be the reason?

i. One pin of electrical device is connected to live wire and another to neutral wire in domestic circuit? Why? What is usual potential differences between these two wires?

7. Numerical Problems.

a. What amount of charge is delivered if a current of 500mA flows for 10s. [Ans 5C]

b. Use Ohm's law to find the unknown value in the given figures.



[Ans: 3A, 18 V, 6 Ohm]

c. The resistance for the heater of an electric kettle is 40 ohm. What is the current flowing through the heater when it is connected to a 240V supply? [Ans: 6A]

d. A resistor is connected across a battery of 3V. A current of 0.5A passes through the resistor. Find the total power produced by the battery. [Ans: 1.5W]

e. A 200W bulb is lighted for six hours. How much energy is consumed? If the cost of a unit is 12 Rs., find the total cost in a month. [36 units, Rs. 432]

f. 10 bulbs of 60W each and two heaters of 1500 watt each are used for two hours daily. Find the units of electricity consumed in 30 days. [Ans: 216 units]

g. In a hostel, 20 LED bulbs of 15W are used 5 hours daily, 10 electric heaters each of 2kW are used continuously for 180 minutes in a day, 20 water heaters of 1500W are used for 5 minutes every day, and 20 irons of 800W are used for 30 minutes every week. What will be the consumption of electricity in a month? What change in the total consumption will occur when all heaters of 2kW are replaced by 1kW heaters? If the cost of a unit is 12 Rs. How much in Rupees of bill can be saved in a month? [Ans: 1952 units, Rs. 10,800]

h. There are two resistors each of resistance 1Ω and 2Ω connected in series across 12V battery. Find:
   i. the equivalent resistance of the series connection.
   ii. the current flowing through each of the resistors.
   iii. The potential difference across each of the resistors.

[Ans: 3Ω, 4A, V_1= 4V, V_2 = 8V]

i. There are two resistors each of resistance 1kΩ and 2kΩ connected in parallel across 12V battery. Find

i. the equivalent resistance of the circut.

ii. the current flowing through the circut.

iii. the current through each of the resistors.

[Ans: 666.67, 0.018A, I_1= 0.012A, I_2 = 0.006A]

Step 4

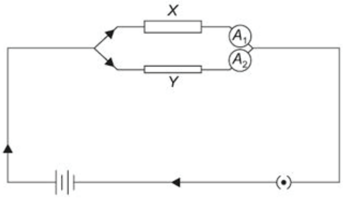
1. Long question answers.

a. Draw the diagram to show series connection and parallel connection of resistors.

b. Derive the formula V= IR, where the terms used have their usual meaning.

c. Let's say you need warm water in the freezing cold of magh but have no access to firewood, petroleum or any electrical heating device. How would you warm water with a battery, copper wire and stainless steel blade? Which principle of physics can be applied here? How is this principle useful in our daily life. Make a list of some household equipments that uses this principle.

d. In the circuit diagram shown, the two wires X and Y are of the same length and same metal, but X is thicker than Y. Which ammeter A_1 or A_2 will indicate more current? Write with a reason.



UNIT

12 UNIVERSE

ESTIMATED TEACHING PERIODS

TH	PR
4	1

Nicolaus Copernicus
(1473-1543)

Curriculum issued by CDC

- Units used to measure the distance between the celestial bodies (light year, astronomical unit)
- Black hole and nebula
- Lifecycle of the star (birth, red giant and death)
- National and international organizations studying astronomy (NAST, NASA, IAU)

Learning outcomes

After completion of this unit, students will be able to:

- be familiar with the distance scale of the universe.
- introduce nebula and black holes.
- describe the life cycle of the stars.
- give general introduction of national and international organizations studying astronomy.

Terms and terminologies

1. Universe: The universe is the vast space including planets, stars, galaxies, and all other forms of matter and energy, and time.
2. Nebula: Nebula is clouds of gas and dust in space in interstellar space.
3. Astronomy: Astronomy is the study of everything in the universe beyond the earth's atmosphere.
4. Protostar: The highly condensed stage of the gas cloud with suitable conditions for thermonuclear fusion is called a protostar.

5. Red giant:	The red giant is the red star formed due to an increase in the surface area and decrease in the nuclear fusion reaction.
6. Supernova:	The exploding red supergiant star is called a supernova.
7. Nova:	A nova is an explosion from the surface of a red giant.
8. White dwarf:	A white dwarf is a small very dense star that is typically the size of a planet that is formed when a low-mass star has exhausted all its central nuclear fuel and lost its outer layers.
9.Neutron star:	A star full of neutrons that is formed when electrons in the core after supernova collide with protons and release neutrons is called a neutron star.
10. Pulsar:	Pulsar is a neutron star that cannot be seen but that sends regular rapid radio signals.
11. Blackhole:	A black hole is a highly dense mass formed from the core after a supernova that has enormous gravity which does not allow even light radiation to escape.
12. Big Bang:	The Big Bang theory states that the universe began as a hot and infinitely dense point.

Introduction

The universe is the vast space including planets, stars, galaxies, and all other forms of matter and energy, and time. Galaxies are a cluster of stars. Star is a celestial body that radiates light and heat and other electromagnetic radiation. The space between the stars is almost empty with traces of interstellar gas and dust. There are a large number of stars in the universe among which the sun is the nearest one from the earth. Other than the sun, the second nearest star from the earth is Proxima Centauri. Astronomy is the study of everything in the universe beyond the earth's atmosphere.

Memory Note

In the sky, the stars form a large group of clusters giving a definite shape called a constellation. Each constellation has its own shape and the number of stars in it at a particular position.

Fact and Reason

A nebula is called a stellar furnace.

The nebula is called a stellar furnace because it gives birth to new stars.

The Stars

stars

The stars are self-glowing heavenly bodies that generate energy themselves by nuclear fusion and radiate energy from their surface and are luminous. The star contains the maximum amount of hydrogen and less helium. Due to high pressure and temperature in the stars nuclear fusion of hydrogen takes place with the release of a tremendous amount of energy. Their surface radiates in the form of heat, light, etc.

Memory Note

The sun is the medium-sized star at the centre of our solar system.

Fact and Reason

The sun is called a star.

The sun is called a star because there is a thermonuclear fusion reaction at its core.

The life cycle of stars

Like living organisms, the stars are also born, live, and die. But their life span is billions of years. The nebula is clouds of gas and dust in interstellar space. The life cycle begins with the formation of a protostar in a nebula.

For example, our sun was formed about 4.6 billion years ago from the nebula. Nebulae are literally part of the births, lives, and deaths of stars. When a star dies, it blows off winds of gas and creates a nebula.

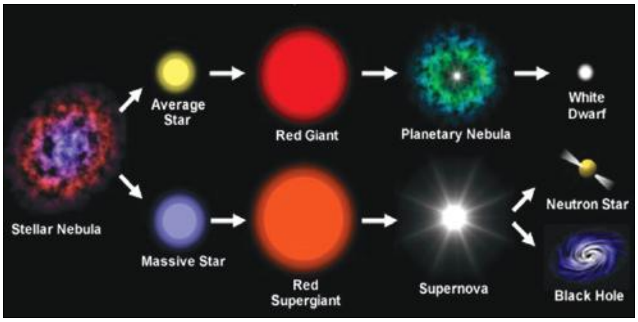
Activity 12.2

Visit your library or search on the internet about different stars in the universe. Collect data about the age of star, size, surface temperature, and their colour.

Star	size	Surface temperature	colour
………….	……………….	…………..	…………

Discuss the variation in temperature and colour of stars.

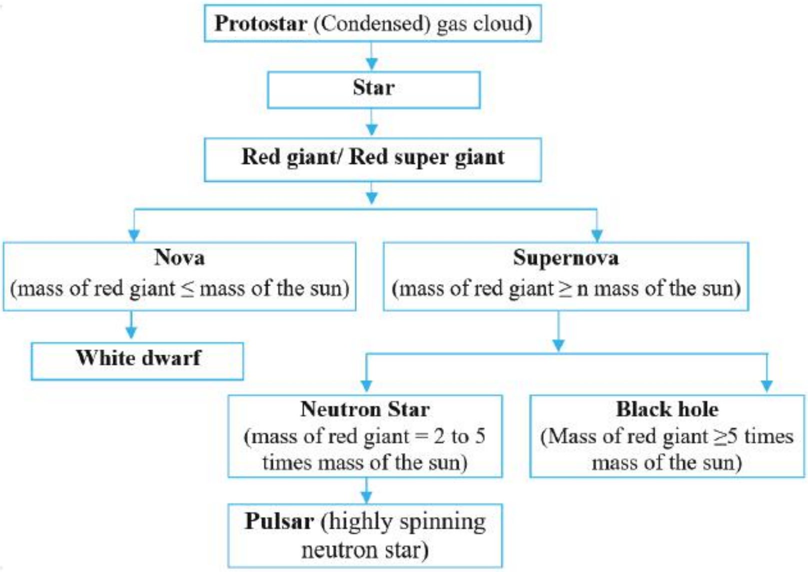
1. Birth of Star



Life cycle of a star

A star is formed due to the contraction of dust particles and gas present in interstellar space. When the dust particles and gas come closer due to their gravitational force of attraction, they form a cloud. The cloud starts to contract due to the movement of the gas molecules towards the centre of the cloud, as a result, density as well as temperature rises. This process of contraction of cloud and increase of density and temperature continues to create a tremendous amount of pressure in the gas core. These high temperature and high-pressure conditions are suitable for thermonuclear fusion in the core. The highly condensed stage of the gas cloud with suitable conditions for thermonuclear fusion is called a protostar.

After the formation of a protostar (highly condensed mass), due to the presence of high pressure and temperature, the nuclear fusion of hydrogen atoms into helium atoms takes place with the release of a tremendous amount of energy. This is the beginning stage of the star which can shine for billions of years with the energy.



2. Death of Star

Everything born must die. The death of a star takes place in the following steps:

i. Formation of red giant

When the hydrogen fuel of the star is exhausted, the outward pressure created by the nuclear reaction stops, and the gravitational force within the star becomes active due to which core matter begins to contract again under its own gravity. However, in the outer shell, hydrogen nuclei fuse to form helium liberating energy. So, the outer shell starts to expand, and its surface area increases. An increase in the surface area and decrease in the nuclear fusion reaction decrease the intensity of radiated energy. Hence, the star becomes red and this stage of the star is called the red giant phase and the star is called the red giant star. The dying red star with an expanded surface is called a red giant.

ii. Formation of supernova or nova.

If the mass of the red giant is several times greater than that of the sun, the core of the red giant contracts while the outer shell expands due to the release of energy. After some time, the outer shell explodes violently with a brilliant flash. The exploding red supergiant star is called a supernova. It is the end of the existence of the star and the star is dead. If the mass of the red giant is equal to or less than that of the sun, the exploding star is called a nova.

Memory note

A supernova is so bright that its peak luminosity can be compared to the luminosity of an entire galaxy.

Fact and Reason

Why does supernova explode?

When the pressure drops low enough in a massive star, gravity suddenly takes over and the star collapses in just seconds.

iii. Formation of the white dwarf

If the mass of the red giant is equal to or less than that of the sun, the red giant loses its expanding outer shell. The core starts to undergo nuclear fusion reaction forming carbon with the release of a tremendous amount of energy which makes the small core glow bright white again. A white dwarf is a small very dense star that is formed when a low-mass star has exhausted all its central nuclear fuel and lost its outer layers. As it cools it changes colours from white to yellow to red and finally disappears forever.

iv. Formation of neutron star

If the mass of the red giant is between two to five times that of the mass of the sun, the red giant becomes a neutron star. A star full of neutrons that is formed when electrons in the core after supernova collides with protons and releases neutrons is called a neutron star.

Memory note

A neutron star does not emit light but when it spins it emits radio waves in the form of a pulse. Hence, they are called pulsars. Pulsar is a neutron star that cannot be seen but that sends regular rapid radio signals.

v. Formation of a black hole

If the mass of the red giant is greater than five times that of the mass of the sun, the red giant becomes a black hole. The massive star undergoes uncontrolled contraction because of the inward pull of its own gravity. The contraction of the star continues until the star becomes so dense that nothing, not even light, can escape from its gravity and this indefinitely dense black hole**.** A black hole is a highly dense mass formed from the core after a supernova, that has enormous gravity, does not allow even light radiation to escape.

Memory note

Though a black hole is invisible, its presence can be felt in two ways:

1) *If a star is observed moving towards the invisible site, we can conclude that the star is moving towards the black hole.*
2) *If the material moves quickly towards the black hole, it becomes very hot and emits X-rays, which can be detected.*

Activity

Use locally available materials to make a model showing different stages in the life cycle of stars.

Scientific facts about the universe

The origin of the universe is the origin of everything. The universe is expanding. This indicates that the galaxies all began close together, billions of years ago.

The most widely accepted explanation about the origin of the universe is the Big Bang theory. The Big Bang theory states that the universe began as a hot and infinitely dense point. All matter, energy, space, and time were created with this bang. The universe started as a hot burst of energy in the distant past. Some 13.7 billion years have passed since the universe began. The universe contains billions of galaxies. Stars in the galaxies are just a tiny part of the total mass of the universe. Scientists say that the universe is made up of matter and energy that cannot be seen. Galaxies contain invisible dark matter and dark energy.

The universe is not static. It's expanding continuously. It is known that the universe's expanding rate is also increasing over time. This discovery was made by using Hubble Space Telescope in 1998. The Big Crunch is one of the scenarios predicted by scientists in which the universe may end. The Big Crunch is a hypothetical scenario for the ultimate fate of the universe, in which the expansion of the universe eventually reverses and the universe collapses. Nothing is at rest in the universe. Satellites revolve around the planets, and planets in the solar system revolve around the sun. Stars like the sun revolve around the galactic centre. Some stars move around the black hole in the galaxy. Larger galaxies have a supermassive black hole at the centre. For example, the Milky Way galaxy has a black hole 'Sagittarius A' at its centre.

Memory note

Scientific theory can change over time as we keep on learning newer facts. According to the geocentric theory earth was believed to be the centre of the universe. Later Heliocentric theory stated that sun is the centre of solar system.

Units to measure the distance between heavenly objects

The heavenly objects are way too far from each other. Some of the common units used to measure celestial distances are listed below.

i. Astronomical unit: The average distance between the sun and the earth is called astronomical unit. 1 AU is equal to 1.5×10^{11} metres.

ii. Light year: The distance travelled by the light in a year in a vacuum is called light year. It is equal to 9.46×10^{15} metres.

$$1 \text{ light year} = 365 \times 24 \times 60 \times 60 \times 3 \times 10^{8}\text{m} = 9.46 \times 10^{15}\text{m}$$

Some national organisations working in field of astronomy

1. NAST

Nepal academy of Science and Technology (NAST) was established in 2039 BS to identify local technologies, modify them, import modern technologies for improving life of the Nepali people. It is about to start a National Space Research Centre.

2. NASO

Nepal Astronomical Society (NASO) was established in 2064 BS and was allowed to work in international level since 2078. It manages astronomy related learning activities in schools such as space robotics, science Olympiad and planetarium. It has discovered more than 1,300 asteroids.

Some international organisations working in field of astronomy

1. IAU

International astronomical union (IAU) was established in 1919 to study the outer space. It declared pluto as a dwarf planet on 2006. IAU also declared Ceres (largest asteroid) as a dwarf planet. Its 12,131 members throughout the globe exchange knowledge and work to generate science learning ability and interest in students.

2. NASA

National Aeronautics and Space Administration (NASA) was established in 1958. NASA trained astronauts and landed on moon on 20 July 1969. Neil Armstrong, Buzz Aldrin and other astronauts travelled to moon in Apollo 11. It has installed a laboratory in the space called International Space Station (ISS).

New horizon satellite of NASA went to explore Pluto in 2006. NASA has sent a total of 5 satellites in the Mars. They are Sojourner, Spirit Opportunity, Curiosity and Perseverance.

Hubble's telescope is a powerful but old telescope. NASA, European Space agency and Canadian Space Agency worked together and launched James Webb Space Telescope in the space on 25 December 2021 to observe the outer space.

Memory note

Energy can neither be created nor be destroyed but it can be transformed from one form to another.

A concept of conservation of energy

According to the Big Bang theory, whatever exists in the universe has a common origin. All the things return to the universe. The total energy remains conserved in the universe. All living creatures have a certain lifespan. Even stars have their life cycle. Biogeochemical cycles circulate matter in the biosphere. For example, water, carbon dioxide that change into starch in plants, get mixed in the soil after its death.

Answer writing skill

1. **What is a nebula?**

   A nebula is an interstellar cloud of molecules like hydrogen, helium, and scattered particles of dust.

2. **What is the nearest star to the sun?**

   The Proxima Centauri is the nearest star to the sun.

3. **Why is a young massive star blue?**

   The young massive star is blue because it has a very high temperature over any other star.

4. **Differentiate between protostar and star:**

The differences between protostar and star are:

SN	Protostar	SN	Star
1	The highly condensed stage of the gas cloud with suitable conditions for thermonuclear fusion is called a protostar.	1	A star is a heavenly object which has a thermonuclear fusion reaction at its core.
2	The thermonuclear reaction is about to start in protostar.	2	The thermonuclear reaction is the source of heat and light energy of the star.

5. **How would the universe end? Their might be various theories out there. Let's discuss on Big crunch.**

Among various theories about the end of the universe, Big Crunch is also an interesting one. According to this theory, in a closed universe, gravity eventually stops the expansion of the universe, after which it starts to contract until all matter in the universe collapses to a point, a final singularity termed the "Big Crunch". It is the opposite of the Big Bang.

6. **What is the fate of a dying star? Does it depend upon the mass of the star? The sun is a middle aged star. What might it turn into if it depletes all of its fuel? Discuss.**

The fate of dying star is either it will evapourate or it will change into neutron star or balck hole based on its mass. A low or medium mass star becomes a red giant at the end of its life cycle. The outer part grows and drifts into space. It forms a cloud of gas called a planetary nebula. The blue-white core of the star left behind cools and becomes a white dwarf. The white dwarf eventually runs out of fuel and dies as a black dwarf. In the case of a high mass star, it becomes a red supergiant that explodes to form a supernova. After the explosion, the remaining core may form a neutron star. If the mass of the star was very massive then the core would change into a black hole. If the sun depletes all of its fuel it will change into white dwarf and finally evaporate until it finishes because it has less mass.

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

   a. What is formed when a main-sequence star begins to run out of hydrogen fuel?

   i. red giant   ii. red super giant
   iii. planetary nebula   iv. red giant or red super giant

b. What is an explosion that leads to a gigantic explosion throwing stars' outer layers?
   i. double ring   ii. black hole
   iii. supernova   iv. massive explosion

c. What does a medium-mass star become at the end of its life?
   i. white dwarf   ii. black dwarf
   iii. neutron star   iv. black hole

d. What are the properties of a white dwarf?
   i. small   ii. hot
   iii. dim   iv. all of them

e. Which of these statements best describes a black hole?
   i. A small, hot, carbon-oxygen core leftover from a massive stars' death.
   ii. An extremely dense mass of neutrons left behind by a collapsing star
   iii. An object with a very slow escape velocity.
   iv. A compact object with an escape velocity greater than the speed of light

2. Define the following, with examples.

a.	Universe	e.	Protostar
b.	Star	f.	Red giant
c.	Supernova	g.	Nova
d.	White dwarf	h.	Neutron star

3. Short question answers.

a. How old is the universe?
b. Give two examples of nebula.
c. State Big Bang theory
d. What is a black hole?
e. What is a pulsar?

Step 2

4. Give reason

a. Nothing is permanently at rest in the universe.
b. All the gaseous masses in the universe do not change into stars.
c. Black holes cannot be observed directly like other celestial bodies.
d. The sun will not change into a black hole.
e. Astronomical unit and lightyear are used as unit for measurement in astronomy.

5. Differentiate between the following.

a. Red giant and red super giant

b. White dwarf and neutron star

Step 3

6. Answer the following questions.

a. Do all stars have the same mass? Write with examples as evidence to support your answer.

b. How does the enormous amount of energy get released in stars?

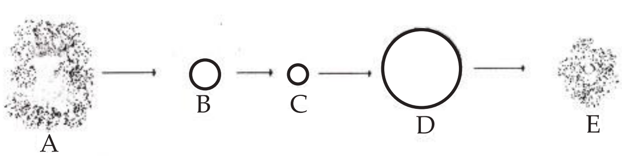
c. Do all stars have same colour? What do the colour of the star suggest about its lifespan?

d. No one has actually observed a black hole directly but predicted it to be there. Are there any evidences of existence of black hole? List them.

e. How well do we understand our universe? Lets make a list of three amazing facts on universe.

f. How do scientists believe in the fact that the universe is expanding?

g. Label A, B, C, D, E in the given figure.



h. Make a chart to show different stages in the life cycle of stars.

i. Explain the concept of conservation of energy in the universe.

Step 4

7. Long question answers.

a. The stars are born in the heart of nebula and dies differently based on its mass.

i. Discuss how the stars are born.

ii. What is the fate of a dying low to medium sized star?

iii. Explain the death of a very massive star.

c. Discuss the role of NASO, NAST, IAU and NASA in astronomy.

d. Convert 1 light year into meter.

UNIT

13 INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

ESTIMATED TEACHING PERIODS

TH	PR
10	4

Vint Cerf
(1943-age 78 years)

Curriculum issued by CDC

- Introduction to telecommunication technology
- Brief working procedure of telecommunication on a short range by the use of simple antenna.
- Brief working procedure of telecommunication on a very long range by the use of satellite.
- Introduction of artificial satellite
- Use of satellite as station for exchanging information around the world collecting information on earth and the space to send to earth
- Use of internet in modern communication
- Introduction to search engine
- Use of basic operators to narrow search results, search non-copyrighted contents and verify authenticity of searched contents
- Online security measures (antivirus, firewall)
- Caution regarding online privacy and digital footprint
- Caution against cyber bullying

Learning outcomes

After completion of this unit, students will be able to:

- introduce telecommunication and its working process.
- mention the importance of artificial satellites in telecommunication technology.
- discuss the usefulness of internet in telecommunication system.
- search for learning materials in the internet.
- adopt online security measures.

Terms and terminologies

1. **Satellite:** A satellite is any object that revolves around a planet.
2. **Artificial satellite:** Satellites that are made by people and launched into orbit using rockets are called artificial satellites.
3. **Uplink:** An uplink is the message signal from a ground station sent up to a satellite.
4. **Satellite transponder:** It is a device that receives the incoming signal and sends it back to the earth station.
5. **Downlink:** A downlink is the message signal from a satellite sent down to one or more ground stations or receivers.
6. **Global position system (GPS):** GPS is a satellite navigation system technology to determine the ground position of an object.
7. **Telecommunication:** Telecommunication is the transmission of encoded sound, pictures, or data over significant distances using radio signals or electrical or optical lines.
8. **Fax:** Fax is the telephonic transmission of scanned printed material to a telephone number connected to a printer or other output devices.
9. **Wireless communication:** Wireless communication is the transfer of information between two or more points that are not connected by a wire.
10. **Carrier signal:** The high-frequency signal generated for modulation is called the carrier signal.
11. **Modulation:** Modulation is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of the modulating signal.
12. **Frequency modulation (FM):** The process of encoding information in a carrier wave by varying the frequency of the wave in proportion to that of the message signal is called frequency modulation.
13. **Amplitude modulation (AM):** The process of encoding information in a carrier wave by varying the amplitude of the wave in proportion to that of the message signal is called amplitude modulation.
14. **Internet:** The internet is a global system of interconnected computer networks that use the standard internet protocol suite to serve billions of users worldwide.
15. **Email:** Electronic mail or email is a method of exchanging digital messages from an author to one or more recipients.
16. **Search engine:** A search engine is a software system that is designed to carry out web searches.

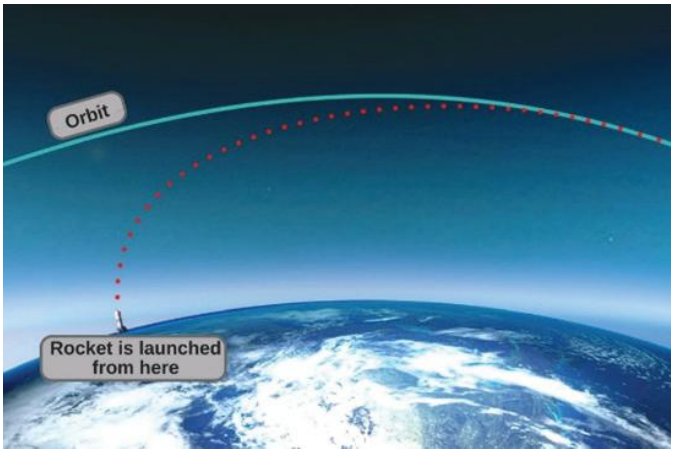
17. Internet security:	Internet security is the mechanism for protecting activities and transactions conducted online over the internet.
18. Firewall:	Firewall is a system that is designed to prevent unauthorised access from entering a private network.
19. Computer virus:	A computer virus is a programme that can replicate its structures and infects other files on a computer.
20. Digital footprints:	Digital footprints are the trail or traces we leave behind as we use the internet.
21. Cyberbullying:	Cyberbullying can be defined as willful and repeated harm caused through the use of computers, cell phones, or other electronic devices.

Introduction

We are living in an era of Information and Communication Technology (ICT). Telephone, mobile phone and fax machine are common to us as communication tools. The use of email and internet in communication is modern communication. Long-distance communication such as with a radio and television is based on a common principle of the sender, channel, and receiver. The use of satellites has brought a revolution in telecommunication.

Satellite

Satellites that are made by people and launched into orbit using rockets are called artificial satellites. The launching of a satellite needs a launch vehicle such as a rocket. First, the satellite has to be taken to the desired altitude then it has to be pushed off at the appropriate velocity to begin and maintain its orbit.



launching rocket to put satellite at orbit

A satellite stays in orbit because of the balance between gravitational pull and centrifugal force. There is no need for an external energy source to keep a satellite in motion. However, there are solar panels and batteries to supply electric current for the functioning of digital components in a satellite.

Fact and Reason

A satellite does not need any external energy source to keep it in motion. Why?

A satellite stays in orbit because of the balance between gravitational pull and centrifugal force. Due to the negligible resistance in space, satellites never lose speed. So, satellites will continue their circular motion around the earth without any external energy source.

Orbit of satellites

Satellites are placed in different orbits based on the application and purpose of the satellite.

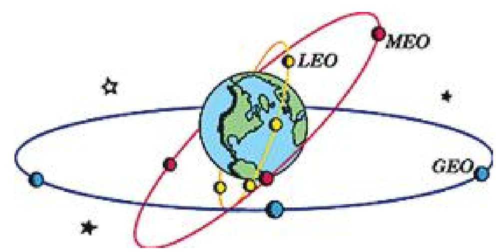
1) **Low Earth Orbit (LEO):** Low earth orbit satellites operate at a distance of about 160 to 2,000 kilometres above the earth's surface. It takes approximately 90 to 120 minutes to circle the earth. If the satellite is built for earth observation, geographic area surveying, satellite phone calls, etc. then orbits closer to the earth are chosen.

2) **Medium Earth Orbit (MEO):** MEO satellite operates at altitudes between 2,000 kilometres and 35, 786 kilometres above the earth's surface. Navigation satellites are placed in MEO.

Memory note

Global Positioning System (GPS) satellites fly in medium earth orbit (MEO) at an altitude of approximately 20,200km with an orbital period of 12hrs.

3) **Geostationary Earth Orbit (GEO):** A geostationary satellite is an earth-orbiting satellite. It is placed at an altitude of approximately 35,786km directly over the equator that revolves in the same direction as the earth rotates. This satellite takes 24 hours to orbit the earth. Communication satellites are placed in GEO.



Geostationary Earth Orbit

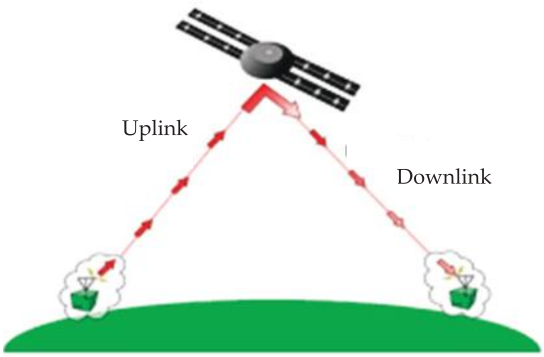
Fact and Reason

Communication satellites are placed in GEO. Why?

Geostationary orbit satellites remain stationary with respect to the earth. The earth station doesn't lose connection with communication satellites in GEO as the earth rotates on its axis. So, the communication satellites are placed in GEO.

Principle of satellite communication

Satellite communication consists of three main components:



principle of satellite communication

Uplink: Earth stations send information in the form of high-powered high-frequency signals to satellites that receive and retransmit the signals back to earth. An uplink is a link from a ground station up to a satellite.

Satellite transponder: The satellite transponder amplifies the incoming signal and changes the frequency. The satellite transponder transmits the signal back to the downlink earth station. Uplink is a device that receives an incoming signal and sends it back to the earth station.

Downlink: The retransmitted signals are then received by other earth stations in the coverage area of the satellite. A downlink is a link from a satellite down to one or more ground stations or receivers.

Memory Note

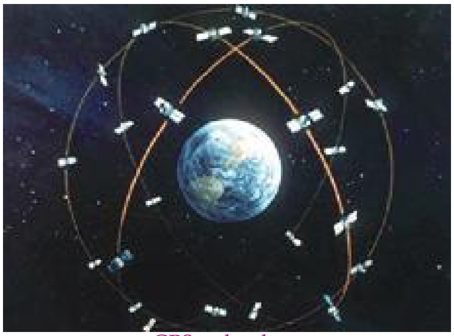
Star link is a constellation of multiple satellites at low earth orbit that provides internet services. It is operated by the SpaceX company of Elon Musk.

Satellite navigation system

Activity

How do you find your location using a smartphone? Find your location using a Global Positioning System (GPS) on a smartphone.

A satellite navigation system is a technology to determine the ground position of an object. It determines the geographic location of ships, aircraft, or any other object. The navigation satellite system with global coverage is called the global navigation satellite system or GNSS. The United States was the first country to introduce satellite technology with the global positioning system or GPS. Russia also has its own satellite navigation system called the Russian global navigation satellite system (RGNSS). There is the Indian regional navigation satellite system or IRNSS in India.



GPS technology

Memory Note

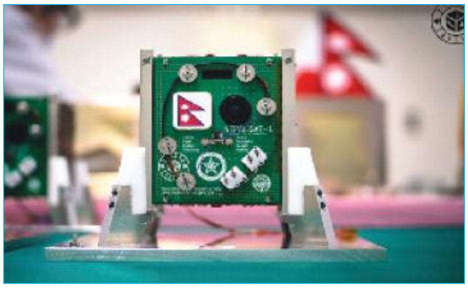
In a typical GPS, 24 satellites can cover the entire earth and their orbital period is of 12 hours.

Applications of GPS

There is a wide application of GPS in modern communication. Position identification is a common use of GPS. Smartphones have GPS service for finding the location of the users. It is also used for path tracking purposes. GPS car navigation helps to identify the route. Most modern aircraft use GPS receivers to provide the pilots and passengers with real-time aircraft positions. GPS trackers used in vehicles help to find their location. GPS surveying is used in mapping and measuring various measures on the earth.

Nepal's first satellite

Nepal's first nanosatellite 'NepaliSat-1' was launched into space from Virginia in the USA on 18 April 2019. It was deployed into low earth orbit (LEO) from the International Space Station on 17 June 2019. The satellite was developed with support of Japan's Kyutech University under the bird's



Nepal's first satellite

project. Nanosatellite weighs about 1.33kg. It revolves around the earth every 90 minutes in the orbit at a height of about 400km. It remains above Nepal for about six to ten minutes to capture a picture of various parts of Nepal and shares information about forests, glaciers, hills, mountains and roads. This satellite was built by two Nepali engineers Awash Maskey and Hareram Shrestha, pursuing space engineering at the Kyushu Institute of Technology (Kyutech) University in Japan.

Use of information and communication technology

Newspapers and magazines

The main function of a newspaper is to report the news. Many newspapers also provide special information to readers, such as weather reports and television schedules. They provide commentary on politics, economics, and arts and culture, and sometimes include entertainment features, such as comics and crossword puzzles.

Telecommunication

Activity

How does your voice reach the next person to whom you make a phone call through cell phone? Discuss.

Telecommunications enable people around the world to contact one another, access information instantly, and communicate from remote areas. A wide variety of information can be transmitted through telecommunication. These include animated pictures, voice and music, computer files and applications, still pictures, telegraphic and fax data. Telecommunication is the transmission of encoded sound, pictures, or data over significant distances using radio signals or electrical or optical lines. It has made communication much easier. Telecommunication messages can be sent in a variety of ways and by a wide range of devices. The messages can be sent from one sender to a single receiver or from one sender to many receivers. For example, a telephone conversation between two people or a facsimile (fax) message is one sender to a single receiver message transmission.

Principle of Telecommunication

There are three steps involved in telecommunication

(Input) Transmitter ⟶ Channel ⟶ Receiver (Output)

1. **Transmitter:** The transmitter is the source of the communication signal. The message is created by using digital tools and directed towards the transmitter for transmission. Radio signals, radio or television broadcasts, internet data, etc. are sent into the channel from the transmitter for transmission. Aerials and circular dishes are used to transmit electromagnetic waves.

2. **Channel:** In telecommunication, the communication signal from the transmitter must travel to another place or device to receive the signal. This route is called the channel for the transmission of the communication signal. The signal travels along with cables in the form of electric current, or through the air in the form of a wave.

Memory Note

Electromagnetic waves are very important in communication because they transfer energy at a high speed.

3. **Receiver:** The communication signal transmitting through a channel must be received in a different place by the receiver. A user receives the information at the end of the process through the receiver and information gets passed on.

Activity

Observe the components of the means of telecommunication such as telephone, cell phone, radio, TV, wifi router, etc., and collect information as shown in the given table below.

Means of communication	Transmitter	channel	Receiver
Telephone handset	Mouthpiece or Transmitter fixed on the handset	Wire	Earpiece or receiver fixed on the handset.
Radio	…………..	…………..	…………
TV	…………..	………….	……………

There are different kinds of technologies used in means of communication to generate a signal, for transmission of signal, and for receiving the signal. Following are some of the telecommunication technologies.

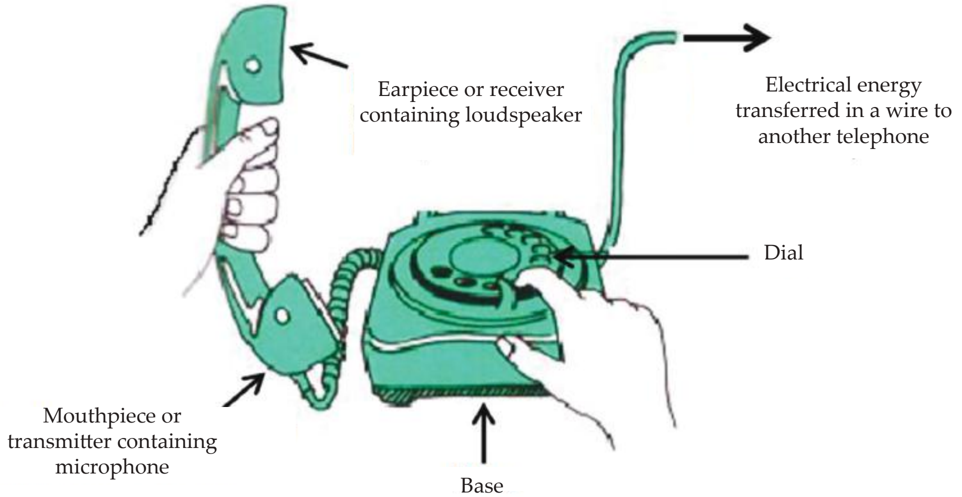
Fax (Facsimile)

In this technology, the original document with a message is scanned with a fax machine first. The scanned data is processed (text or images) and converted as an electric signal, and then transmitted through the telephone system. The receiving fax machine reconverts the coded image and prints a paper as the output of the message transmission process.

fax machine

Telephone communication

A telephone handset has two main parts called the mouthpiece and the earpiece. The mouthpiece is the part to send voice in. There is a microphone that converts sound waves into electric currents. The electric current carries the signal along the telephone wires to the other telephone. The electrical message goes into the earpiece. There is the conversion of electrical signal into sound through a small loudspeaker. Finally, the person at the receiver's end hears the original person's voice.



Working mechanism of telephone

Fact and Reason

The telephone is a good means of communication between places that are connected by electrical wires. Why?

The message gets transmitted as an electrical current through wires. An electric current can travel quickly over long distances. So, the telephone is a good means of communication between places that are connected by electrical wires.

Wi-Fi

Wifi

Wi-Fi is a wireless local area network (WLAN) technology. Wi-Fi signal is transmitted using radio waves. It allows an electronic device to transfer data or connect to the internet using radio waves. Wi-Fi allows computers and other devices to communicate over a wireless network. The device's wireless adapter translates data into a radio signal. The wireless router receives the signal, decodes it, and sends information to the internet.

Memory Note

When we connect our mobile with a Wi-Fi network then our mobile continuously sends and receives a signal through the air. It is also based on the principle of the transmitter, channel, and receiver.

Cell phones

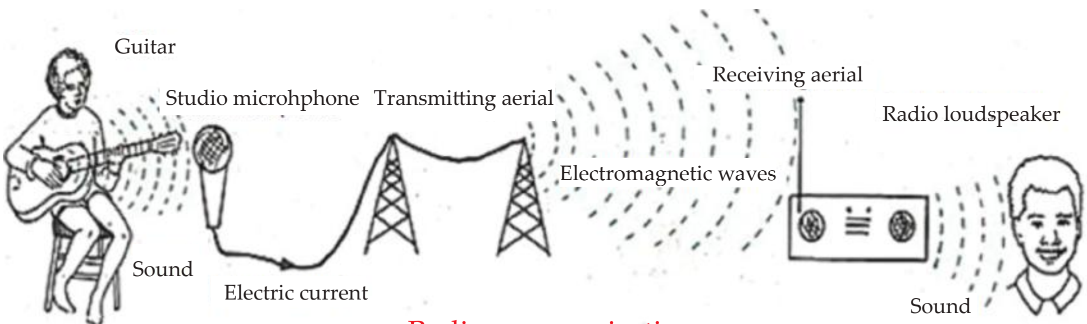
A cellular telephone (mobile phone) uses radio signals to communicate between the set and an antenna. A mobile phone is a bidirectional radio that enables simultaneous transmission and reception.

Radio communication

Activity

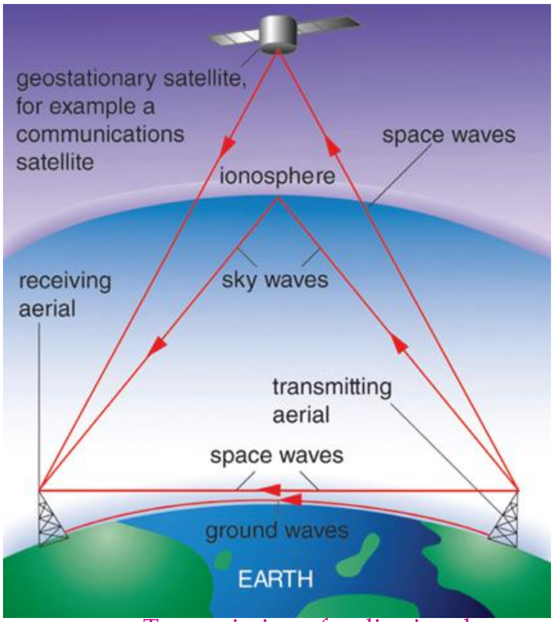
How does a radio station work and how are radio waves transmitted?

The radio can be used to communicate over long distances without any wires connecting the source and receiver. The radio is an important means of providing information. It provides an opportunity for people who cannot access television and cannot read to keep up to date on news, entertainment, and information. It is more easily accessed than the TV and newspaper. The information that is given over the radio can be broadcast to a large number of listeners.



Radio communication

In radio communication, radio waves produced and transmitted from one radio station on the earth are reflected by the satellite to other places on the earth. The waves reflected by the satellite are received and repeated locally by local transmitters. These repeated waves are received and changed into the original sound by receivers in radios.



Transmission of radio signal

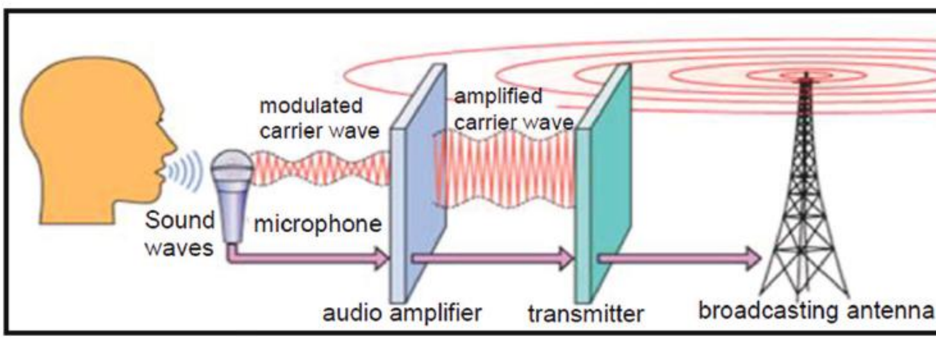
Each radio station transmits its own programme on its own radio frequency. So, there are many different radio frequencies in the air at the same time. We tune in to select the radio wave transmitted by the station that we want to listen to. In radio communication technology, the strength of the message signal should be increased so that it can travel longer distances. This can be achieved through modulation during the transmission of the signal.

Modulation

Activity

Make a list of FM stations that have coverage in your locality. Collect the data related to their frequency of broadcasting. Tune in FM and AM stations on your device. What difference do you notice in the frequencies used and the output sound quality? Discuss this with your friends.

In telecommunication, information, messages, data, and signals are sent from one location to another within seconds. Such a fast transmission is possible through the use of modulation in a communication system. Modulation techniques are applied in modern cellular and communications technology.



transmission of radio waves

The use of modulation enhances the range of the signals. The message signals to be transmitted is known as modulating signal. The frequency of such a signal is usually low. This signal is modified according to a high-frequency wave. This high-frequency signal generated for modulation is called the carrier signal. Such a higher frequency carrier can travel much farther than the baseband signal. Modulation is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of the modulating signal.

Fact and Reason

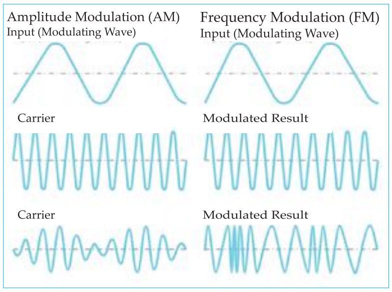
Why is modulation necessary in radio communication?

The frequency of the message signals to be transmitted is low. The strength of the message signal should be increased to transmit up to long distances. So, radio communication signals are modulated to transmit correctly in long-distance range.

Types of modulation

There are two modulation methods. Amplitude modulation (AM) and frequency modulation (FM).

Frequency Modulation (FM)



Sometimes a radio programme is added to the carrier in such a way that the programme signal causes fluctuations in the carrier's frequency. This process of encoding information in a carrier wave by varying the frequency of the wave in proportion to that of the message signal is called frequency modulation. FM stations are broadcast at a much higher frequency than AM stations. The higher frequency FM signal suffers less interference and the quality of the sound is much better.

Amplitude modulation (AM)

Another way of sending a radio signal is to make the peaks of the carrier wave bigger or smaller. The process of encoding information in a carrier wave by varying the amplitude of the wave in proportion to that of the message signal is called amplitude modulation. AM broadcasting covers much larger areas than FM broadcasting. On the other hand, AM broadcasting is more susceptible to noises.

Fact and Reason

Music radio stations tend to choose FM instead of AM. Why?

FM broadcasting can be sent at higher frequency which means less interference and high quality of sound than the AM. Therefore, music radio stations tend to choose FM instead of AM.

Differences between FM and AM

S.N	AM or Amplitude Modulation	S.N	FM or Frequency Modulation
1.	AM works by modulating the amplitude of the signal or carrier transmitted according to the information being sent, while the frequency remains constant.	1.	In FM, information is encoded by varying the frequency of the wave and the amplitude is kept constant.

2.	AM frequency ranges from 535kHz to 1705kHz.	2.	FM frequency ranges in a higher spectrum from 88MHz to 108MHz
3.	AM waves have a much larger range.	3.	FM waves have a small range in terms of the geographical regions they can cover.

Television transmission

Phulchoki television tower of Nepal

Television pictures are also transmitted by electromagnetic waves. The signal is transmitted and received in exactly the same way as for radio, but in this case, the message includes information about the pictures as well as the sound. Television systems send and receive pictures and sound by means of electronic signals transmitted through wires and optical fibres or by electromagnetic radiation. Television is the most widespread form of communication in the world.

Internet as a modern communication tool

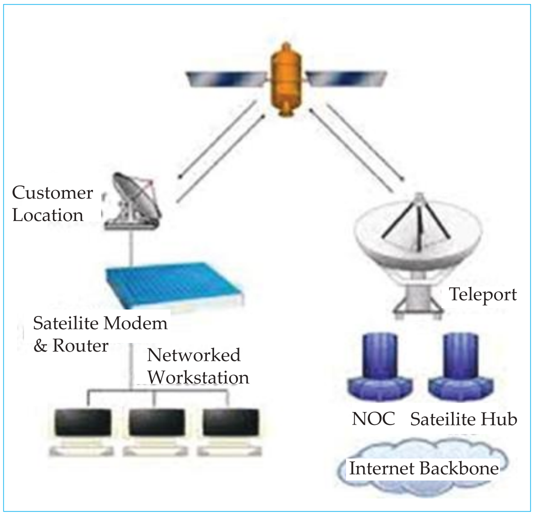
Activity

How is the internet used for communication in your surrounding? Make a list of the use of the internet in communication. What is the advantage of such communication? Discuss the role of the internet as a modern method of communication.

Communication	Advantage
Audio/Video call	....
Online TV	
Email	

Internet is a computer-based global information system. Thus internet is a global system of interconnected computer networks that use the standard internet protocol suite to serve billions of users worldwide. The internet carries an extensive range of information resources and services, such as the interlinked hypertext documents of the World Wide Web (WWW). It provides the facility to explore knowledge from any part of the world at any time.

Internet communication technology is also based on the principle of the transmitter, channel, and receiver. The data generated is transmitted through air, wires, or optical fibre. In the case of long-range data transmission, it is done through satellites.



Internet

Memory Note

Internet is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless, and optical networking technologies.

The internet has many important applications. Communication, finding books and study materials, health and medicine services, travel services, entertainment, shopping, business, research, etc. are some of the common applications of the internet. The internet has modified the mode of communication. Most traditional communications media including telephone, music, film, and television are being reshaped or redefined by the internet. The use of the internet in communication gave birth to new services such as social media, online phone calls, two-way interactive video calls, and Internet Protocol Television (IPTV). Newspaper, books, and other print publishing are adapting to Web technology.

Email

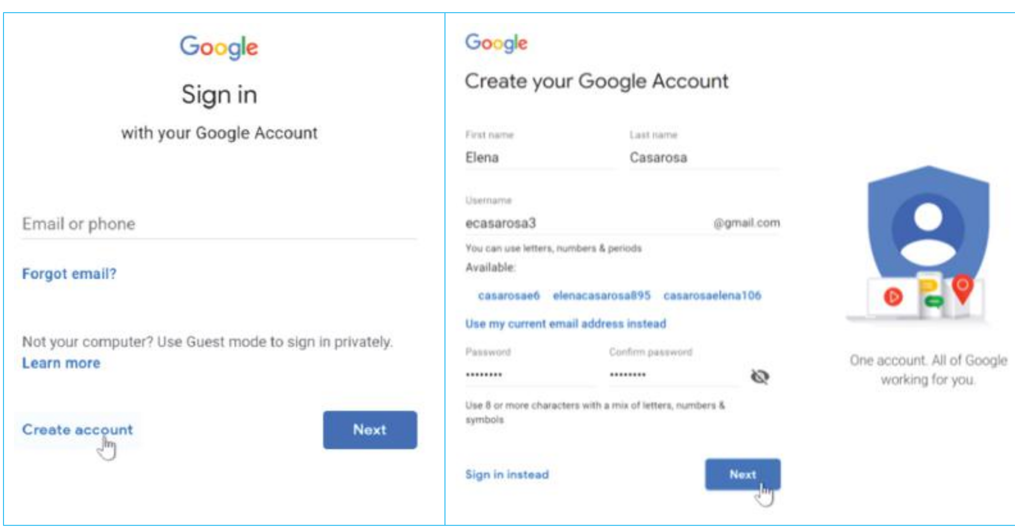
Electronic mail, most commonly referred to as email or e-mail is a method of exchanging digital messages from an author to one or more recipients. It is a reliable tool for communication. We can send a message within a while from one part of the world to another. We need an internet connection in our device to send an email through an email service provider. Several companies provide email services. For example, www.gmail.com, www.yahoo.com, etc. are email service providing companies. We need to create an account in email service providing companies to send an email through them.

Activity

Follow the steps to create a Gmail account. Compose an email to your friend. You also request your friend to send an email to you. Check the email that was sent to you. Finally, sign out of your account.

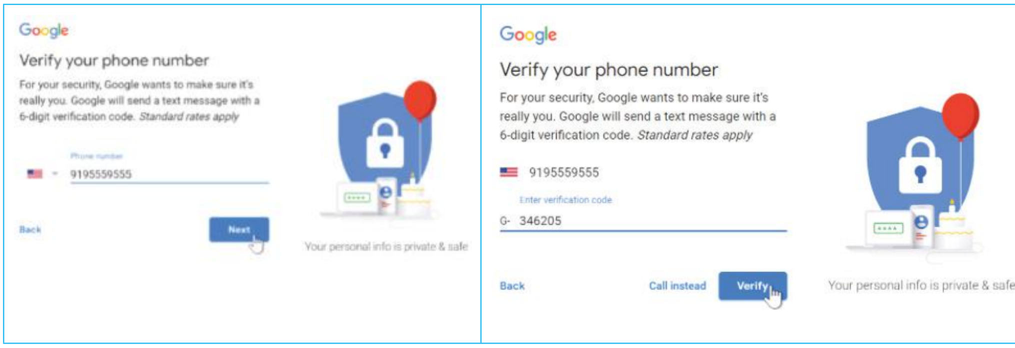
We need to provide some basic information like **name**, **birth date**, **gender**, and **location while creating a Gmail account**. We also need to choose a **name** for our new Gmail address (e.g. nepal2021@gmail.com). Once we create an account, we will be able to send an email and check the email that is sent by others to our address. Following are the steps to create a Gmail account.

1. Go to www.gmail.com
2. Click Create an account
3. The sign-up form will appear. Follow the directions by entering the required information.



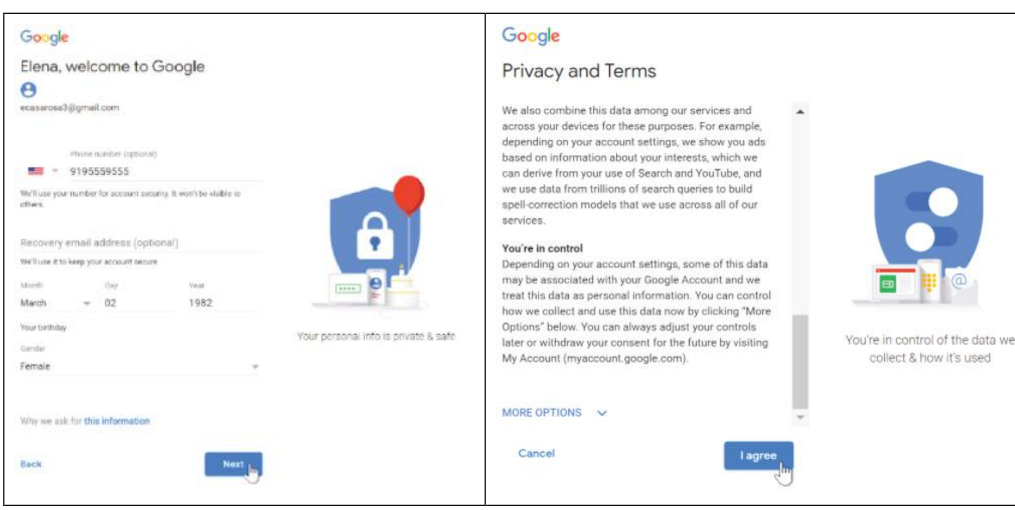
4. Next, enter your **phone number** to verify your account. Google uses a two-step verification process for account security. Then click on next.

5. You will receive a text message from Google with a **verification code. We have to enter that code** to complete the account verification.

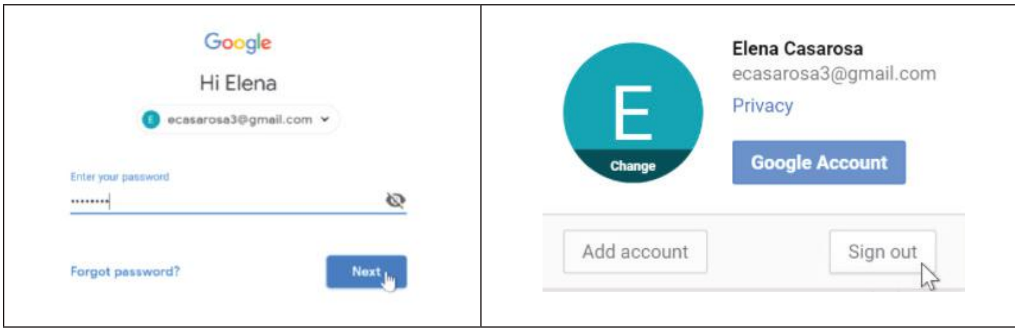


6. Next, we will see a form to enter some of our personal information, like name and birthday. Click on next to continue.

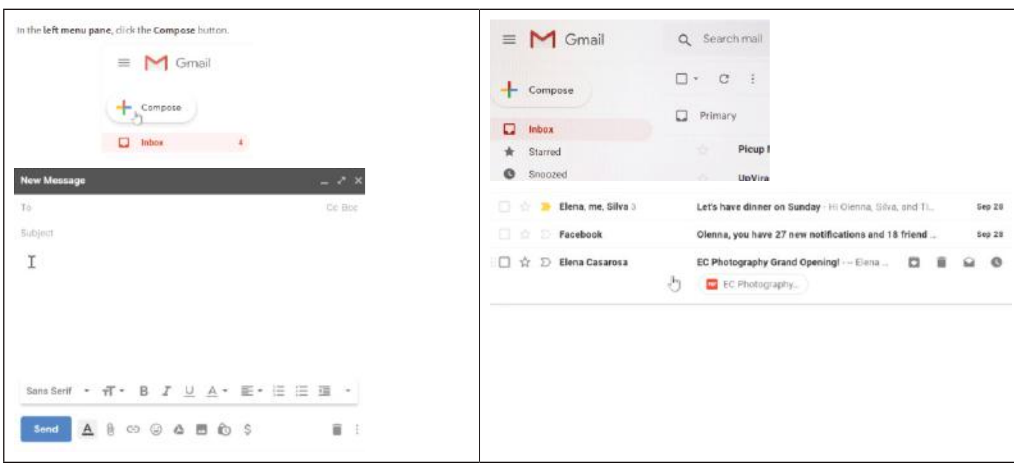
7. We need to review Google's Terms of Service and Privacy Policy for confirmation about creating a Gmail account. Then click on **I agree to proceed ahead**. Finally, you will get a notification that your account is created.



8. To sign in next time, go to www.gmail.com.
9. Type '**user name**' (email address) and '**password**', then click '**Next**'.
10. To sign out of account, locate the circle with the first initial letter of the name in the top-right corner of the page. Click the circle and select '**Sign-out**'.



11. To compose an email. In the left menu pane, click the Compose button.
12. The compose window will appear in the lower-right corner of the page.



13. We need to add one or more recipients (e.g., nepal2021@gmail.com) to the To: field. Type a subject for the message. Write your message and finally click on send to send your email.
14. Any message that we receive will go to the Inbox. To check an email sent to our address, we need to click on the Inbox button. By default, an unread message appears in bold. We need to click on the link with the boldface letters to read the message.

Use of internet to find study materials

Search engine

A search engine is a software system that is designed to carry out web searches. The commonly used search engines are www.google.com, www.bing.com, etc. When a user enters a search term, the search engine looks at the website page titles, contents, and keywords. It has indexed and uses step-by-step operations to produce a list of sites. In the search result, the most relevant websites are displayed at the top of the list. We can search our educational matter on the internet by using a search engine. All the matter that we search on the internet is not free to use in our work like slide preparation. The educational matter is kept on the internet under the copyright of the author or publisher. It means the matter on the internet is an intellectual property. We can easily read the copyright for learning purposes. If we use a sentence or figure from internet resources then we need to mention the reference of the website used. However, some internet resources are free to use. For example, the content on the website https://britannicalearn.com is free to use.

Google *Bing*

Duck Duck Go *Ask.com*

icon of various search engine

Activity 13.7

Search free educational matter related to ICT unit of class 9 science and technology on the internet to prepare PowerPoint slides. Present your slides in the classroom.

Google has made search work very easy for its users through search operators. The use of search operators limits the display of unwanted results. For example, when we search a term or terminologies with double quotation (i.e., "science and technology in Nepal") in Google then the search results displayed will contain the exact same phrases in websites it suggests. So, the use of a search operator makes our search work fast, more specific, and reliable. Some examples of Google search operators are given below:

Search operator	Explanation	Example
Inurl	Tells the search engine to find the pages on a site that has a targeted search term in the URL (link).	inurl: the human brain
Quotation Marks (“”)	Quotation marks tell the search engine to return documents if and only if they contain the exact phrase or string of words between quotes.	“ICT in Nepal”
AND	The AND operator tells the search engine to return only documents with all the keywords we entered.	inurl: plant tissues and animal tissues
OR	The OR operator tells the search engine to return documents if they contain one or more keywords.	inurl:plant tissues or animal tissues
-	The “-” operator tells the search engine to exclude documents from a search if they contain the keywords	inurl:plant cell – animal cell
*	The asterisk broadens a search by finding words that start with the same letters	*: evolution
site:	This operator restricts results to only those from a specified site.	site:ekantipr.com
filetype:	Restrict results to those of a certain file type like .pdf, .docx, .pptx, etc.	Plant tissues filetype:pptx
weather:	To find the weather for a specific location.	weather: Kathmandu
map:	It forces Google to show map results for a locational search.	map: Sindhuli

Internet security

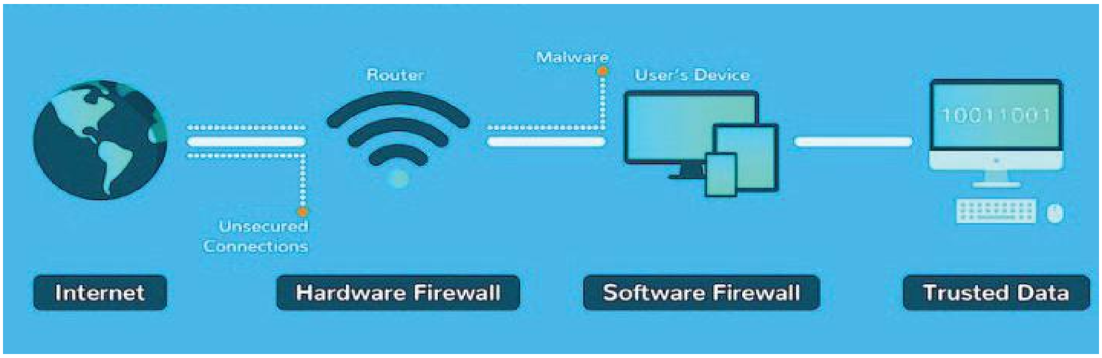
Internet security is the mechanism for protecting activities and transactions conducted online over the internet. It includes browser security, website security, and network security. Its objective is to establish rules and measures to use against attacks over the internet. The common attacks on the internet are through malicious software. Malicious software is used to disrupt computer operation, gather sensitive information, or gain access to private computer systems. Thus, internet security is essential to protect users from threats such as hacking into computer systems, email addresses, or websites. Firewall settings, installation of internet security applications in our computers, etc. can maintain our internet security.

Memory Note

Malicious software can infect and inherently damage systems. Identity theft by hackers creates data steal problems such as bank account information and credit card numbers.

Firewall

A firewall's purpose is to create a safety barrier between a private network and the public internet. A firewall is a system that is designed to prevent unauthorised access from entering a private network. A firewall filters the information that comes from the internet to our computer's database. If there are some kinds of harmful data from an incoming source like the internet, networking, wireless data transfer, etc., then the firewall blocks that data file. A strong firewall mechanism is especially important to a large organisation such as a banking system. In a bank, there are lots of computers in a network. In the banking system, there is a huge amount of personal data related to the banking details of customers.



Firewall in action

Fact and Reason

Why is a firewall called a safety barrier?

A firewall filters the information that comes in from the internet. A firewall blocks unwanted data and permits wanted data. So, a firewall is called a safety barrier.

Antivirus

Some popular antivirus

A computer virus is a programme. When a virus file enters our computer then it attaches itself to the files stored on the computer and damages them. Thus, a computer virus is a programme that can replicate its structures and infects other files on a computer. The typical purpose of a virus is to take over a computer to steal data. Computer virus infection can damage data or software, delete some or all files, slow down the speed of a computer, etc. A computer virus can spread through an illegal copy of software i.e. cracked version of the software that is developed and uploaded on the internet by hackers. The virus also spreads through networks, removable storage media like pen drives. One of the major ways to keep our computer safe from virus attacks is by installing an antivirus application.

Antivirus is also a computer programme that scans the incoming files and searches for known threats. It also monitors the behaviour of all programmes. If a suspicious programme is found then the antivirus either deletes that file or keeps it in quarantine. There are several antiviruses like Norton, Kaspersky, etc. commercially available in the market to purchase and install on our computer.

Fact and Reason

Downloading cracked software from the internet and installing it on our computer can be harmful. Why?

Cracked software is illegal. Such software is not developed by authorised companies but provide a feature to skip fee for software registration. But there is a chance of installing cracked software mixed with a virus that was developed by a team of attackers. Once a user has downloaded and installed such software, the malware hidden inside can steal information from their computer. It can control the browser to download more malware.

Digital footprint

Activity 13.8

Recall your one-week activities on the internet. For example, what did you search? What video did you watch on YouTube, etc? Is it possible to find the records of your activities? Discuss this with your friends.

We search for different kinds of information on the internet. Whatever we do on the internet remains in the form of data memory. When we visit websites to get information, do social sharing, send messages, and email, we leave behind information through our recorded digital identity. Thus, digital footprints are the trails or traces we leave behind as we use the internet. It is also termed a cyber shadow or digital shadow.

digital foot print

Our digital footprints reveal a lot about us. Comments on social media, website visits, abuse, and email records are all part of our online history which can possibly be seen by other people or tracked in a database. People don't realise the extent to which their data and activities online are being monitored and recorded suspiciously. Our digital footprints are monetised by organisations like internet service providers.

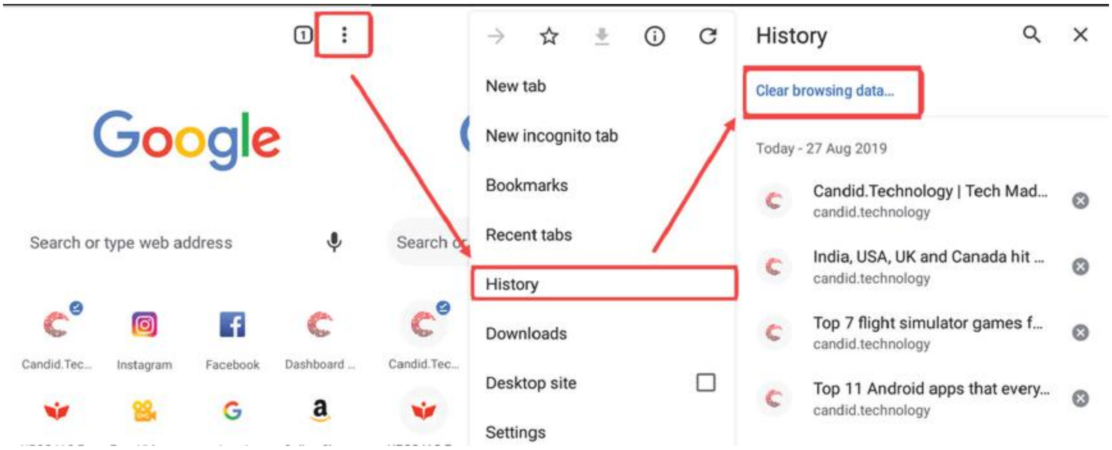
Digital footprints have both positive and negative impacts. For example, if we keep our records saved in social media then it saves our time while logging in again and again. On the other hand, if we log in from an unknown device then there may be a chance of personal data being hacked through hacking computer programmes. Some of the mobile applications or computer applications might be collecting personal information without our permission. Sometimes cookies and trackers are also stored on our browser to monitor online activity.

Memory Note

Social media activities leave a record behind. If anyone is found involved in social crime through social media, they can be charged as a convict through the police investigation.

We can follow some steps to reduce our digital footprint. We have to delete all tracking cookies and browsing history from our browsers regularly. The trackers will not be able to follow us if we delete cookies from suspicious sites that get saved on our devices. We can follow instructions provided by the browser company to delete history data, cookies, remembered passwords, etc.

for browsers like Safari, Chrome, Edge, etc. The figure given below shows the procedure to delete history in the Chrome browser.



Cyberbullying

Technology provides a way to cause harm anonymously. For example, one friend downloads a photo of another friend from social media. He edits the photo in funny looks over the animal's body. He posts that photo in all his friend's groups. This type of activity will make it uncomfortable for the student with whom such bullying was done. Cyberbullying takes place over digital devices like cell phones, computers, tablets, etc. It can occur through SMS, text, and apps, or online in social media, forums, or gaming where people can view, participate in, or share content. Thus, cyberbullying can be defined as wilful and repeated harm caused through the use of computers, cell phones, or other electronic devices.

Cyberbullying

Cyberbullying includes sending, posting, or sharing negative, harmful, false, or mean content about someone else. It can include sharing personal or private information about someone else causing embarrassment or humiliation. Students have to follow safety technology and social media habits to remain safe from cyberbullying. We should never share our personal information with all in common groups on social media. If anyone is being bullied then his or her first step is to inform parents or guardians. We can take legal steps against cyberbullying, too.

Activity

Make a survey work about identifying different kinds of cyberbullying activities that people in your surrounding have faced. Also, ask about the action taken to solve the problem. Finally, keep a record in the format given below.

Cyberbullying activity faced	Action taken to solve the problem

Answer writing skill

1. **What is a communications satellite?**

   A communications satellite is an artificial satellite stationed in space for telecommunications.

2. **What is the full form of GPS?**

   The full form of GPS is Global Positioning System.

3. **Banking networks need a strong firewall system, why?**

   Hackers target banking networks to steal the banking details of customers through cyber-attack. That's why you need a firewall to protect them.

4. **Differentiate between uplink and downlink.**

   The differences between uplink and downlink are:

SN	Uplink	SN	Downlink
1	An uplink is the message signal from a ground station sent up to a satellite.	1	A downlink is the message signal from a satellite sent down to one or more ground stations or receivers.
2	The uplink signal is at a higher frequency than downlink.	2	The downlink signal is at a lower frequency than uplink.

5. Explain the role of the Google search operator with an example.

Google's search operators are popular features that allow you to refine your search. They work by telling Google which words in the query should have the highest import. For example, the 'filetype' operator can be used to find the results related to a particular file format like .docx, .pptx, .pdf, etc. If we want to search pdf files about evolution then we can search by typing evolution filetype: pdf. The result of our search contains pdf files published about evolution.

6. How is cyberbullying different from in-person bullying?

In-person bullying is possible when the bullied one comes in contact with bullies directly. On the other hand, cyberbullies don't have to confront people face-to-face. Cyberbullying happens at any time. It is anonymous and is potentially broadcast to a wider audience. In case of bullying on an online platform like social media, posts can be difficult to remove and can last forever.

EXERCISE

Step 1

1. Choose the best answers from the given alternatives.

a. Where are communications satellites placed?

i. low earth orbit | ii. medium earth orbit
iii. geostationary orbits | iv. high elliptical orbit

b. What is a radio wave signal propagating from one point to another following the surface of earth is called?

i. skywave | ii. ultrasonic wave
iii. soundwave | iv. ground wave

c. Which search string would give you the result displaying the pdf files about evolution?

i. filetype: evolution pdf | ii. evolution filetype:pdf
iii. evolution: filetype pdf | iv. filetype evolution:pdf

d. Which of the following is the way to handle cyberbullying?

i. follow the person in social media
ii. inform parents or a teacher

iii. get in a fight with the person
iv. delete the messages

e. Which of the following is a key function of a firewall?

i. monitoring	ii. copying
iii. moving	iv. deleting

2. Define the following, with examples.

a. Low earth orbit (LEO)	b. Medium earth orbit (MEO)
c. Geostationary orbit (GEO)	d. Carrier signal
e. Modulation	f. Internet
g. Search engine	h. Digital footprint
i. Cyberbullying	j. Satellite

3. Short Question Answers.

a. What is an artificial satellite?
b. Define geostationary satellite.
c. What is a global positioning system?
d. Give the name of Nepal's first satellite.
e. Define telecommunication.
g. What is a computer virus?
h. Write two examples of computer antivirus software.

Step 2

4. Give reason.

a. A satellite does not need any external energy source to keep it in motion.
b. Communication satellites are placed in GEO.
c. It is possible to transmit communication signals from one part of the world to the opposite part.
d. Explain the role of satellites in communication.
e. Music radio stations tend to choose FM instead of AM.
f. A firewall is called a safety barrier.
g. Downloading and installing cracked software from the internet can be harmful.

5. Differentiate between the following.

a. Uplink and downlink
b. Wireless communication and wired communication

c. Fax and email
d. Frequency modulation and amplitude modulation
e. Firewall and antivirus

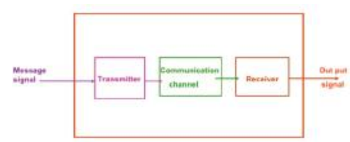
Step 3

6. Answer the following questions.

a. Explain the role of waves in telecommunication.
b. Thousands of communication satellites are launched in low earth orbit. How do they help in communication?
c. Cyberbullying is a serious problem all around the globe. Present your view with a supporting statement.
d. One of your friends says that a firewall removes viruses. Make him clear about firewall by comparing it with computer antivirus.

Step 4

7. Long questions answers.



a. What is shown in the given figure? Explain the function of each of the components shown in this process.
b. Is there any special program you listen to in a FM radio? Is FM radio in your city also available in some other cities? Why? Why not?
c. Have you ever noticed that sometimes the mobile devices and PC overheat even though it has no defect in hardware? or have you noticed any application software malfunction? What might be the reasons? What should be installed in PC to avoid such activities?
d. Do you have Facebook account, Instagram account or tiktok account? Have you made any post in those accounts? Have you given a thought about how is it going to affect your life in future? Let's give a thought about it and decide what kinds of activities we should not do in digital social platform.
e. Internet communication is a revolution in the field of communication. Justify
f. Let's suppose your guardians started using mobile banking. What should they be aware of? Provide any three suggestions for them regarding online security measures.

UNIT
14 ATOMIC STRUCTURE AND CHEMICAL BOND

ESTIMATED TEACHING PERIODS

TH	PR
11	2

John Dalton
(1766-1844)

Curriculum issued by CDC

- Introduction of atomic structure
- Nuclear stability, neutron proton ratio and nuclear size
- Radio activity
- Introduction of radioactivity
- Radioactive emissions (α, ß and γ radiations)
- Introduction of nuclear fission and fusion
- Conditions required for nuclear fission and fusion
- Introduction of nuclear energy
- Usefulness of nuclear energy
- Valency and ways of determination of valency
- Introduction, type, formation and examples of ions
- Introduction of chemical bonds and its types
- Conditions of formation of electrovalent bonds (NaCl, $CaCl_2$, MgO) and covalent bonds (HCl, H_2O and CH_4)
- Construction of molecular formula using Criss cross method, atomic weight and molecular weight.

Learning outcomes

After completion of this unit, students will be able to:
- draw and describe the atomic structure.
- introduce radioactive emissions and the conditions under which radioactive emissions occur.
- give a general introduction to nuclear fission and nuclear fusion and to mention the conditions required for atomic reactions.
- explain the usefulness if atomic energy
- explain the conditions and processes of chemical bonding.
- explain the general concept of valency and ions.
- write the molecular formula using Criss cross method and to calculate molecular weight.

Terms and terminologies

1. Matter:	Anything that occupies space and has mass is called matter.
2. Pure matter:	The matters which are composed of the same kind of substances are called pure matters.
3. Impure matter:	The matters which are composed of different substances are called impure matters.
4. Atoms:	Atoms are the smallest particles of an element that take part in chemical reactions without division.
5. Protons:	Protons are positively charged sub-atomic particles of an atom.
6. Neutrons:	Neutrons are chargeless sub-atomic particles of an atom.
7. Electrons:	Electrons are negatively charged sub-atomic particles of an atom.
8. Valance shell:	The outermost shell of an atom from where loss or gain of electrons takes place is called the valence shell.
9. Valance electron:	The total number of electrons that are present in the valence shell are called valence electrons.
10. Valency:	The combining capacity of an element or a radical with another element or radical to form a compound or molecule is called valency.
11. Variable valency:	The occurrence of multiple valencies of helium element is called variable valency.
12. Duplet state:	The arrangement of two electrons in the K-shell of an atom is called a duplet state.
13. Duplet rule:	The tendency of elements by which they try to maintain two electrons in their valence shell either by transferring or sharing electrons is called the duplet rule.
14. Octet state:	The state of having eight electrons in the valence shell of an atom is called the octet state.
15. Octet rule:	The tendency of elements by which they try to maintain eight electrons in their valence shell either by transferring or sharing electrons is called the octet rule.
16. Radicals:	Radicals are the charged atoms or groups of atoms having a common charge which act as a single unit during a chemical reaction.
17. Electropositive radical:	The atoms or groups of atoms that have a positive charge in them are called electropositive radicals.
18. Electronegative radical:	The atom or group of atoms that have a negative charge in

	them are called electronegative radicals.
19. Chemical bond:	The force of attraction by which atoms are held together in a molecule is called a chemical bond.
20. Electrovalent bond:	The chemical bond which is formed by the transfer of electrons from the valence shell of metal to the valence shell of a non-metal is called an electrovalent bond.
21. Covalent bond:	The chemical bond formed by the sharing of electron pairs in between two or more non-metal atoms is called a covalent bond.
22. Molecular formula:	The molecular formula of a molecule is the symbolic representation of the molecule of an element or a compound in molecular form.
23. Atomic weight:	Atomic mass (weight) is the sum of the numbers of protons and neutrons present in the nucleus of an atom.
24. Radioactive elements:	Those elements whose atoms spontaneously disintegrate into lighter nuclei are called radioactive elements.
25. Radioactive emissions:	The particles released by the radioactive substances are called radioactive emissions.
26. Nuclear energy:	The energy stored in the nucleus of an atom is called nuclear energy.
27. Nuclear fission:	The splitting of the heavy nucleus of an atom into two lighter nuclei is called nuclear fission.
28. Thermonuclear fission:	The process in which light nuclei of the atoms combine to form a heavier nucleus with the release of energy in presence of high temperature and pressure is called thermonuclear fusion.

Introduction

Anything that occupies space and has mass is called matter, e.g., stone, water, oxygen etc. All substances are made of matter. Matter can be pure and impure. Pure matters are composed of the same kind of substances. Impure matters are composed of different substances. Elements and compounds are pure matters. Homogeneous and heterogeneous mixtures are impure matters.

Matter is made of tiny particles called atoms.

Atom

Atoms are the smallest particles of an element that take part in chemical reactions without division. Atoms of an element are similar in all features.

Atoms of different elements are different from each other. For example, all atoms of gold have the same features but atoms of gold and atoms of silver are different from each other.

There are altogether 118 different types of atoms of 118 different elements.

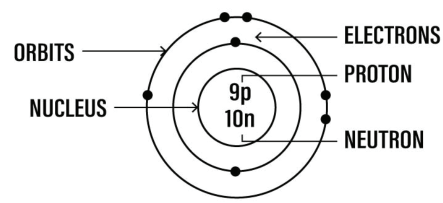
Memory Note

The word "atom" comes from the Greek word for uncuttable or undivided.

Activity

Make a clay model of an atom.

Structure of an atom



The diameter of the atom is approximately 10^{-10}m. In each atom, there are three fundamental particles. They are electron, proton, and neutron. Protons and neutrons are present at the nucleus of an atom whereas electrons revolve around the nucleus in fixed orbits (shells). Protons are positively charged sub-atomic particles of an atom. The mass of a proton is equal to the mass of a hydrogen atom which is 1 amu (atomic mass unit). Neutrons are chargeless sub-atomic particles of an atom. The mass of each neutron is 1 amu. Electrons are negatively charged sub-atomic particles of an atom. The mass of an electron is $\frac{1}{1837}$ amu.

Memory Note

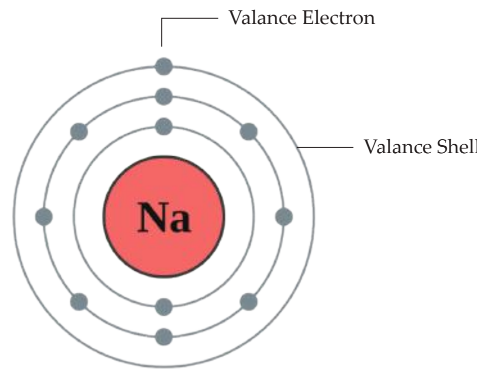
A positively charged hydrogen ion (H+) is also called a proton because it has only one proton.

Summary of fundamental or subatomic particles of an atom

S. N	Fundamental particle	symbol	Position	Mass in amu	Charge in esu
1	Electron	e^-	Orbit	1/1837	-1 e.s.u
2	Proton	P^+	Nucleus	1	+1 e.s.u
3	Neutron	n^0	Nucleus	1	0 e.s.u

Valence shell valence electrons

The outermost shell of an atom from where loss or gain of electrons takes place is called the valence shell and the total number of electrons that are present in the valence shell (outer shell) are called valence electrons. For example, valence electrons in sodium, magnesium, and chlorine are 1, 2, and 7 respectively. Valence electrons determine the valency of an atom.



Most of the atoms of different elements tend to gain or lose or share valence electrons to attain stable electronic configuration. To be in a stable electronic configuration, an element should have eight electrons in its outermost shell (except K shell as an outermost shell). Therefore, an atom tends to be stable by fulfilling the need of eight electrons in its outermost shell (two electrons if K shell is the outermost shell). For this, they take part in chemical combinations with other atoms or radicals and become stable.

Valency

The combining capacity of an element or a radical with another element or radical to form a compound or molecule is called valency. According to the new concept, "The total number of electrons lost, gained or shared by an atom during a chemical combination is called valency." Valency of sodium is one because its atom loses one electron during a chemical combination and valency of oxygen is two because its atom gains two electrons during a chemical combination. Similarly, the valency of carbon is four as its atom shares four electrons during a chemical combination.

Examples,

1. Find out the valency of aluminium in $AlCl_3$.
   In $AlCl_3$, three atoms of chlorine combine with one atom of aluminium. So, the valency of aluminium is three.
2. Find out the valency of hydrogen and phosphate in $H_3 PO_4$.
   In $H_3 PO_4$, three atoms of hydrogen combine with one phosphate radical. So, the valency of phosphate is three and that of hydrogen is one.

Memory Note

The largest atom(caesium) is approximately nine times bigger than the smallest atom(helium).

Fact and Reason

The valency of chlorine is one, why?

The valency of chlorine is one as its atoms gain one electron from the atom of other elements during a chemical reaction to gain a stable electronic configuration.

Electronic configuration table of first 20 elements

SN	Element	Symbol	Atomic number	Electronic configuration			
				K	L	M	N
1	Hydrogen	H	1	1			
2	Helium	He	2	2			
3	Lithium	Li	3	2	1		
4	Beryllium	Be	4	2	2		
5	Boron	B	5	2	3		
6	Carbon	C	6	2	4		
7	Nitrogen	N	7	2	5		
8	Oxygen	O	8	2	6		
9	Fluorine	F	9	2	7		
10	Neon	Ne	10	2	8		
11	Sodium	Na	11	2	8	1	
12	Magnesium	Mg	12	2	8	2	
13	Aluminium	Al	13	2	8	3	
14	Silicon	Si	14	2	8	4	
15	Phosphorus	P	15	2	8	5	
16	Sulphur	S	16	2	8	6	
17	Chlorine	Cl	17	2	8	7	
18	Argon	Ar	18	2	8	8	
19	Potassium	K	19	2	8	8	1
20	Calcium	Ca	20	2	8	8	2

Variable valency

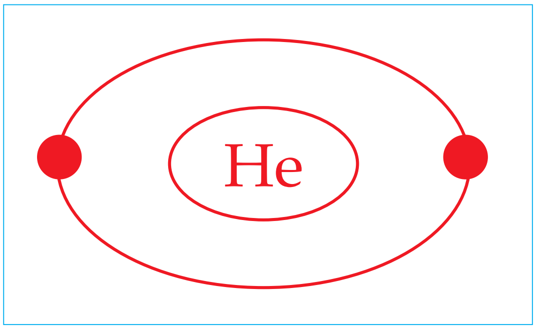
We know that iron makes two types of compounds with chlorine. They are $FeCl_2$ and $FeCl_3$. Did you notice two types of valency in $FeCl_2$ and $FeCl_3$? In $FeCl_2$ valency of iron is 2 and in $FeCl_3$ valency of iron is 3. That means iron has multiple valencies, 2 and 3. The occurrence of multiple valencies of an element is called variable valency. The existence of variable valency of the elements means that they can give, take or share a different number of electrons with different atoms or different radicals. The transitional elements in the modern periodic table show variable valency because they have two incomplete outer shells.

The elements and their variable valency are given in the table below:

Element	Lower valency		Higher valency	
	Radical	Valency	Radical	Valency
Copper	Cuprous (Cu^{+})	1	Cupric (Cu^{++})	2
Mercury	Mercurous (Hg^{+})	1	Mercuric (Hg^{++})	2
Gold	Aurous (Au)	1	Auric (Au^{+++})	3
Iron	Ferrous (Fe^{++})	2	Ferric (Fe^{+++})	3
Tin	Stannous (Sn^{++})	2	Stannic (Sn^{++++})	4

Duplet and duplet rule

Helium is the first member of inert gases. It has only two electrons and according to the $2n^2$ rule, these two electrons are present in the first shell (K-shell). So, the arrangement of two electrons in the K-shell of helium atom is called a duplet state. Inert gases like helium remain in atomic form. Similarly, some elements like H, Li, try to maintain two electrons in the shell K (last shell) either by transferring or sharing electrons which is called the duplet rule. The tendency of elements by which they try to maintain two electrons in their valence shell (last shell) either by transferring or sharing electrons is called the duplet rule.



atomic structure of helium

Memory Note

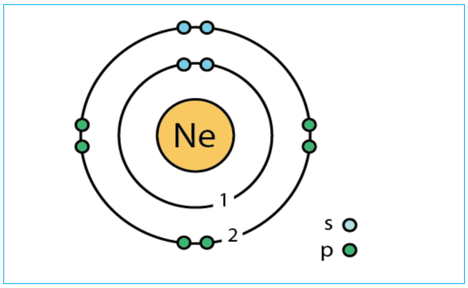
The most abundant type of atom in the universe is the hydrogen atom.

Fact and Reason

A Helium atom remains stable in its atomic form, why?

Since a Helium atom has a duplet state, it does not take part in a chemical reaction and remains stable in its atomic form.

Octet and octet rule



The figure of atomic structure of neon

Except for helium, the other five inert elements have eight electrons in their valence shell. In other words, they are in a stable electronic configuration. The state of having eight electrons in the valence shell (last shell) of an atom is called the octet state. The presence of two electrons in helium (He) and eight electrons in Ne, Ar, Kr, Xe, and Rn is the main cause of the stability of these elements. Hence, they have zero combining capacity (valency).

The elements which have more or less than eight electrons in their last shell are chemically unstable and they always try to achieve this condition which is called the octet rule. So, the tendency of elements by which they try to maintain eight electrons in their valence shell (last shell) either by transferring or sharing electrons is called the octet rule.

Radical (Ion)

Radicals are the charged atoms or groups of atoms having a common charge which act as a single unit during a chemical reaction. They have either a positive charge or a negative charge. Hence, they do not occur in free form and make different types of compounds.

Memory Note

The mass of the proton is the same as a neutron but 1837 times greater than the mass of the electron.

Fact and Reason

Radicals are highly reactive, why?

Radicals are the charged particles formed by losing or gaining electron(s). They try to pair their unpaired electrons. So, radicals are highly reactive and least stable.

Types of ions or radicals

Based on an electric charge, radicals are of two types:

1. Electropositive radicals or basic radicals

The atoms or groups of atoms that have a positive charge in them are called electropositive radicals or basic radicals. Some examples of electropositive radicals with their valencies are given below:

Monovalent	Bivalent	Trivalent	Tetravalent
Hydrogen(H^{+})	Beryllium (Be^{++})	Boron (B^{+++})	Stannic (Sn^{++++})
Lithium (Li^{+})	Magnesium (Mg^{++})	Aluminium (Al^{+++})	Plumbic (Pb^{++++})
Sodium (Na^{+})	Calcium (Ca^{++})	Chromium (Cr^{+++})	Silicon (Si^{++++})
Potassium (K^{+})	Barium (Ba^{++})	Manganic (Mn^{+++})	
Ammonium (NH_4^{+})	Zinc (Zn^{++})		
Caesium (Cs^{+})	Nickel (Ni^{++})		
	Manganous (Mn^{++})		

2. Electronegative radicals or acidic radicals

The atom or group of atoms that have a negative charge in them are called electronegative radicals or acidic radicals. Some examples of electronegative radicals are given below:

Monovalent	Bivalent	Trivalent
Fluoride (F^{-})	Oxide (O^{--})	Nitride (N^{---})
Chloride (Cl^{-})	Sulphide (S^{--})	Phosphide (P^{---})
Bromide (Br^{-})	Sulphite (SO_3^{--})	Phosphite (PO_3^{---})
Nitrite (NO_2^{-})	Sulphate (SO_4^{--})	Phosphate (PO_4^{---})
Nitrate (NO_3^{-})	Carbonate (CO_3^{--})	
Cyanide (CN^{-})	Zincate (ZnO_2^{--})	
Hydroxide (OH^{-})	Silicate (SiO_3^{--})	
Chlorate (ClO_3^{-})	Peroxide (O_2^{--})	
Bisulphate (HSO_4^{-})	Dichromate ($Cr_2O_7^{--}$)	
Bicarbonate (HCO_3^{-})	Thiosulphate ($S_2O_3^{--}$)	

Chemical bond

Inert gases have eight electrons in their valence shell except for helium. Due to stable electronic configuration, inert gases are stable. Other elements which do not have duplet or octet states are unstable. Metals have one, two, or three electrons in their valence shell whereas active non-metals have five, six, or seven electrons in their valence shell. Metals try to lose electrons from the valence shell to be stable whereas non-metals try to gain electrons to attain a stable electronic configuration. However, some elements share electrons to obtain a stable electronic configuration. Thus, atoms lose, gain or share electrons to obtain a stable electronic configuration. It is the main cause of the chemical reaction.

Memory Note

Losing, gaining, or sharing electrons by an atom to obtain a stable electronic configuration is the main cause of chemical reactions.

Fact and Reason

Why does chemical reaction occur?

The chemical reactions occurs because most of the elements are not stable by the octet or duplet rule.

When an atom loses electrons, it gains a positive charge and when it gains electrons it acquires a negative charge. In between these opposite charges, there is a force of attraction which is called a chemical bond. So, the force of attraction by which atoms are held together in a molecule is called a chemical bond. For example, in CH_4 one atom of carbon and four atoms of hydrogen are held together by a bond.

plastic model of methane

There are various types of chemical bonds but we will discuss electrovalent and covalent bonds only.

a) **Electrovalent bond or Ionic bond**

The chemical bond which is formed by the transfer of electrons from the valence shell of metal to the valence shell of a non-metal is called an electrovalent bond. The compounds which are formed by the transfer of electrons from a metal to a non-metal are called electrovalent compounds. They contain electrovalent bonds. For example, NaCl, KCl, $CaCl_2$, $MgCl_2$, CaO, etc.

During electrovalent bonding, metals lose their electrons and acquire positive charge, i.e. cation. Similarly, non-metals gain electrons and acquire negative charges, i.e. anion. In between these opposite charges, there is a force of attraction which is called the electrostatic force of attraction.

Memory Note

Losing, gaining, or sharing electrons by an atom to obtain a stable electronic configuration is the main cause of the chemical reaction.

Characteristics of electrovalent or ionic compounds

i. They have high melting and boiling points.

ii. They conduct electricity in a molten state or aqueous solution.

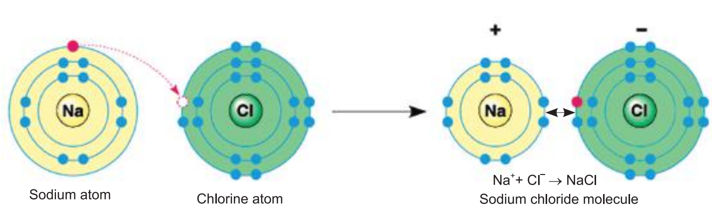
iii. They dissolve in water.

Memory Note

In the electrovalent compounds, the force of attraction is strong and more energy is required to break the force apart. So ionic substances have high melting and boiling points.

Formation of sodium chloride (NaCl)

Sodium chloride is an electrovalent or ionic compound. It is formed by the transfer of one electron from the sodium atom to the chlorine atom.



Formation of Sodium chloride molecule

In sodium chloride, sodium is a metal and chlorine is a non-metal. A sodium atom has one electron in its valence shell, whereas a chlorine atom has seven electrons in its valence shell. The sodium atom donates its one valence electron to the valence shell of the chlorine atom. Hence, sodium gains a positive charge and chlorine gains a negative charge. There is a force of attraction between two opposite charges which is called an electrovalent bond. This bond keeps Na^+ and Cl^- together in the form of a molecule, i.e. NaCl.

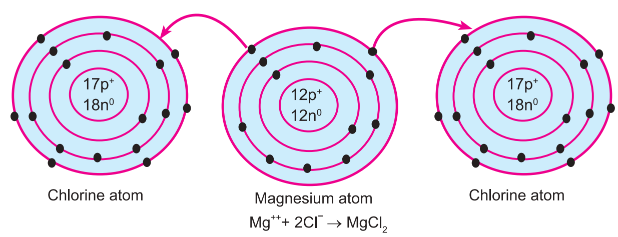
Fact and Reason

NaCl is an ionic compound, why?

During the formation of NaCl, there is a transfer of an electron from the atom of sodium to the atom of chlorine. It is the combination of two ions Na^+ and Cl^- with an ionic bond. So, NaCl is an ionic compound.

Formation of magnesium chloride ($MgCl_2$)

Magnesium chloride is an electrovalent compound. It is formed by the transfer of two electrons from one magnesium atom to two chlorine atoms. In magnesium chloride, magnesium is a metal and chlorine is a non-metal. A magnesium atom has two electrons in its valence shell, whereas a chlorine atom has seven electrons in its valence shell. During chemical combination, the magnesium atom donates its two electrons to each chlorine atom. As a result, magnesium acquires two positive charges and two chlorine atoms gain one negative charge each. Now, a chemical bond is formed between one magnesium and two chlorine atoms.



Formation of Magnesium chloride molecule

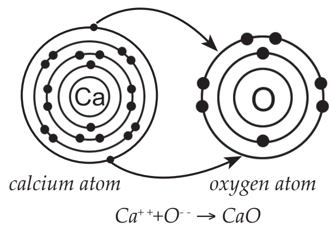
Fact and Reason

Magnesium chloride is an electrovalent compound. Why?

The magnesium chloride is formed by the transfer of electrons from magnesium to chlorine atoms. The transfer of electrons makes an electrovalent bond between them. Therefore, magnesium chloride is an electrovalent compound.

Formation of calcium oxide

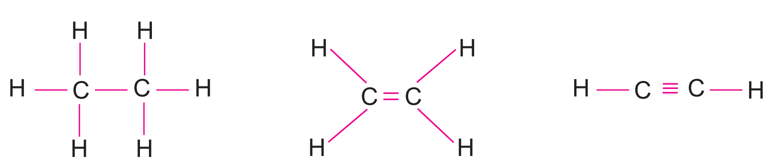
Calcium oxide is an example of an electrovalent compound. It is formed by combining calcium metal and oxygen non-metal. Calcium has an electronic configuration of 2, 8, 8, 2, and oxygen has an electronic configuration of 2, 6. According to the octet rule, the above electronic configuration shows that calcium has two extra electrons and oxygen requires two more electrons to attain an octet state. Thus, to make calcium oxide, calcium loses two electrons to produce calcium ions (Ca^{++}). Similarly, the oxygen atom gains two electrons to make an oxide ion (O^{--}). The electrostatic force between positively charged calcium ion and negatively charged oxygen ion binds them to produce calcium oxide. It is an electrovalent bond. Hence calcium oxide is formed by the transfer of electrons from calcium to oxygen.



formation of calcium oxide molecule

Covalent bond

The chemical bond formed by the sharing of electron pairs in between two or more non-metal atoms is called a covalent bond. It is represented by a line (–) in between the bonded atoms. When one pair of electrons is shared, it is called a single covalent bond and represented by only one line (–). Similarly, when two pairs and three pairs of electrons are shared, they are called double covalent bonds and triple covalent bonds respectively. A double covalent bond is represented by two lines (=) and a triple covalent bond are represented by three lines (≡). For example:



structural formula of ethane ethene and ethyne

The compounds which have covalent bonds are called covalent compounds. These compounds are formed by sharing of electron pair/s between non-metallic atoms. Examples: Carbon dioxide (CO_2), Ammonia (NH_3), Water (H_2O), Methane (CH_4), etc. They have generally low melting and boiling point.

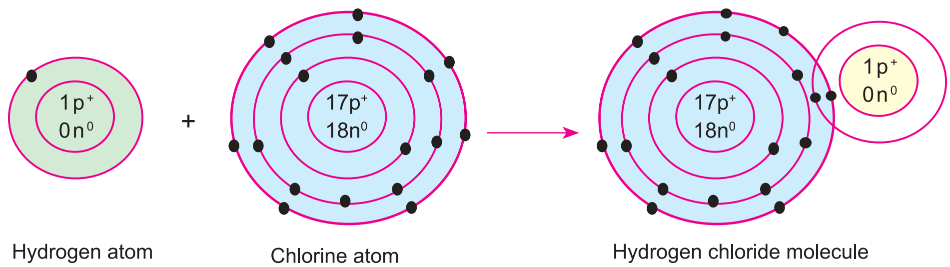
Activity

In covalent compounds, the force of attraction is very weak. So, less energy is required to break the force apart. So covalent substances have low melting and boiling points.

Characteristics of covalent compounds

i They are insoluble in water.
ii. They have low melting and boiling points.
iii. They do not conduct electricity.

Formation of hydrochloric acid (HCl)

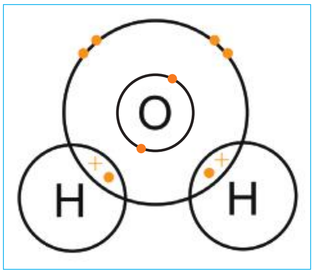


Formation of Hydrogen chloride molecule

Hydrochloric acid is formed by sharing one pair of electrons between a hydrogen atom and a chlorine atom. In hydrochloric acid, there is one hydrogen atom and one chlorine atom. A hydrogen atom has only one electron in its shell. So, it requires one more electron to get a duplet state. Similarly, a chlorine atom has seven electrons in its valence shell. So, it requires one more electron to get an octet state. Therefore, a hydrogen atom and a chlorine atom share one pair of electrons to get a stable electronic configuration. As a result, a hydrogen chloride (HCl) molecule is formed.

Formation of the water molecule

In water, there is one oxygen atom and two hydrogen atoms. The electronic configuration of oxygen is 2, 6 and that of hydrogen is 1. According to the octet rule, it needs two electrons to attain a stable electronic configuration. Similarly, in hydrogen, there is one valence electron. It needs one more electron to be stable by the duplet rule. Now two hydrogen atoms share one electron each with the same oxygen atom. Therefore, one oxygen atom combines with two hydrogen atoms to form a water molecule.



formation of the water molecule

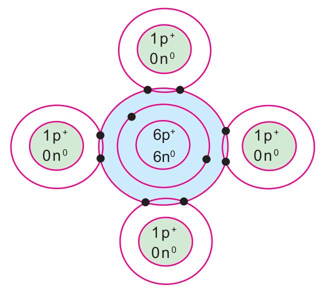
Fact and Reason

Why is water a covalent molecule?

Water molecule is formed as a result of sharing of electrons between one oxygen atom and two hydrogen atoms. The hydrogen atoms are covalently bonded with oxygen atoms. Therefore, water is a covalent molecule.

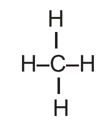
Formation of methane

In a methane molecule, there is one carbon atom and four hydrogen atoms. A carbon atom has four electrons in its valence shell. So, it shares its electrons with four electrons of other atoms to get an octet state. Similarly, a hydrogen atom has only one electron in its valence shell. So, it shares its electrons with one electron of other atoms to get a duplet state. Here, four electrons of a carbon atom combine with one



Molecular structure of Methane

Or,



(Methane)

Memory Note

The number of neutrons in the nucleus plays a major role in determining the atom's mass and radioactivity.

Fact and Reason

CH_4 is a covalent compound, why?

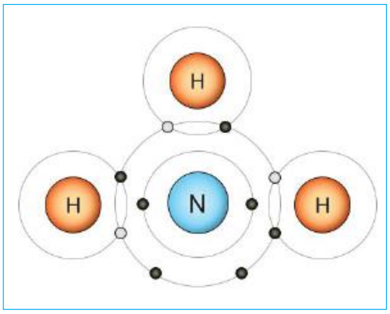
During the formation of CH_4, there is a mutual sharing of electrons between an atom of carbon and four atoms of hydrogen. It is the combination of two non-metals with covalent bonds. So, CH_4 is a covalent compound.

Activity

Make a model of a methane molecule.

Formation of ammonia

In ammonia, there is one nitrogen atom and three hydrogen atoms. The electronic configuration of nitrogen is 2, 5. In this electronic configuration, there are five electrons in the valence shell of nitrogen. According to the octet rule, it needs three electrons to attain a stable electronic configuration. Similarly, hydrogen needs one more electron in its K-shell to be stable by the duplet rule. Therefore, one nitrogen shares one electron with each of the three hydrogen atoms. Three hydrogen atoms are now covalently bonded with single nitrogen. Hence ammonia molecule is formed.



formation of the ammonia molecule

Fact and Reason

Ammonia is a covalent compound. Why?

Ammonia molecule is formed when three hydrogen atoms share electrons and bond covalently with a nitrogen atom. Therefore, ammonia is a covalent compound.

Differences between electrovalent and covalent compounds

SN	Electrovalent compounds	SN	Covalent compounds
1	The compounds formed by the transfer of electrons between atoms are called electrovalent compounds.	1	The compounds formed by sharing of electron pairs between atoms are called covalent compounds.
2	They can conduct electricity in a molten/solution state.	2	They cannot conduct electricity.
3	They have high melting and boiling points.	3	They have low melting and boiling points.
4	They contain metal atoms in their molecules. Examples: NaCl, $MgCl_2$, $AlCl_3$ etc.	4	They do not contain metal atoms in their molecules. Examples: H_2O, NH_3, CH_4 etc.

Molecular formula

The molecular formula of a molecule is the symbolic representation of the molecule of an element or a compound in molecular form. It represents the actual number of atoms of different elements in a molecule. For example, the molecular formula of sodium chloride is NaCl. It shows that one molecule of sodium chloride (NaCl) consists of one atom of sodium (Na) and one atom of chlorine (Cl). Elements like hydrogen, nitrogen, oxygen, chlorine, bromine, and iodine have two atoms in their molecule, viz. H_2, N_2, O_2, Cl_2, Br_2, and I_2 respectively. So, they are called diatomic molecules.

Memory Note

Every year our body replaces about 98%of its atoms.

Fact and Reason

An atom of inert gases represents an atom as well as a molecule, why?

In the case of inert gases, i.e. He, Ne, Ar, Kr, Xe, and Rn, the single-atom represents the atom as well as molecule because they are monoatomic molecules with a stable electronic configuration.

Method of writing molecular formula

We should follow these steps to write the correct molecular formula of a molecule.

i. Write the symbol of basic (positive) and acidic (negative) radicals side by side.

ii. Write the valency of each radical in the upper right corner of each.

iii. Exchange the valency of these radicals. Take HCF if it is necessary.

iv. Combine radicals with exchanged valency.

v. If radicals have different atoms, enclose within brackets.

For example

For example,

1. Sodium chloride

Na Cl
1 1

Na_1 Cl_1

NaCl

2. Calcium chloride

Ca Cl
2 1

Ca_1 Cl_2

$CaCl_2$

3. Aluminium chloride

Al Cl
3 1

Al_1 Cl_3

$AlCl_3$

4. Carbon tetrachloride

C Cl
4 1

C_1 Cl_4

CCl_4

5. Boron oxide

B O
3 2

B_2 O_3

B_2O_3

6. Ammonium sulphate

NH_4 SO_4
1 2

NH_4 SO_4
1 2

$(NH_4)_2SO_4$

7. Calcium sulphate

Ca $\quad SO_4$

2 $\quad$ 2

Ca $\quad SO_4$

2 $\quad$ 2

$CaSO_4$

8. Aluminium nitrate

Al $\quad NO_3$

3 $\quad$ 1

Al $\quad NO_3$

3 $\quad$ 1

$Al(NO_3)_3$

9. Calcium bicarbonate

Ca $\quad HCO_3$

2 $\quad$ 1

Ca $\quad HCO_3$

2 $\quad$ 1

$Ca(HCO_3)_2$

Information from molecular formula

i. The molecular formula represents one molecule of a substance.

ii. It indicates the total number of atoms of the same or different elements in each molecule.

iii. It indicates the percentage composition of each element present in the compound.

iv. The valency or combining capacity of each element can be found from the molecular formula. i.e., In the ammonia molecule (NH_3), the valency of nitrogen is three and that of hydrogen is one.

v. We can calculate molecular weight from the molecular formula. For example, the molecular weight of ammonia (NH_3) = N × 1 + H × 3 = 14 × 1 + 1 × 3 = 14 + 3 = 17 a.m.u.

Memory Note

There are about 2×10^{21} atoms of oxygen in a drop of water.

Atomic weight

We know that protons, neutrons, and electrons have some mass. The mass of an electron is negligible in comparison to the mass of a proton and neutron. Therefore, atomic mass (weight) is the sum of the numbers of protons and neutrons present in the nucleus of an atom. It is represented by 'A'. Atomic mass is calculated by:

Atomic mass (A) = the number of protons (p^+) + number of neutrons (n°)

$$\boxed{A = p^+ + n^\circ}$$

SOLVED NUMERICAL

Calculate the mass of an oxygen atom. (Hint: oxygen atoms have 8 protons and 8 neutrons).

Solution:

We have,

No. of protons (p^+) = 8

No. of neutrons (n^0) = 8

Therefore, atomic mass = no. of p^+ + no. of n° = 8 + 8 = 16

SOLVED NUMERICAL

Calculate the number of neutrons in a sodium atom whose atomic number is 11 and atomic mass is 23.

Solution:

We have,

Atomic number = 11

Atomic mass = 23

We know,

Atomic number (Z) = no. of protons = 11

Atomic mass = no. of p^+ + no. of n°

or, $23 = 11 + n^\circ$

or, $23 - 11 = n^\circ$

Therefore, $n^\circ = 12$

Molecular Weight

The molecular weight of a molecule is the sum of the atomic weight of all atoms of the molecule. It is calculated by adding the atomic weight of the atoms present in a molecule.

i) Molecular weight of water (H_2O)

$= H \times 2 + O \times 1 = 1 \times 2 + 16 \times 1 = 18$ a.m.u.

ii) Molecular weight of nitric acid (HNO_3)

$= H \times 1 + N \times 1 + O \times 3 = 1 \times 1 + 14 \times 1 + 16 \times 3 = 1 + 14 + 48 = 63$ a.m.u.

iii) Molecular weight of aluminium sulphate [$Al_2\,(SO_4)_3$]

$= Al \times 2 + 3\,(S \times 1 + O \times 4) = 27 \times 2 + 3\,(32 \times 1 + 16 \times 4) = 54 + 3(96) = 342$ a.m.u.

Radioactive elements

Elements whose atoms spontaneously disintegrate into lighter nuclei are called radioactive elements. For example, thorium (Th), uranium (U), Radium (Ra), Plutonium (Pu), etc. They are used as nuclear fuel.

Memory Note

Uranium is still an abundant natural resource and could provide us with energy for many years. Rocks that contain a lot of uranium are called uranium ore. According to the Department of Mines and Geology (DoMG) in Nepal, there is a large deposit of uranium in upper Mustang, which borders China.

Fact and Reason

Radioactive elements are non-renewable energy sources, why?

Radioactive materials are formed through a series of processes that have taken place over millions of years. Once these materials are used to produce energy, they will not be available again. So, radioactive elements are non-renewable energy sources.

Radioactive emission

symbol of radioactivity

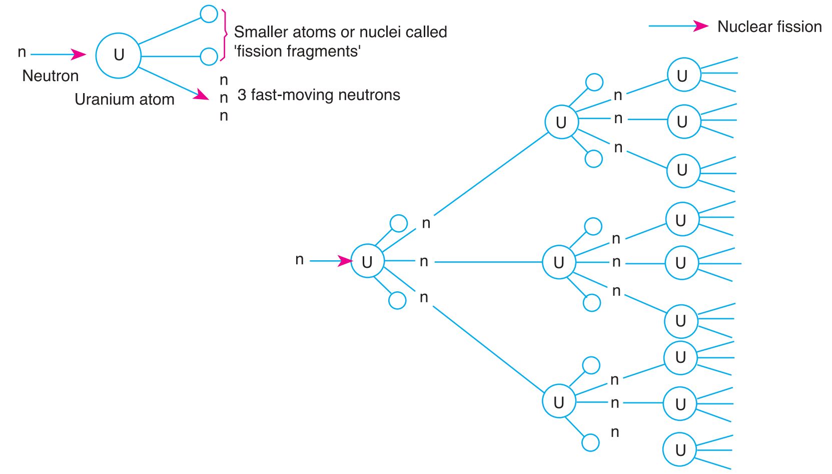
Radioactivity was discovered in 1896 by scientists Henri Becquerel and Marie Curie. It is the spontaneous disintegration of an unstable nucleus followed by the emission of an energetic particle such as a photon. The particles released by the radioactive substances are called radioactive emissions. There are three kinds of radioactive emissions. These are alpha particles, beta particles, and gamma particles.

Nuclear energy or atomic energy

A large amount of energy is stored in the nucleus of an atom. The energy stored in the nucleus of an atom is called nuclear energy. Nuclear energy gets released during nuclear fusion and nuclear fission. Nuclear reactors are used for nuclear powerplant for the generation of electricity. A nuclear reactor is a device in which a nuclear reaction is initiated and controlled. It produces a tremendous amount of heat. Thus, produced heat boils the working fluid, which runs the steam engine. The steam engine rotates generators to produce electricity.

Nuclear fission

Nuclear energy is also obtained by splitting the heavy nucleus of elements like uranium in presence of neutrons. Thus, the splitting of the heavy nucleus of an atom into two lighter nuclei is called nuclear fission. Controlled nuclear fission produces a huge amount of energy.



A chain reaction showing the splitting of uranium atoms

In a nuclear power plant, uranium atoms are struck by slow-moving neutrons. So, uranium splits into two lighter nuclei of barium ($_{56}Ba^{141}$) and krypton ($_{36}Kr^{92}$) along with the release of a huge amount of energy.

$$\boxed{U^{235} + {_0}n^1 \rightarrow {_{56}}Ba^{141} + {_{36}}Kr^{92} + 3\ {_0}n^1 + \text{Energy}}$$

During this process, three neutrons are also released. They split three other nuclei of uranium. This reaction continues rapidly and is known as a chain reaction. So, a huge amount of energy is released from nuclear fission. Such energy is used for boiling water. Steam from the boiling water is used to rotate turbines connected with a generator in nuclear power plants and electricity is generated.

Memory Note

The United States, France, Japan, Germany, etc. have nuclear power plants. France generates 75% of its electricity from nuclear power plants. It is the world's largest net exporter of electricity and gains over €3 billion per year from this.

Fact and Reason

The uncontrolled nuclear reaction in a nuclear power plant is fatal for life in its surrounding, why?

If a nuclear chain reaction in a nuclear power plant is uncontrolled, all the nuclei in the piece of uranium split in a fraction of a second, and a devastating explosion occurs. Such an explosion occurred when atom bombs were dropped on Hiroshima and Nagasaki of Japan by America in 1945. So, the uncontrolled nuclear reaction in a nuclear power plant is fatal for life in its surrounding.

Nuclear fusion

Nuclear energy is produced when two light nuclei combine to form a heavy nucleus. This process is called nuclear fusion. Thus, the process in which light nuclei of the atoms combine to form a heavier nucleus with the release of energy in presence of high temperature and pressure is called thermonuclear fusion.

Example: $\boxed{{}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0n^1 + \text{energy released}}$

Nuclear fusion requires very high temperature and high pressure. So, nuclear fusion occurs in the sun and other stars. It also occurs in hydrogen bombs. The energy produced from nuclear fusion is more than that from nuclear fission. It is not possible to control the nuclear fusion reaction.

Differences between nuclear fusion and nuclear fission.

SN	Nuclear Fusion	SN	Nuclear Fission
1	Nuclear fusion is a process in which the nuclei of light atoms are combined to form a nucleus of a heavier atom.	1	Nuclear fission is a process in which the splitting of a heavier nucleus into two lighter nuclei takes place.
2	The energy released from nuclear fusion is much higher than that from nuclear fission.	2	In comparison to nuclear fusion, less energy gets released from nuclear fission.
3	This process is clean and radioactive by-products are not generated.	3	This process is not clean, and hazardous radioactive by-products are generated.
4	It is an uncontrolled reaction as in a hydrogen bomb.	4	It can be carried out in a controlled way as in a nuclear power plant.

Advantages of nuclear energy

i. Nuclear energy does not produce greenhouse gases.

ii. It is a powerful source of energy. From a small amount of nuclear fuel to a very large amount of energy can be produced.

Disadvantages of nuclear energy

i. Nuclear power plants produce radioactive waste. This waste is small in amount but very dangerous.

ii. If the power plant is not safe and radioactive waste leaks, serious illness and death can occur.

iii. The cost of uranium is cheap, but the power plants are expensive to build.

Memory Note

Every 18 to 24 months, a power plant must shut down to remove its spent uranium fuel, which becomes radioactive waste.

Fact and Reason

Why is nuclear energy not a good source of energy for Nepal?

Nuclear energy is not a good source of energy for Nepal because it needs highly advanced technology and lots of installation costs.

Answer writing skill

1. **Define the duplet rule.**

   The tendency of an atom to maintain 2 electrons in the first K-shell of an atom by gaining or losing electrons is called the duplet rule.

2. **Define electrovalent bond. Give two examples of compounds that have an electrovalent (ionic) bond.**

   A chemical bond that is formed by the transfer of valence electrons from a metal to non-metal is called an electrovalent bond or ionic bond. Examples of compounds having electrovalent bonds are $NaCl$, $CaCl_2$, etc.

3. **Why is an atom electrically neutral?**

   An atom is electrically neutral because the number of positively charged protons is equal to the number of negatively charged electrons. Therefore, the net charge is zero.

4. **Write any two differences between chlorine and chloride.**

Differences between chlorine and chloride are:

SN	Chlorine	SN	Chloride
1	Chlorine is a molecule.	1	Chloride is radical.
2	It is electrically neutral.	2	It is negatively charged.

5. **Write three characteristics of electrovalent compounds.**

Three characteristics of the electrovalent compound are:

i. The electrovalent compound has a high melting point and boiling point.

ii. They are soluble in water.

iii. They can conduct electricity in solution or molten form.

6. **Despite of toxic radiations most of the countries are researching on nuclear energy. Why is nuclear energy being researched? Put forward your hypothesis.**

Despite of toxic radiations, the developed countries are investing a lot in nuclear energy because:

i. Nuclear energy does not produce greenhouse gases.

ii. It is a powerful source of energy.

iii. From a small amount of nuclear fuel to a very large amount of energy can be produced.

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

a. Where are electrons found?

i. orbit ii. nucleus

iii. everywhere iv. nowhere

b. What is the mass of a proton?

i.	1 amu	ii.	2 amu
iii.	1/1837 amu	iv.	0 amu

c. How many valence electrons do elements at octet state have?

i.	2	ii.	3
iii.	7	iv.	8

b. What is the valency of carbonate?

i.	1	ii.	2
iii.	3	iv.	4

d. What kind of bond is found between sodium and chlorine in sodium chloride?

i.	covalent	ii.	electrovalent
iii.	coordinate covalent	iv.	all

2. Define the following, with examples.

a.	Element	b.	Atom
c.	Electronic configuration	d.	Valence shell
e.	Valence electrons	f.	Valency
g.	Radicals	h.	Duplet state
i.	Octet state	j.	Chemical bond
k.	Radioactive elements	l.	Atomic energy

3. Short question answers.

a. What is a molecular formula?
b. Define molecular weight.
c. How many elements are there?
d. What are the three elementary particles of an atom?
e. What is a neutron?
f. Define the mass of an electron.
g. Define the atomic mass of oxygen.
h. What is nuclear energy?
i. List radioactive emissions.

Step 2

4. Give reason.

a. The valency of sodium is one.
b. The valency of helium is zero.
c. Radicals are very reactive.
d. Inert gases occur in atomic form.
e. Neon is called inert gas.
f. Sodium chloride is called an electrovalent compound.
g. Ammonia is called a covalent compound.
h. Research on nuclear energy must be controlled.

5. Differentiate between the following.

a. Proton and electron
b. Electropositive radical and electronegative radical
c. Ionic bond and covalent bond
d. Electrovalent compound and covalent compound
e. Nuclear fusion and nuclear fission

Step 3

6. Answer the following questions.

a. Write the valency of given radicals

i.	Carbonate	v.	Sulphate
ii.	Silicate	vi.	Ammonium
iii.	Hydroxide	vii.	Phosphate
iv.	Nitrate	viii.	Bisulphate

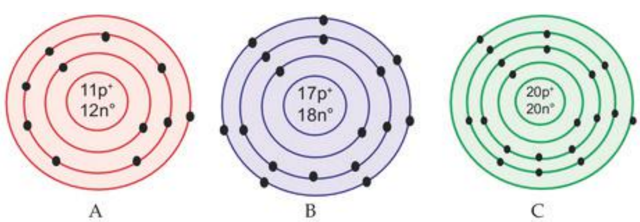
b. What information do you get from the molecular formula?
c. Explain the formation of the electrovalent compound with one example.
d. Explain the formation of the covalent compound with one example.
e. Write three characteristics of the electrovalent compound.
f. Write three characteristics of the covalent compound.
g. Write down the molecular formulae of the given compounds by the criss-cross method.

i. Aluminium chloride
ii. Calcium carbonate
iii. Ammonium nitrate
iv. Magnesium carbonate
v. Ferrous carbonate
vi. Sodium hydroxide
vii. Silver chloride
viii. Sodium sulphate
ix. Calcium silicate
x. Ammonium phosphate
xi. Calcium phosphate
xii. Ferric chloride
xiii. Ammonium hydroxide
xiv. Gold chloride

Step 4

7. Long question answers.

a. Study the given figures and answer the following questions:



i. Name the elements A, B, and C.
ii. Write down the valency of each element.
iii. Name the compound formed by the combination of elements A and B. Also, write the type of the bond with reason.
iv. Name the compound formed by the combination of elements C and B. Also, draw the molecular structure of the resultant compound

b. Draw the atomic structure of the following atoms:
i. Sodium
ii. Potassium
iii. Chlorine
iv. Aluminium

c. Calculate the molecular weight of CO_2, CH_4, $CaCO_3$, and $(NH_4)_2SO_4$.

UNIT
15
CHEMICAL REACTION

ESTIMATED TEACHING PERIODS

TH	PR
5	1

Avogadro
(1776–1856 AD)

Curriculum issued by CDC

- Introduction to the chemical reaction
- Introduction, writing method and types of chemical equation
- Balanced chemical equation and hit and trial method of balancing chemical equation
- Importance of chemical reactions in our daily life
- Exothermic and endothermic reaction

Learning outcomes

After completion of this unit, students will be able to:

- introduce chemical reactions and chemical equations.
- Write a balanced chemical equation.
- introduce endothermic and exothermic reaction with examples.
- describe the importance of chemical reaction in daily life.

Terms and terminologies

1. Chemical reaction: The combination, decomposition, or displacement that occurs in the molecules of matter during a chemical change is called a chemical reaction.
2. Reactants: The elements or compounds that take part in a chemical reaction are called reactants.
3. Products: The elements or compounds that are formed as a result of chemical change are called products.
4. Chemical equation: The symbolical representation of a chemical reaction is called a chemical equation.
5. Word equation: The chemical reaction expressed by writing the full names of reactants and products is called a word equation.

6. Chemical equation: The chemical reaction expressed by writing symbols and molecular formulae of reactants and products is called a chemical equation.

7. Skeleton chemical equation: The chemical equation in which the total number of atoms of each element in reactants and products are not equal is called an unbalanced or skeleton chemical equation.

8. Balanced chemical equation: The chemical equation written by balancing the total number of atoms of each element in reactants and products is called abalanced chemical equation.

9. Exothermic reaction: The chemical reaction which releases heat during the chemical change is called an exothermic reaction.

10. Endothermic reaction: The chemical reaction which absorbs heat during the chemical change is called an endothermic reaction.

Introduction

When hydrogen gas (H_2) burns in the air (O_2), water (H_2O) is formed. Here, hydrogen and oxygen combine to form water. When calcium carbonate ($CaCO_3$) is heated, it decomposes into calcium oxide (CaO) and carbon dioxide (CO_2). Similarly, when iron (Fe) powder is kept in copper sulphate solution ($CuSO_4$), copper (Cu) and iron sulphate ($FeSO_4$) are formed. Here, iron displaces copper from copper sulphate solution. These are some examples of chemical changes.

$$H_2 + O_2 \xrightarrow{burn} H_2O$$

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

The combination, decomposition, or displacement that occurs in the molecules of matter during a chemical change is called a chemical reaction. It can be represented by an equation. The elements or compounds that take part in a chemical reaction are called reactants, whereas the elements or compounds that are formed as a result of chemical change are called products. Reactants are written on the left side of an arrow and products are written on the right side of the arrow. The direction of the arrow indicates the reactants and the products.

Memory Note

Scientists used battery polarity to weigh the elements.

Activity

Put a piece of granulated zinc in a test tube and pour 1ml of dilute hydrochloric acid. Observe the reaction.

Examples:

Zinc + Sulphuric acid → Zinc sulphate + Hydrogen

$$\underbrace{Zn + H_2SO_4}_{\text{(Reactants)}} \rightarrow \underbrace{ZnSO_4 + H_2}_{\text{(Products)}}$$

$$\underbrace{HCl + NaOH}_{\text{(Reactant)}} \rightarrow \underbrace{NaCl + H_2O}_{\text{(Product)}}$$

Chemical equation

The chemical reactions can be represented using symbol. The symbolic representation of a chemical reaction is called a chemical equation. The chemical equation may be a word equation or formula equation.

Word equation

The chemical reaction expressed by writing the full names of reactants and products is called a word equation. It takes more space, cannot be balanced and does not help to calculate molecular weight.

Examples:

Hydrogen + Oxygen → Water

Calcium carbonate $\xrightarrow{\Delta}$ Calcium oxide + Carbon dioxide

Formula equation

The chemical reaction expressed by writing symbols and molecular formulae of reactants and products is called a chemical equation. A chemical equation is more informative than a word equation.

Examples:

$2H_2 + O_2 \xrightarrow{\Delta} 2H_2O$

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

Memory Note

Technetium was the first artificially produced element.

Fact and Reason

The formula equation is more informative.

The formula equation is more informative because it can show the total number of atoms too.

Unbalanced chemical equation

The chemical equation in which the total number of atoms of each element in reactants and products are not equal is called an unbalanced or skeleton chemical equation.

For example:

$KClO_3 \xrightarrow{\Delta} KCl + O_2$

In the above equation, the number of oxygen atoms in the reactant and product sides is not equal so it is called an unbalanced chemical equation.

Balanced chemical equation

The chemical equation written by balancing the total number of atoms of each element in reactants and products is called a balanced chemical equation. In this chemical equation, the number of atoms of each element is equal in reactants and products. It gives more information than the unbalanced chemical equation. A balanced chemical equation proves the law of conservation of mass. In the above equations, the number of atoms of different elements in reactant and product sides is equal. So, they are called balanced chemical equations.

Memory Note

According to Dalton's atomic theory, atoms can neither be created nor be destroyed and remain intact before and after the chemical reaction. So, every chemical equation should be balanced.

Fact and Reason

The chemical equation should be balanced.

The chemical equation should be balanced to satisfy the law of conservation of mass.

Methods of Writing Balanced Chemical Equations

The following points should be remembered while balancing the chemical equations:

i. First of all, the chemical change is written correctly in the form of a word equation.

For example, Nitrogen + Hydrogen → Ammonia

ii. The word equation is written correctly in the form of a formula equation or chemical equation.

For example, $N_2 + H_2 \rightarrow NH_3$

iii. The number of atoms of each element is balanced by using a suitable coefficient without changing the molecular formulae of reactants and products.

$N_2 + 3H_2 \rightarrow 2NH_3$

iv. The number of atoms in the biggest molecule should be balanced before balancing the number of hydrogen and oxygen atoms.

Some Examples of Balanced Chemical Equation

1. **Word equation :** Potassium chlorate $\xrightarrow{\text{heat}}$ Potassium chloride + Oxygen

   Unbalanced chemical equation: $KClO_3 \xrightarrow{\Delta} KCl + O_2$

   Balanced chemical equation: $2KClO_3 \xrightarrow{\Delta} 2\,KCl + 3O_2$

2. **Word equation :** Sodium + Chlorine ⟶ Sodium chloride

   Unbalanced formula equation : $Na + Cl_2 \longrightarrow NaCl$

   Balanced formula equation: $2Na + Cl_2 \longrightarrow 2\,NaCl$

3. **Word equation :** Potassium + Oxygen ⟶ Potassium oxide

   Unbalanced formula equation : $K + O_2 \longrightarrow K_2O$

   Balanced formula equation: $4K + O_2 \longrightarrow 2K_2O$

4. **Word equation :** Magnesium + Oxygen ⟶ Magnesium oxide

   Unbalanced formula equation : $Mg + O_2 \longrightarrow MgO$

   Balanced formula equation: $2\,Mg + O_2 \longrightarrow 2\,MgO$

5. **Word equation:** Calcium carbonate $\xrightarrow{\text{heat}}$ Calcium oxide + Carbon dioxide

   Balanced formula equation: $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

6. **Word equation :** Zinc + Hydrochloric acid $\longrightarrow$ Zinc chloride + Hydrogen

Unbalanced formula equation: $Zn + HCl \longrightarrow ZnCl_2 + H_2$

Balanced formula equation: $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

7. **Word equation :** Calcium chloride + Silver nitrate $\longrightarrow$ Calcium nitrate + Silver chloride

Unbalanced formula equation: $CaCl_2 + AgNO_3 \longrightarrow Ca(NO_3)_2 + AgCl$

Balanced formula equation: $CaCl_2 + 2AgNO_3 \longrightarrow Ca(NO_3)_2 + 2AgCl$

8. **Word equation :** Hydrogen peroxide $\xrightarrow{\text{catalyst}}$ Water + Oxygen

Unbalanced formula equation: $H_2O_2 \xrightarrow{MnO_2} H_2O + O_2$

Balanced formula equation: $2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$

Memory Note

A periodic table was used to correctly predict elements that hadn't been discovered.

Information obtained from the balanced chemical equation

The following pieces of information can be obtained from a balanced chemical equation.

i. The names and symbols of reactants and products

ii. The total number of atoms or molecules of reactants and products

iii. The ratio of molecular weight of reactant and product molecules

iv. The type of chemical reaction

Limitation of a Balanced Chemical Equation

A balanced chemical equation cannot provide the following information:

i. The physical state of reactants and products

ii. The concentration of reactants

iii. Conditions required for reaction like heat, light, pressure, catalyst, etc.

iv. The rate of chemical reaction

Importance of chemical reaction in our daily life

i. Photosynthesis is the most important chemical reaction that produces food for all life forms.

ii. The acid-base reaction treats gastritis.

iii. Respiration is the oxidation reaction that produces energy in our body.
iv. Digestion is a chemical reaction where complex food is broken down into essential nutrients.
v. Petroleum produces energy to power vehicles from a chemical reaction.
vi. The chemical reaction inside the dry cell produces electricity.

Exothermic reaction

The chemical reaction which releases heat during the chemical change is called an exothermic reaction.

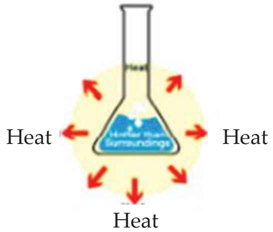
For example,

$C + 2H_2 \rightarrow CH_4 + Heat$

$C + O_2 \rightarrow CO_2 + Heat$

$CaO + H_2O \rightarrow Ca(OH)_2 + Heat$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + H$



Endothermic reaction

The chemical reaction which absorbs heat during the chemical change is called an endothermic reaction.

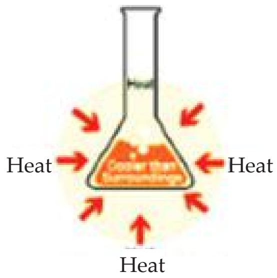
For example,

$N_2 + O_2 \xrightarrow{\Delta} 2NO$

$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2 \uparrow$

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2 \uparrow$

$NaNO_2 + NH_4Cl \xrightarrow{\Delta} NaCl + 2H_2O + N_2 \uparrow$



Answer writing skill

1. What is a chemical reaction?

The combination, decomposition or displacement that occurs in the molecules of matter during a chemical change is called a chemical reaction.

2. What are reactants?

The chemical substances which take part in a chemical reaction are called reactants.

3. **Why should chemical equations be balanced?**

Chemical equations must be balanced to satisfy the law of conservation of mass.

4. **Differentiate between exothermic and endothermic reactions.**

The differences between exothermic and endothermic reactions are:

SN	Exothermic reaction	SN	Endothermic reaction
1	The chemical reaction which releases heat during the chemical change is called an exothermic reaction.	1	The chemical reaction which absorbs heat during the chemical change is called an endothermic reaction.
2	It increases the temperature of the surrounding.	2	It decreases the temperature of the surrounding.

5. **Write down the information obtained from a balanced chemical equation.**

The following pieces of information can be obtained from a balanced chemical equation.

i. The names and symbols of reactants and products.

ii. The total number of atoms or molecules of reactants and products.

iii. The ratio of molecular weight of reactant and product molecules.

6. **How can we change magnesium ribbon into magnesium nitrate? Express in the chemical equation.**

When a magnesium ribbon is burnt, it gives magnesium oxide.

$2Mg + O_2 \rightarrow 2\,MgO$

Magnesium oxide gives magnesium hydroxide in water.

$Mg\,O + H_2\,O \rightarrow Mg\,(OH)_2$

When magnesium hydroxide reacts with nitric acid, neutral substances like salt (i.e., magnesium nitrate) and water are formed.

$Mg\,(OH)_2 + 2HNO_3 \rightarrow Mg\,(NO_3)_2 + 2H_2O$

EXERCISE

Step 1

1. **Choose the best answer from the given alternatives.**

   a. In which equation the number of atoms on the reactant side is not equal to the number of atoms in a product?

i.	Balanced chemical equation	ii.	Skeletal equation
iii.	Both	iv.	None

   b. What does a balanced chemical equation mean?

      i. Equal number of particular atoms in reactant and product
      ii. Unequal number of atoms in reactant and product
      iii. Both
      iv. None

   c. What is a chemical reaction?

i.	Combination of atoms	ii.	Rearrangement of atoms
iii.	Decomposition of compound	iv.	All of them

   d. What information is obtained from a balanced chemical equation?

      i. Rate of reaction
      ii. Name of reactants
      iii. Type of chemical reaction
      iv. ii and iii

   e. Which one is an exothermic reaction?

      i. Burning of coal
      ii. Decomposition of potassium chlorate
      iii. Decomposition of calcium carbonate
      iv. None

2. **Define the following, with examples.**

a.	Chemical reaction	b.	Chemical equation
c.	Reactants	d.	Products

3. **Short question answers.**

   a. What are reactants in the given equation?

   $HCl + NaOH \rightarrow NaCl + H_2O$

b. What is an exothermic reaction? Give an example.
c. What is an endothermic reaction? Give an example.
d. What is a formula equation? Show with an equation.

Step 2

4. Give reason.

a. Chemical equations must be balanced.
b. A formula equation is more informative than a word equation.
c. Exothermic reaction heats the surrounding.
d. Endothermic reaction cools the surrounding.

5. Differentiate between the following.

a. Word equation and formula equation
b. Skeletal equation and balanced chemical equation
c. Exothermic reaction and endothermic reaction

Step 3

6. Answer the following questions.

a. Write any four pieces of information that can be obtained from a balanced chemical equation.
b. What are the demerits of the word equation?
c. Discuss the importance of chemical reaction in our daily life.
d. Conver given word equations into balanced formula equations.
   i. Hydrogen + Nitrogen $\rightarrow$ Ammonia
   ii. Phosphorus + Oxygen $\rightarrow$ Phosphorus pentoxide
   iii. Calcium carbonate $\xrightarrow{\Delta}$ Calcium oxide + Carbon dioxide
   iv. Hydrochloric acid + Sodium hydroxide $\longrightarrow$ Sodium chloride + Water
   v. Ammonium chloride + Calcium hydroxide $\longrightarrow$ Calcium chloride + Ammonia + Water

Step 4

7. Long question answers.

a. Write down the method of writing a balanced chemical equation.

b. Write any four limitations of a balanced chemical equation.

c. Write the balanced chemical equations of the following unbalanced equations.

i. $KClO_3 \xrightarrow{\Delta} KCl + O_2$

ii. $Na + Cl_2 \rightarrow NaCl$

iii. $Na_2CO_3 + CaCl_2 \rightarrow CaCO_3 + NaCl$

iv. $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

v. $H_2SO_4 + KOH \rightarrow K_2SO_4 + H_2O$

d. If we are making an omelet for lunch, we must burn fire and heat the egg. What kind of activities here are exothermic and what are endothermic reaction?

e. We cannot live without chemical reactions. Defend the statement.

UNIT

16 SOME GASES

ESTIMATED TEACHING PERIODS	TH	PR
	4	2

Henry Cavendish
(1731-1810)

Curriculum issued by CDC

- Introduction of hydrogen, oxygen and nitrogen
- Laboratory preparation, physical properties, chemical properties and uses of hydrogen, oxygen and nitrogen.
- Introduction, formation and importance of ozone layer.
- Ozone layer depletion, its causes and effects

Learning outcomes

After completion of this unit, students will be able to:

- describe the laboratory preparation of hydrogen, oxygen and nitrogen along with their characteristics.
- describe the usefulness of hydrogen and oxygen gas.
- explain the formation, depletion and importance of ozone layer.

Terms and terminologies

1. Hydrogen:	Hydrogen is the lightest, simplest and reactive element.
2. Haber's process:	The process in which hydrogen reacts with nitrogen at 500°C temperature and 200 atm. pressure in the presence of an iron catalyst and molybdenum promoter to give ammonia gas is called Haber's process.
3. Hydrogenation:	The process in which hydrogen combines with unsaturated hydrocarbons to give saturated hydrocarbons is called hydrogenation.
4. Oxygen:	Oxygen is the life-supporting gas that helps in respiration.
5. Ozone:	Ozone is a pale blue gas containing three oxygen atoms.
6. Ozone layer:	The layer of ozone gas situated at a height of 25-40 km from the earth's surface is known as the ozone layer.

7. Ozone layer depletion: Thinning of the ozone layer especially due to human activities is known as ozone layer depletion.

8. CFCs: CFCs (chlorofluorocarbons) are a group of industrial organic compounds that contain carbon, fluorine and chlorine.

9. Ozone hole: The ozone hole is the severe depletion in the concentration of ozone.

Introduction

The earth is surrounded by a thick layer of air which is called the atmosphere. The air consists of various gases like nitrogen, oxygen, carbon dioxide, neon, argon, water vapour, etc. About 99% volume of the air is occupied by nitrogen and oxygen.

SN	Gases in air	Volume %
1	Nitrogen (N_2)	78.08 %
2	Oxygen (O_2)	20.95 %
3	Carbon dioxide (CO_2)	0.0360 %
4	Argon (Ar)	0.93 %
5	Neon (Ne)	0.002 %
6	Hydrogen (H_2)	0.00005 %
7	Ozone (O_3)	0.000004 %
8	Other gases	0.003945%

composition of air

Many elements exist in a gaseous state. Some of them are hydrogen, helium, nitrogen, oxygen, neon, chlorine, argon, krypton, etc. Gases are very useful for human beings as well as other organisms. Hydrogen gas is used to fill balloons and prepare vegetable ghee. Oxygen gas is used by living organisms for breathing. Nitrogen gas is used for making chemical fertilizers. Carbon dioxide is used by green plants for photosynthesis. It is also used in soft drinks like Coca-Cola, beer, soda water, etc.

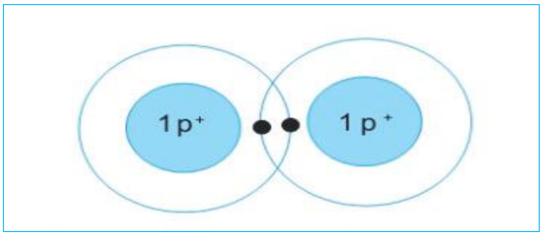
Memory Note

Pure gases are made up of just one atom. Neon is an example of pure gas.

Some of these gases can be produced in the science laboratory.

Hydrogen gas

Symbol	H
Atomic number	1
Atomic mass	1
Valency	1
Molecular formula	H_2
Molecular weight	2
Electronic configuration	$1s^1$



molecular structure of hydrogen

Discovery

Henry Cavendish, a British scientist, discovered hydrogen gas in 1766 AD and named it "inflammable gas". Later in 1783 AD, Antony Lavoisier proposed the name hydrogen (Greek word, hydro-water, genas – produce) because it produces water on burning with oxygen.

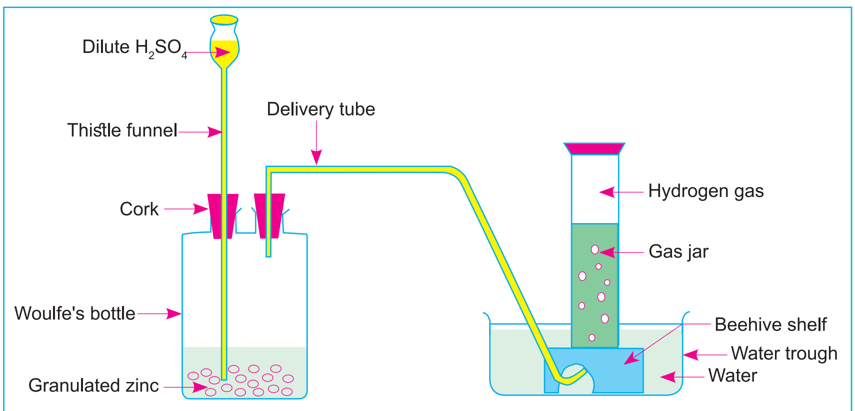
Occurrence

Hydrogen is the lightest, simplest and reactive element. Thus, it does not occur in a free state in nature. In a combined state, it is present in different compounds like water, acids, hydrocarbons, carbohydrates, etc. A large amount of hydrogen is present in the sun and its trace is present in volcanic gases. The chief source of hydrogen on the earth is water.

Memory Note

A small chunk of the pure sodium metal or potassium metal dropped into water causes a big flash and bang.

Laboratory Preparation of Hydrogen Gas



Laboratory preparation of hydrogen gas (H_2)

Principle

In the laboratory, hydrogen gas can be prepared by the reaction of zinc granules with dilute hydrochloric acid or dilute sulphuric acid.

Zinc + dil. Hydrochloric acid $\rightarrow$ Zinc chloride + Hydrogen

$Zn + \text{dil. } 2HCl \rightarrow ZnCl_2 + H_2$

Apparatus required

i. Woulfe's bottle
ii. Thistle funnel
iii. Gas jar
iv. Delivery tube
v. Water trough
vi. Beehive shelf

Chemicals required

i. Dilute hydrochloric acid (HCl)
ii. Zinc granules (Zn)

Procedure

i. Keep some granules of zinc in Woulfe's bottle and arrange the apparatus as shown in the figure.

ii. Pour dilute hydrochloric acid through the thistle funnel. When zinc reacts with dilute acid, it gives off hydrogen gas. This gas passes through the delivery tube. The gas is collected in the gas jar by downward displacement of water.

Memory Note

The experiment should be performed away from the fire; otherwise, hydrogen itself burns and may cause an explosion.
If the reaction occurs slowly, we should use a little amount of copper sulphate to accelerate the reaction.
Impurities present in the zinc also plays a role as a positive catalyst in the reaction.

Activity

Prepare hydrogen gas in the laboratory.

Precautions

i. The apparatus should be made airtight.
ii. We should take granulated impure zinc.
iii. We should not use concentrated sulphuric acid.
iv. The lower end of the thistle funnel must be dipped in the acid solution.

v. The experiment must be conducted away from the fire.

Fact and Reason

We should use impure granulated zinc to prepare hydrogen gas in the laboratory, why?

We should use impure granulated zinc to increase the rate of chemical reaction because pure zinc reacts very slowly with dilute acid.

Why can we not use concentrated sulphuric acid instead of dilute sulphuric acid to prepare hydrogen in the laboratory?

Concentrated sulphuric acid produces sulphur dioxide gas (SO_2) in place of hydrogen gas. So, we should use dilute sulphuric acid to prepare hydrogen gas in the laboratory.

Hydrogen gas is collected by downward displacement of water, why?

Hydrogen is the lightest known gas. It cannot be collected in an open gas jar. Also, hydrogen is slightly soluble in water. So, it is collected by the downward displacement of water.

Test of Hydrogen Gas

When a burning match stick is introduced into the gas jar containing the gas produced, the gas burns with pale-blue flame and the matchstick gets extinguished with a pop sound. It proves that the gas is hydrogen.

Physical Properties of Hydrogen Gas

i. It is a colourless, odourless and tasteless gas.

ii. It is the lightest gas.

iii. It is neutral to indicators.

iv. It is slightly soluble in water.

v. It becomes liquid at –253°C and becomes solid at –259°C.

Fact and Reason

Why do people use hydrogen gas to fill in air balloons?

People use hydrogen gas to fill in air balloons because hydrogen gas is the lightest among all the gases and flies up in the air.

Activity

Light a match stick and bring it near a test tube. Does it produce pop sound?

Chemical Properties of Hydrogen Gas

i. **Reaction with air**

Hydrogen gas burns with air or oxygen and forms water.

$$2H_2 + O_2 \xrightarrow{\Delta} 2H_2O$$

ii. **Reaction with halogens**

Halogens like fluorine, chlorine, bromine react with hydrogen to give corresponding acids.

$H_2 + F_2 \xrightarrow{\text{In dark}} 2\ HF$ (Hydrofluoric acid)

$H_2 + Cl_2 \xrightarrow{\text{Light}} 2HCl$ (Hydrochloric acid)

iii. **Reaction with metals**

Metals like sodium, potassium, etc. react with hydrogen gas to give corresponding metallic hydrides.

$2Na + H_2 \xrightarrow{300°C} 2NaH$ (Sodium hydride)

$Ca + H_2 \xrightarrow{300°C} CaH_2$ (Calcium hydride)

iv. **Reaction with metallic oxides**

Hydrogen reduces the metallic oxides into free metals when it is passed through heated metallic oxides. This property of hydrogen is called the reducing property of hydrogen.

reducing property of hydrogen

$$CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$$

$$PbO + H_2 \xrightarrow{\Delta} Pb + H_2O$$

v. **Reaction with nitrogen**

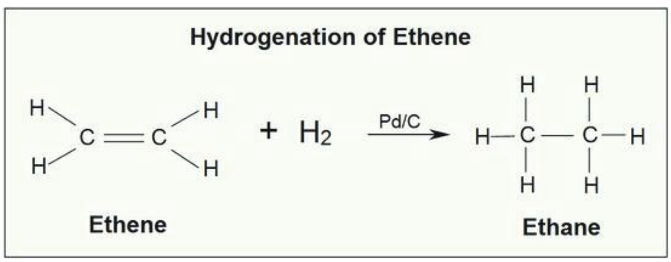
Hydrogen reacts with nitrogen at 500°C temperature and 200 atm. pressure in the presence of an iron catalyst and molybdenum promoter to give ammonia gas.

$$3H_2 + N_2 \xrightarrow{500°C,\ 200\ atm.\ Fe/Mo} 2NH_3$$

vi. **Reaction with unsaturated hydrocarbons**

Hydrogen combines with unsaturated hydrocarbons to give saturated hydrocarbons.

$C_2H_4 \xrightarrow{Ni} C_2H_6$ (Ethene) (Ethane)



Memory Note

Vegetable oil is unsaturated fat. Hydrogenation converts vegetable oil into vanaspati ghee which is saturated fat.

Uses of Hydrogen Gas

i. It is used in the manufacturing of vegetable ghee by the process of hydrogenation.

ii. It is used as fuel in rockets.

iii. It is used in the manufacturing of ammonia gas and chemical fertilizers.

iv. It is used as a reducing agent.

v. It is used for making oxyhydrogen flame for cutting and welding metals.

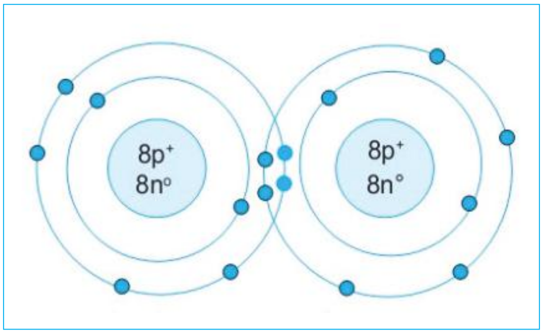
Fact and Reason

Hydrogen and oxygen gases are used in welding and cutting metals, why?

Oxy-hydrogen flame is produced when a mixture of hydrogen and oxygen is burned. This flame produces a very high temperature of about 3000°C. So, it is used in welding and cutting metals.

Oxygen gas

Symbol	O
Atomic number	8
Atomic mass	16
Valency	2
Molecular formula	O_2
Molecular weight	32
Electronic configuration	$1s^2, 2s^2, 2p^4$



molecular structure of oxygen gas

Discovery

Oxygen was discovered by Swedish chemist "Scheele" in 1773 AD and named fire air or vital air. An English scientist Joseph Priestly called it perfect gas or very active gas. In 1776 AD, French scientist Antony Lavoisier gave the name "oxygen".

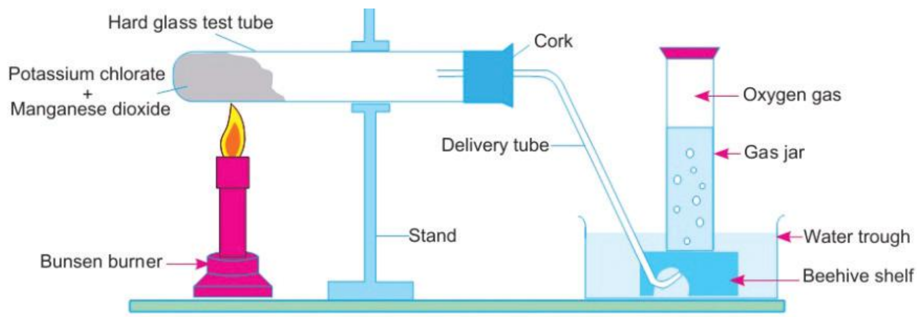
Occurrence

Oxygen occurs free as well as in a combined state in nature. It constitutes about 48% of the earth's crust and about 21% of the atmosphere. In a combined state, it is present as a constituent of different compounds like acid, base, salt, fat, carbohydrate, protein, sand, etc. About 72% of the human body is occupied by oxygen.

Laboratory Preparation of Oxygen Gas

Oxygen gas can be prepared in the laboratory by using heat or without using heat.

1. By using heat



laboratory preparation of oxygen gas by using heat

Principle

When the 3:1 ratio of potassium chlorate and manganese dioxide is heated at about 250 °C, we get oxygen gas.

Potassium chlorate Potassium chloride + Oxygen

$$2KClO_3 \xrightarrow{250°C,\ MnO_2} 2KCl + 3O_2$$

Apparatus required

i.	Hard glass test tube	ii.	Delivery tube
iii.	Water trough	iv.	Beehive shelf
v.	Gas jar	vi.	Bunsen burner

Chemicals required

i.	Potassium chlorate ($KClO_3$)	ii.	Manganese dioxide (MnO_2)

Procedure

i. The 3:1 ratio of potassium chlorate and manganese dioxide is kept in the hard glass test tube and the apparatus is set as shown in the figure.

ii. Heat is supplied by Bunsen burner.

iii. When potassium chlorate is decomposed, it gives off oxygen gas.

iv. The oxygen gas produced in the hard glass test tube is collected in the gas jar by downward displacement of water.

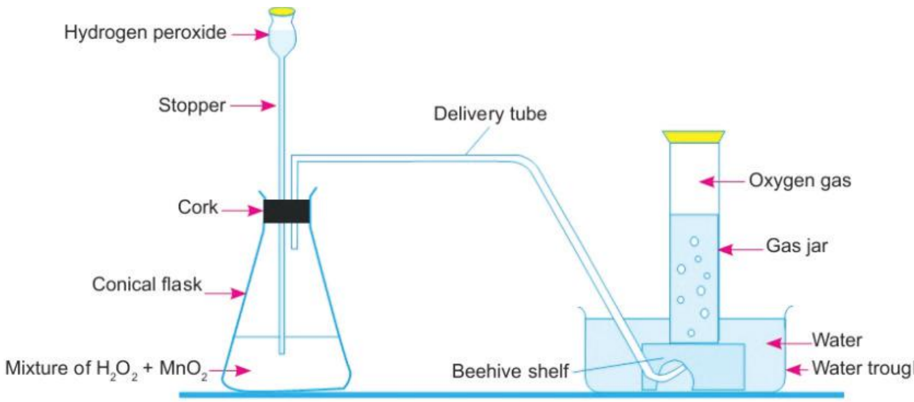
Precautions

i. The hard glass test tube should be made inclined.

ii. Heat should be supplied constantly.

iii. The apparatus should be made airtight.

2. Without using heat



laboratory preparation of oxygen gas without using heat

Principle

Oxygen gas can be prepared in the laboratory by the decomposition of hydrogen peroxide in the presence of manganese dioxide.

$$\text{Hydrogen peroxide} \xrightarrow{MnO_2} \text{Water} + \text{Oxygen}$$

$$H_2O_2 \xrightarrow{MnO_2} H_2O + O_2$$

Memory Note

Oxygen is not inflammable but a very good supporter of combustion. Nascent oxygen is an atomic form of oxygen that is produced during a chemical reaction. It is more reactive and has more internal energy.

Fact and Reason

Why is manganese dioxide used in the production of oxygen gas?

Manganese dioxide is used in the production of oxygen gas because it is a positive catalyst that increases the rate of a chemical reaction.

Apparatus required

i. Conical flask

ii. Thistle funnel

iii. Delivery tube
iv. Gas jar
v. Beehive shelf
vi. Water trough

Chemicals required:

i. Hydrogen peroxide
ii. Manganese dioxide

Procedure

i. Keep some manganese dioxide in the conical flask and arrange the apparatus as shown in the figure.

ii. Pour hydrogen peroxide drop by drop with the help of the stopper.

iii. When hydrogen peroxide decomposes in the presence of manganese dioxide, it gives off oxygen gas.

iv. Oxygen gas produced in the conical flask is passed through the delivery tube and is collected in the gas jar by downward displacement of water.

Fact and Reason

Oxygen gas is collected by downward displacement of water, why?

Oxygen is a light gas. Also, it is less soluble in water. So, oxygen is collected by the downward displacement of water.

Test of Oxygen Gas

i. When a burning matchstick is brought near the mouth of the gas jar, the flame becomes brighter indicating that the gas jar is filled with oxygen gas.

ii. When a burning magnesium ribbon is kept inside the gas jar, it burns and gives white ash of magnesium oxide (MgO). It also proves that the gas is oxygen.

Fact and Reason

Why does a burning lighter glow brighter when introduced in a gas jar with oxygen gas?

A burning lighter glows brighter when introduced in a gas jar with oxygen gas because oxygen gas helps in combustion.

Activity 1

- Take some potassium permanganate in a hard glass test tube.
- Heat the test tube gently by using a Bunsen burner. A gas is produced during this process.
- Collect the gas in a test tube.
- Identify the gas produced by this process.

$$2KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$$

Physical Properties of Oxygen

i. Oxygen is a colourless, odourless and tasteless gas.

ii. It is slightly soluble in water.

iii. It is a neutral gas. So, it does not change the colour of litmus paper.

iv. It is non-combustible but supports combustion.

v. It becomes liquid at –183°C and solid at –219°C temperature.

Chemical Properties of Oxygen

i. Combustion:

Oxygen does not burn itself but it supports combustion. Objects burn more brightly in oxygen than in air. Metals like sodium, potassium, calcium, etc. burn in oxygen with a bright flame and form corresponding oxides.

$4Na + O_2 \xrightarrow{\Delta} 2Na_2O$ (Sodium oxide)

$2Mg + O_2 \xrightarrow{\Delta} 2MgO$ (Magnesium oxide)

ii. Reaction with non-metals:

Non-metals like carbon, sulphur, phosphorus, etc. burn in oxygen and form corresponding oxides.

$C + O_2 \xrightarrow{\Delta} CO_2$ (Carbon dioxide)

$S + O_2 \xrightarrow{\Delta} SO_2$ (Sulphur dioxide)

iii. Reaction with organic compounds:

Organic compounds like hydrocarbon, fat, carbohydrate, etc. react with oxygen and form carbon dioxide, water and energy.

$CH_4 + 2O_2 \xrightarrow{\Delta} CO_2 + 2H_2O + \text{Energy}$

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\Delta} 6CO_2 + 6H_2O + \text{Energy}$$

iv. **Reaction with hydrogen:**

Oxygen combines with hydrogen in the presence of an electric spark and gives water.

$$O_2 + 2H_2 \longrightarrow 2H_2O$$

v. **Reaction with nitrogen:**

Oxygen combines with nitrogen at about 3000°C and forms nitric oxide. This reaction takes place in the atmosphere during lightning.

$$O_2 + N_2 \xrightarrow{3000°C} 2NO \text{ (Nitric oxide)}$$

Memory Note

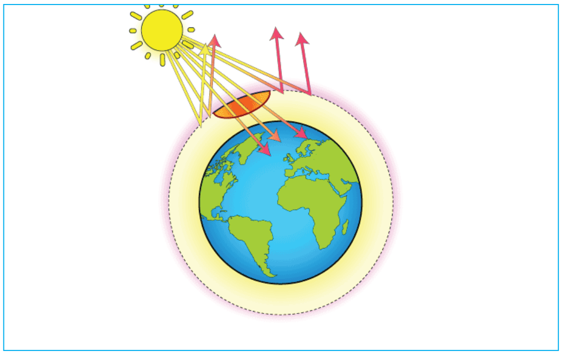
Oxygen gas is soluble in water. The dissolved oxygen in water is used by aquatic animals for their respiration.

Uses of Oxygen

i. It is used by living organisms to produce energy during respiration.
ii. It is used for artificial breathing in hospitals.
iii. It is used for making oxy-hydrogen flame for cutting and welding metals.
iv. Mountaineers, deep-sea divers, miners and astronauts carry oxygen cylinders for breathing.
v. Liquid oxygen is used as fuel in rockets and missiles.

Ozone

Ozone (O_3) is a pale blue gas containing three oxygen atoms. It is mostly found in the stratosphere and trace amounts in the troposphere. When inhaled by humans, ozone causes respiratory problems, lung damage, chest pain and breathing difficulty. But, its presence in the stratosphere is beneficial to all living organisms on the earth.



ozone layer

The layer of ozone gas situated at a height of 25-40km from the earth's surface is known as the ozone layer. This layer absorbs and reflects about 99% of UV rays that strike the earth's atmosphere and also retain heat on the earth. As it absorbs harmful UV rays that might cause adverse effects in living organisms, it is also called the protective layer.

Formation of ozone in the stratosphere

The air in the stratosphere is continuously hit by UV radiation which causes ozone molecules to form and break. The oxygen molecules in the stratosphere are continuously broken into oxygen atoms in presence of UV rays.

$$O_2 \xrightarrow{\text{UV rays}} O + O$$

These oxygen atoms then combine with molecular oxygen to form ozone.

$$O + O_2 \xrightarrow{\text{UV rays}} O_3$$

In this process, a large number of UV rays are absorbed.

Memory Note

The word "ozone" means smelly in Greek because the gas has a strong odour.

Fact and Reason

The ozone layer is a protective layer.

The ozone layer is called the protective layer because it blocks harmful solar radiation.

Importance of ozone layer

i. It prevents most of ultraviolet rays from reaching earth.

ii. It maintains temperature of the earth.

iii. It keeps earth warm where living things can thrive.

Depletion of the ozone layer

The rate of formation of ozone and its destruction is almost the same if the gases produced by human activities are neglected. Human activities have produced a large number of chemicals that destroy the ozone layer. The chemicals and gases which destroy the ozone layer are called ozone layer depleting chemicals.

Thinning of the ozone layer especially due to human activities is known as ozone layer depletion. Compounds like CFCs (chlorofluorocarbons), CCl_4 (carbon tetrachloride), CH_3Br (Methyl bromide), NO_x (oxides of nitrogen) and $CHCl_3$ (methyl chloroform), which are generated from human activities are carried away into the stratosphere. CFCs are the most common ozone-depleting chemicals. The presence of CFCs in the upper atmosphere was discovered in 1974 A.D. They are extensively found in foams, coolants like Home AC, car ACs, refrigerators, freezers and aerosol sprays like room sprays, deodorants, spray paints and burning plastics.

Memory Note

One chlorine molecule from a CFC can destroy up to 100,000 ozone molecules.

Fact and Reason

CFC is replaced by ammonia in the refrigerator.

The CFC is replaced by ammonia in the refrigerator because CFC depletes the ozone layer but ammonia does not.

CFCs are responsible for ozone layer depletion and the excessive greenhouse effect. CFCs produce free elements like chlorine, bromine etc. which break the molecules of ozone into oxygen. A single chlorine atom produced from a CFC molecule can destroy about one-lakh molecules of ozone. They also stay in the stratosphere for about 20-100 years. Continuous depletion of billions of ozone molecules makes ozone layer thinner. The region of the ozone layer where ozone concentration is too low is called ozone hole.

i) Destruction of ozone by CFC

$$CFCl_3 \xrightarrow{\text{UV rays}} CFCl_2 + Cl$$

$$Cl + O_3 \rightarrow ClO + O_2$$

$$2ClO \rightarrow 2Cl + O_2$$

Memory Note

CFC molecules are highly stable and can last for up to 100 years.

Fact and Reason

Most countries have banned the use of CFC, why?

Most countries have banned the use of CFC because this chemical contributes to ozone layer depletion and the greenhouse effect. As a result, it affects the climate of the whole earth.

Effects of ozone layer depletion

The effects of the ozone layer depletion are adversely equal on plants, animals, humans, ecosystems and the earth as a whole. When the ozone layer is depleted, UV rays easily penetrate the earth's atmosphere and are absorbed inside. This results in adverse effects on living organisms. Some of these effects are explained below.

1. Effects on human health

i. Skin burns and irritation
ii. DNA damage and mutation
iii. Skin cancers and eye cataract.
iv. Loss of immunity power

2. Effect on other animals

i. Skin damage in aquatic animals and amphibians.
ii. Mutation and infertility in aquatic animals.
iii. Spread of epidemics and pathogenic diseases among animals.
v. The low survival rate of eggs and larvae of invertebrates.

3. Effects on plants

i. A decrease in productivity occurs as a result of disturbed photosynthesis.
ii. Crop cycle changes due to the change in weather and climate patterns.
iii. Plants diseases spread and loss of biodiversity occurs since the hot climate favours plant pathogens.
iv. Commercial farming, agriculture, horticulture etc. are severely affected.

4. Effects on weather and climate

i. Global warming is caused and the earth's temperature increases.
ii. Change in weather and climate is common.
iii. Polar ice caps melt and the ocean level rises leading to the flooding of coastal areas.
iv. The imbalance and destruction of several delicate ecosystems occur.

Ways to protect the ozone layer

Much of the ozone layer depletion can be blamed on human activities, population growth, industrialisation and manufacturing. Though the data of 2016 AD suggest some signs of ozone hole healing, it still takes decades to get good results. The ozone layer protection can be done in the following ways.

i. Ban CFCs in air conditioners, coolers, aerosols and foams.

ii. Coolants like CFC and HCFC should be completely replaced by HFC (Hydrofluorocarbon) as HFC does not destroy ozone.

iii. The use of nitrogenous fertilizers and the burning of plastics should be controlled.

iv. We should replace CFC with safer alternatives in asthma inhalers, room sprays, deodorants, etc.

Memory Note

Ultraviolet rays can also have bad effects on nature. They can kill plankton, which is a major source of food in the ocean's food chain.

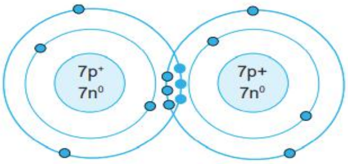
Fact and Reason

We should not buy a refrigerator containing CFC, why?

We should not buy a refrigerator containing CFC because CFC is both greenhouse gas and an ozone-depleting chemical. It destroys the ozone layer and contributes to global warming affecting the climate of the earth.

Nitrogen gas

Symbol	N
Atomic number	7
Atomic mass	14
Valency	3 and 5
Molecular formula	N_2
Molecular weight	28
Electronic configuration	$1s^2, 2s^2 2p^3$



Molecular structure of nitrogen

Discovery

Nitrogen gas was discovered by Scottish scientist Daniel Rutherford in 1772 AD and named mephitic air (a poisonous gas). Lavoisier studied its properties and named it azota, i.e., a gas having no life. Finally, the name nitrogen was derived from nitre (KNO_3), which has nitrogen as one of the elements.

Occurrence

Nitrogen occurs free as well as in a combined state in nature. In a free state, it is present in the atmosphere at about 78.08% by volume. In a combined state, it is present in different types of compounds like ammonia, nitre, ammonium salts, nitrate compounds, etc.

Memory Note

Calcium hypochloride is an inorganic compound with the formula $Ca(ClO)_2$. It is marketed as chlorine powder or bleach powder for water treatment.

Laboratory Preparation of Nitrogen Gas

In the laboratory, nitrogen gas is prepared by heating a mixture of ammonium chloride and sodium nitrite in a solution state.

Ammonium chloride + Sodium nitrate Sodium chloride + Water + Nitrogen gas

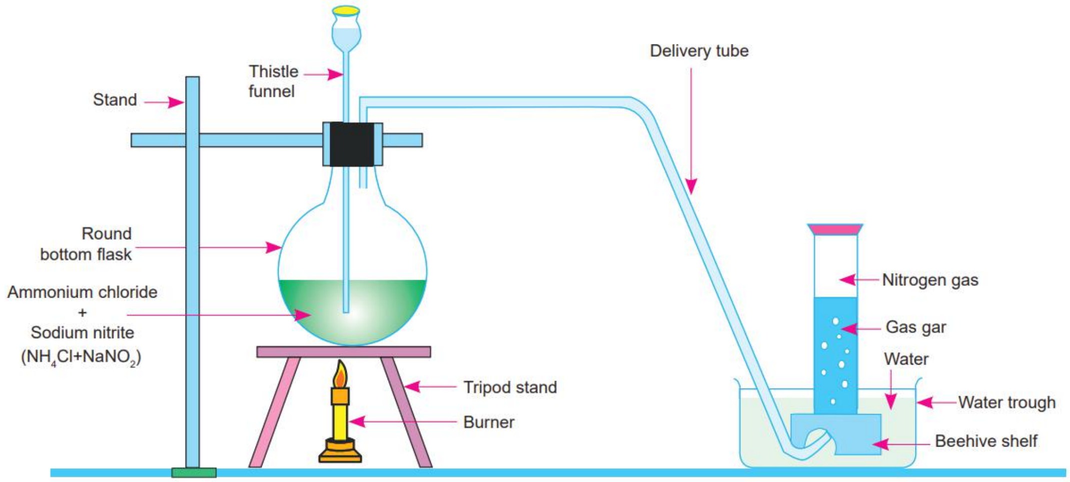
$$NH_4Cl + NaNO_2 \quad NaCl + H_2O + N_2$$

Apparatus required

i. Round bottom flask (R.B. flask)
ii. Delivery tube
iii. Gas jar
iv. Water trough
v. Beehive shelf
vi. Burner
vii. Cork
viii. Stand
ix. Tripod stand

Chemicals required

i. Ammonium chloride (NH_4Cl)
ii. Sodium nitrite ($NaNO_2$)



Laboratory preparation of nitrogen gas

Procedure

i. Make a mixture of ammonium chloride and sodium nitrite and keep it in a round bottom flask.

ii. Make a solution by adding some water and stir.

iii. Arrange the apparatus as shown in the figure.

iv. Supply heat with the help of a Bunsen burner.

On heating the mixture, reaction takes place in two steps as given below and produces nitrogen gas.

$$NH_4Cl + NaNO_2 \rightarrow NH_4NO_2 + NaCl$$
$$NH_4NO_2 \rightarrow 2H_2O + N_2$$
$$NH_4Cl + NaNO_2 \rightarrow NaCl + 2H_2O + N_2$$

Nitrogen gas thus produced is collected in the gas jar by the downward displacement of water.

Precautions

i. The apparatus should be made airtight.

ii. Moderate heat should be supplied during reaction.

iii. The burner should be removed as soon as nitrogen gas starts to evolve.

Test of Nitrogen Gas

i. When a burning match stick is inserted inside the gas jar, the match stick gets extinguished. It proves that the gas is nitrogen. Carbon dioxide gas also extinguishes the fire. So, some amount of lime water is added to the gas jar. If it does not give milky white colour, it proves that the gas is nitrogen.

ii. When a burning magnesium ribbon is inserted into the gas jar of nitrogen, it burns in nitrogen gas forming a yellow powder of magnesium nitride (Mg_3N_2).

Physical Properties of Nitrogen Gas

i. It is a colourless, odourless and tasteless gas.
ii. It is lighter than air.
iii. It is neutral to the indicators.
iv. It neither burns nor supports combustion.
v. It is insoluble in water.
vi. It liquifies at –196°C and solidifies at –210°C.

Chemical Properties of Nitrogen Gas

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 temperatures. But at high temperatures, the bonds between nitrogen atoms break and induce certain chemical reactions.

i. Reaction with hydrogen

Nitrogen combines with hydrogen at about 500°C and 200 to 600 atmospheric pressures in the presence of iron as a catalyst and molybdenum as a promoter to give ammonia.

$N_2 + 3H_2 \rightarrow 2NH_3$

ii. Reaction with oxygen

Nitrogen combines with oxygen at about 3000°C to give nitric oxide.

$N_2 + O_2 \rightarrow 2NO$

iii. Reaction with metals

Nitrogen combines with metals to give metallic nitrides.

$3Ca + N_2 \rightarrow Ca_3N_2$ (Calcium nitride)

$2Al + N_2 \rightarrow 2AlN$ (Aluminium nitride)

$3Mg + N_2 \rightarrow Mg_3N_2$ (Magnesium nitride)

Uses of Nitrogen Gas

i. It is used in the manufacture of ammonia gas, nitric acid, nitroglycerine, etc.

ii. It is used in the fuel tanks of aeroplanes to prevent an explosion.

iii. It is used in a high-temperature thermometer to reduce evaporation.

iv. It is used in electric bulbs to provide an inert atmosphere.

v. It is used in the manufacture of nitrogenous fertilizers like ammonium nitrate, ammonium sulphate, etc.

vi. Liquid nitrogen is used as a cooling agent.

Fact and Reason

Nitrogen gas is comparatively less reactive at normal temperature, why?

Nitrogen gas is comparatively less reactive at normal temperature because nitrogen is a diatomic molecule with a triple covalent bond between nitrogen atoms. So, it is difficult to break the triple covalent bond at normal temperature for the chemical reaction.

Answer writing skill

1. **Write the name of the lightest gas found on the earth? Name the gas that helps in the burning of fire.**

   The lightest gas found on the earth is hydrogen gas.

   The gas that helps in burning is oxygen.

2. **Which chemical is heated in laboratory to produce oxygen gas?**

   Potassium chlorate is heated in laboratory to produce oxygen gas.

3. **We cannot use concentrated sulphuric acid for the laboratory preparation of hydrogen gas. Why?**

   We cannot use concentrated sulphuric acid for the laboratory preparation of hydrogen gas because if we use concentrated sulphuric acid, sulphur dioxide gas will be produced instead of hydrogen gas.

4. **Differentiate between oxygen and ozone.**

   The differences between oxygen and ozone are:

SN	oxygen	SN	ozone
1	It supports burning.	1	It does not support burning.
2	It helps in respiration.	2	It is poisonous.

5. **Write four uses of oxygen gas.**

Uses of oxygen are listed below:

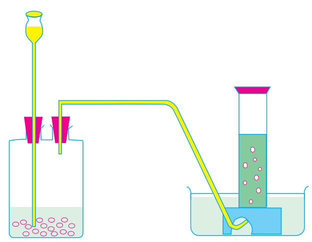
i) Oxygen is used by all living organisms for respiration and artificial respiration in hospitals.

ii) Oxygen is used to produce an oxy-hydro flame for welding metal and is also used as a fuel in rockets.

iii) Oxygen supports in burning of hydrocarbons and other substances.

iv) Oxygen is used in sea diving and mountain climbing.

6. **Study the given diagram and answer the following questions.**



i) **Which gas is being collected in the gas jar?**

Hydrogen gas is being collected in the gas jar.

ii) **How is this gas tested?**

The pure hydrogen gas burns in the air with a pale–blue flame. So, we need to introduce a burning match stick near the gas jar. If a pale blue flame is formed with a pop sound it is hydrogen gas.

iii) **Write down the balanced chemical equation involved in this process.**

Hydrogen gas is prepared in the laboratory by dissolving granulated zinc in dilute sulphuric acid or hydrochloric acid.

$Zn + dil.H_2SO_4 \rightarrow ZnSO_4 + H_2$

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. How much of the atmosphere is occupied by oxygen by volume?

i.	20.95%	ii.	78.08%
iii.	0.03%	iv.	0.04%

b. What is the molecular weight of hydrogen?

i.	1	ii.	2
iii.	16	iv.	8

c. Which gas is necessary to produce oxyhydrogen flame?

i.	Oxygen	ii.	Hydrogen
iii.	Hydroxyl ion	iv.	Oxygen and hydrogen

d. What is the molecular formula of ozone?

i.	O_2	ii.	O_3
iii.	O	iv.	H_2

e. What is responsible for ozone layer depletion?

i.	CFCs	ii.	Methyl bromide
iii.	Oxides of nitrogen	iv.	All of them

2. Define the following, with examples.

a.	Hydrogenation	b.	Ozone
c.	Ozone layer	d.	Ozone hole
e.	Ozone layer depletion	f.	CFC
g.	Atmosphere	h.	Haber's process

3. Short question answers.

a. Enlist the percentage composition of air.

b. Name the chemicals with a molecular formula that are required for the laboratory preparation of hydrogen gas.

c. Name the chemicals with a molecular formula that are required for the laboratory preparation of oxygen gas without heat.

d. Name the chemicals with a molecular formula that are required for the laboratory preparation of oxygen gas by using heat.

e. Give examples of gases that depletes ozone layer other than CFC.

Step 2

4. Give reason.

a. We use impure zinc during the laboratory preparation of hydrogen gas.

b. Concentrated sulphuric acid is not used during the laboratory preparation of hydrogen gas.

c. Hydrogen is used to fill balloons.

d. Oxygen gas is essential for living beings.

e. Oxygen is collected by the downward displacement of water.

f. Most countries are banning the use of CFC.

g. Ozone layer is called protective layer.

5. Differentiate between the following.

a. Lab preparation of oxygen with heat and without heat

b. Oxygen and ozone

Step 3

6. Answer the following questions.

a. How can we be sure that the gas produced in laboratory is actually hydrogen?

b. If we decomposed hydrogen peroxide, oxygen should be produced. How can we test if it is oxygen?

c. Ozone layer is protective shell. Justify the statement with at least three points.

d. How does depletion of the ozone layer lead to global warming?

e. How does CFC destroy ozone molecules? Explain with the help of chemical equations.

f. Write any three uses of hydrogen gas, oxygen gas and nitrogen gases.

g. Write any four physical properties of hydrogen, oxygen and nitraogen gases.

h. How is ozone layer formed? Show with a chemical reaction.

Step 4

7. Long question answers.

a. How is nitrogen prepared in the laboratory? Draw a well-labelled figure showing the laboratory preparation of nitrogen gas with its chemical equation.

b. How is hydrogen gas prepared in the laboratory? Give a balanced chemical equation with a neat and well-labelled figure.

c. Write any four chemical properties of hydrogen gas with a balanced chemical equation.

d. Give any four precautions which should be followed during laboratory preparation of hydrogen gas.

e. Write down three chemical properties of oxygen and nitarogen gas.

f. Draw a well-labelled figure showing the laboratory preparation of oxygen gas by using heat with its chemical equation.

g. Draw a well labelled diagram to show laboratory preparation of hydrogen gas, oxygen gas with and without heating.

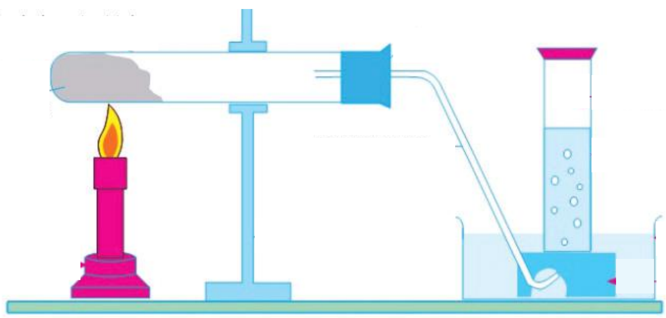
h. Ozone layer depletion is a global problem. Is there anything we can personally do to reduce the rate of ozone layer depletion? Enlist few opinions.

i. Excessive solar radiations are observed over the Antarctica. What are the causes and effect of such activity?

j. Draw a well-labelled figure showing the laboratory preparation of oxygen gas without using heat with its chemical equation.

8. **What happens when (write with balanced chemical equation):**
   a. Hydrogen burns with oxygen?
   b. Hydrogen is passed over heated lead oxide?
   c. Oxygen reacts with nitrogen at about 3000°C?
   d. Metals react with oxygen?
   e. Methane react with oxygen?

9. **Study the given diagram and answer the following questions.**



   i. Which gas is being collected in the gas jar? Write down the sure test of the gas.
   ii. Write down the balanced chemical equation involved in this process.
   iii. Write any three uses of the gas.

UNIT

17 SOME METALS AND NON-METALS

ESTIMATED TEACHING PERIODS

TH	PR
4	1

Nicander of Colophon
(197 BC- 170BC)

Curriculum issued by CDC

- Introduction to metals and nonmetals
- Physical properties and chemical properties of metals and non-metals
- Source and importance of Zn, Fe, Na and K in human body
- Modes of lead and mercury contamination and their harmful effects on human body

Learning outcomes

After completion of this unit, students will be able to:

- clarify the concept of metals and non-metals.
- mention the source and importance of essential minerals in human body.
- identify the harmful effects of mercury and lead on human body.

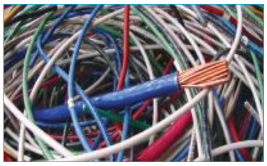
Terms and terminologies

1. Metals: Metals are those electropositive elements that are good conductors of heat and electricity.
2. Malleability: The property of a metal due to which it can be beaten into thin sheets is called malleability.
3. Ductility: The property of a metal due to which it can be drawn into a long wire is called ductility.
4. Non-metals: Non-metals are those electronegative elements that are bad conductors of heat and electricity.
5. Lustre: A brilliant metallic soft glow is called lustre.

Introduction

There are altogether 118 elements known till today. It is very difficult to study all these elements separately. So, based on characteristics, they are divided into three groups, i.e., metals, non-metals, and metalloid. Of the 118 elements, more than 80% of the elements are metals and the rest of the elements are non-metals and metalloid. Elements like iron, copper, aluminium, silver, gold, etc. are metals. Metals are being used by human beings from pre-historic times. Metals are used for making cooking utensils, weapons, wires, bodies, and parts of vehicles, rods, engines, industrial materials, coins, and many more. Iron is present in the blood. It absorbs oxygen from the lungs.

weapons



wires

industrial materials

coin

utensils

vehicles body parts

rods

engines

Memory Note

The majority of the elements are metals.

Metals

Metals are those electropositive elements that are good conductors of heat and electricity. They form electropositive ions by losing electrons. Examples: Copper, gold, iron, aluminium, sodium, mercury, calcium, zinc, etc.

a. Physical properties of metals

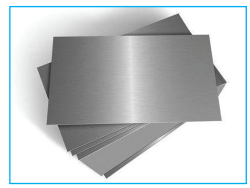
i. **Physical state**: Most of the metals exist in a solid-state at normal temperature but mercury is found in a liquid state.

ii. **Hardness:** Most of the metals are hard but lithium, sodium, and potassium are soft.

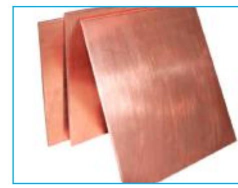
iii. **Density:** Most metals have high density except lithium, sodium, and potassium.

iv. **Lustre:** Pure metals have a brilliant metallic lustre, e.g., gold has a yellow shine and silver has a white shine.

v. **Conductivity:** Metals are good conductors of heat and electricity. Therefore, metals are used for making cooking utensils and electric wires.



aluminium sheet



copper sheet

vi. **Malleability:** The property of a metal due to which it can be beaten into thin sheets is called malleability. The metallic bond do not break while hammering but slides. As a result metal change into thin sheet.

copper wire

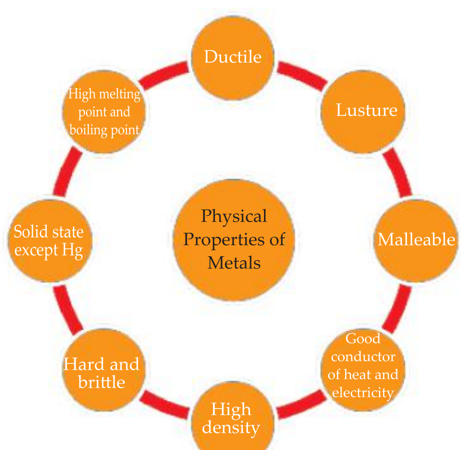
vii. **Ductility:** The property of a metal due to which it can be drawn into a long wire is called ductility. Most metals are ductile except lithium, sodium, potassium, and mercury.

viii. **Melting points and boiling points**: Hard metals with high density have high melting and boiling points but soft metals with low density have low melting and boiling points.

ix. **Electric charge:** Metals lose electrons from their valence shell and form electropositive ions.

$NaCl \rightarrow Na^+ + Cl^-$

$KCl \rightarrow K^+ + Cl^-$



Memory Note

Metals that are used to make coins are called coinage metals. For example, gold, silver, copper.

Fact and Reason

Why do most of the metals have a high melting point and boiling point in general?

Metals have strong metallic bonding. To break this strong metallic bond, we need to supply a large amount of heat. So, metals have high melting and boiling points.

b. Chemical properties of metals

i. **Reaction with oxygen**: When metals are heated with oxygen, they form corresponding metal oxides.

Examples:

$4Na + O_2 \xrightarrow{\Delta} 2Na_2O$

$4K + O_2 \xrightarrow{\Delta} 2K_2O$

$2Mg + O_2 \xrightarrow{\Delta} 2MgO$

$2Ca + O_2 \xrightarrow{\Delta} 2CaO$

ii. **Reaction with hydrogen**: Some active metals like sodium, potassium, calcium, etc. react with hydrogen and form unstable hydrides.

Examples:

$2Na + H_2 \longrightarrow 2NaH$ (Sodium hydride)

$2K + H_2 \longrightarrow 2KH$ (Potassium hydride)

$Ca + H_2 \longrightarrow CaH_2$ (Calcium hydride)

iii. **Reaction with acids**: Most of the active metals react with acids and produce salt and hydrogen gas. Examples:

$Zn + \text{dil. } 2HCl \longrightarrow ZnCl_2 + H_2$

$Mg + \text{dil. } 2HCl \longrightarrow MgCl_2 + H_2$

$Zn + \text{dil. } H_2SO_4 \longrightarrow ZnSO_4 + H_2$

$Mg + \text{dil. } H_2SO_4 \longrightarrow MgSO_4 + H_2$

Non-metals

Non-metals are those electronegative elements that are bad conductors of heat and electricity. Examples: Oxygen, nitrogen, sulphur, chlorine, iodine etc.

Differences between metal and non-metal

SN	Metals	SN	Non-metals
1	Metals are electropositive in nature.	1	Non-metals are electronegative.
2	Metals are malleable.	2	Non-metals are non-malleable.
3	Metals are ductile.	3	Non-metals are non-ductile.
4	They are good conductors of heat and electricity.	4	Non-metals are poor conductors of heat and electricity except graphite.
5	Most metals exist in a solid state at room temperature except mercury.	5	Non-metals exist in all three states at room temperature.
6	They possess metallic lustre except for lithium.	6	They do not contain metallic lustre except iodine and graphite.
7	They are generally hard except sodium and potassium.	7	They are generally soft except diamond.
8	Metals form basic oxides.	9	Non-metals form acidic oxides.
9	Metals react with acid to give salt and hydrogen gas	10	Non-metals usually do not form salt and hydrogen gas.

Memory Note

Uranium was named shortly after the discovery of Uranus.

Fact and Reason

Why are metals used to make electrical wires?

Metals are used to make electrical wires because they are ductile and good conductors of electricity.

Activity

What objects made of metals are used in your house?

Biological inorganic substances

Generally, six types of non-metals, viz. carbon (C), hydrogen (H), nitrogen (N), oxygen (O), phosphorus (P), and sulphur (S) are found in the bodies of living organisms. Similarly, different types of metals are also found in the bodies of living beings. These metals include sodium (Na), potassium (K), calcium (Ca), zinc (Zn), magnesium (Mg). These metals and non-metals are found in the form of compounds. Substances like protein, nucleic acid, lipids, etc. are formed from these elements, which are also known as biological inorganic substances. These elements have a great role in the bodies of living organisms.

Role of Metals in Organisms

Among the above-mentioned metals, Na, Mg, K, and Ca are found in large amounts whereas metals like Mn, Fe, Co, Cu, Zn, and Mo are found in small amounts.

Zinc in Organisms

Zinc is a very important metal though it is found in a small amount in the bodies of organisms. It is essential to life. It plays an important role in the biological processes of all living organisms (humans, animals, and plants).

Source of zinc

Dairy products such as milk, curd, and cheese provide zinc for us. It is also present in seeds of sunflower, pumpkin, mushroom, walnut, etc. Egg and meat are also good sources of zinc.

seeds of sunflower

seeds of pumpkin

seeds of mushroom

seeds of wall nut

Memory Note

Zinc comprises an estimated 0.004% of the earth's crust.

Role of zinc in the human body

i. It regulates the menstrual cycle in women and fertility in men.

ii. It increases the immune system.

iii. It produces sense of taste and smell.

iv. It prevents pneumonia, diarrhoea, and other infectious diseases.

v. Zinc is crucial for cell division, protein synthesis, the immune system, and growth.

Memory Note

Foods with a higher concentration of zinc include red meat, poultry, toasted wheat items, spinach, pumpkin seeds, nuts, beans, mushrooms, etc.

Fact and Reason

Why is zinc important in a child's diet?

Zinc is a trace element that is essential for cell division. It helps in the normal growth and development of infants and children. Zinc improves the immunity of the body and resistance against infections.

Effect of lack of zinc on the human body

i. Slow healing of wounds

ii. Diarrhoea

iii. Loss of hair

iv. Decline in sense of smell

Iron

Iron is an important metal for us. It is present in our red blood cells. It absorbs oxygen from the lungs. It gives a red appearance to the red blood cells.

Source of iron

Iron can be obtained from milk, meat, and fish. It is also present in broccoli and cereals.

milk

meat

vegetables

The function of iron in the human body

i. It helps in respiration.
ii. It reduces tiredness.
iii. It improves the immunity system.
iv. It helps in the formation of DNA.

Effect of lack of iron in the body

i. Low RBC count
ii. Anaemia
iii. Tiredness and weakness

Sodium

Sodium ions are very important for the functioning of the nervous system. They help in the sodium-potassium pump.

Source of sodium

Sodium is found in table salt, baking soda, meat, fish, eggs, milk, beet, etc.

table salt

baking soda

olives

The function of sodium in the body

i. It helps in muscle contraction.
ii. It helps to balance the amount of water in the body.
iii. It helps to maintain blood pressure and blood volume.
iv. It helps in the transfer of nerve impulses.

Effect of lack of sodium in the body

i. Swelling of cells
ii. Loss of reflexive movements
iii. Muscle twitching and seizure
iv. Confusion and sluggishness

Potassium

Potassium is a mineral that helps to regulate fluid in the body. It is found inside cells and is necessary for good health.

Source of potassium

Many foods contain potassium, including all meats, some types of fish, many fruits, vegetables, legumes, etc.

legumes

meat

fruits

Function of potassium

i. It helps in the normal functioning of the cells.
ii. It helps to balance the volume of liquid inside the cell.
iii. It helps to build protein and muscle.
iv. It helps in the normal growth of the body.

Effect of lack of potassium on the body

i. Nausea and vomiting
ii. Extremely low blood pressure and fainting
iii. Bloating, constipation, and abdominal cramp
iv. Weakness, fatigue, and muscle cramp

Memory Note

Neurons and muscle cells are electrically excitable cells. Ions (Na+, K+) in our bodies cause an electrical impulse. Neurons send messages electrochemically.

Mercury

The poisonous effect of mercury in the human body is called hydrargyria.

Sources:

Contaminated fish, tube light, thermometer etc.

Effects:

One drop of mercury may block blood vessels and cause the death of the victim. The compounds of mercury damage the brain. Similarly, they weaken the ability to speak, hear and see things.

Fact and Reason

Mercury is dangerous to humans, why?

Mercury is a metal known to be highly toxic, especially due to its ability to damage the central nervous system. So, mercury is dangerous to humans.

Lead

Lead poisoning is an environmental hazard that is capable of causing mental retardation, behavioural disturbance, and brain damage.

Sources:

Some cosmetic lip products, colouring pigments, lead-based paints, contaminated soil, aeroplane fuel, some toys, and some metal jewellery.

Effects:

i. Symptoms like headache, abdominal pain, change in behaviour, lack of brain development, etc. occur in children.

ii. Blood cannot combine with oxygen due to the presence of lead which causes anaemia.

iii. Lead accumulates in bones which affects the formation of blood cells in the bone marrow.

Memory Note

Humans can be exposed to lead while eating food and drinking water containing lead. The exposure may happen from dishes or glasses that contain lead. It may also be due to inhaling lead dust from lead-based paints or lead-contaminated soil.

Fact and Reason

Lead poisoning causes anaemia. Give reason.

Acute poisoning of lead can damage red blood cells in the bloodstream. It limits their ability to carry oxygen to the organs and tissues that need it, thus causing anaemia.

Answer writing skill

1. Which non-metals have metallic lustre?

Graphite and iodine are non-metals that have lustre.

2. What gives the blood its red colour?

Iron gives the blood its red colour.

3. Aluminium is used to make a pressure cooker. Why?

Aluminium is used to make a pressure cooker because

i. It is malleable. It can be changed into the desired shape.

ii. It is a good conductor of heat.

iii. It is tensile. It does not break easily and makes strong pots.

4. How differently do zinc and mercury affect our body?

Differences between effects of zinc and mercury in human body are:

SN	Effect of zinc	SN	Effect of mercury
1	Zinc helps to prevent diarrhoea, pneumonia, etc.	1	Mercury is harmful to our health.
2	Zinc improves the immunity system.	2	Mercury causes mental retardation.

5. Enlist some ways in which metals are being used in our surroundings.

Some ways in which metals are being used in our surrounding are:

i. It is used to make utensils, electrical wires, etc.

ii. It is used to make coins, jewellery, etc.

iii. It is used to construct bridges, buildings, etc.

iv. It is used to make body parts of planes, rockets, vehicles, etc.

6. Explain the importance of the sodium-potassium pump.

The sodium-potassium pump is very important for the human body. It is essential to exchange information between neurons and the brain, to regulate heartbeat and body temperature, to keep muscles sound, to control the pH of solutions in the cells, etc. Various disorders like migraine, muscle spasm, paralysis, etc. occur in the body due to irregularity in sodium and potassium pump. Therefore, there should be a proper balance in sodium and potassium ions in the human body.

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. Which one is a harmful metal?

i.	Sodium	ii.	Potassium
iii.	Mercury	iv.	Zinc

b. Which metal helps to balance fluid volume inside the cell?

i.	Potassium	ii.	Sodium
iii.	Zinc	iv.	Iron

c. Which metal helps to form red blood cells?

i.	Iron	ii.	Zinc
iii.	Sodium	iv.	Potassium

d. What is the ability to be drawn into wire called?

i.	Malleability	ii.	Ductility
iii.	Lustre	iv.	Conductivity

e. What is the melting point of silver?

i.	960°C	ii.	1083°C
iii.	63.5°C	iv.	180°C

2. Define the following, with examples.

a. Metal
b. Malleability
c. Ductility
d. Metalloid
e. Non-metals

3. Short question answers.

a. Give an example of a metal that has high melting and boiling points.

b. Which metal exists in a liquid state at normal temperature and pressure?

c. Which non-metal has lustre?

d. Which metal is neither malleable nor ductile?

e. Which non-metal conducts electricity?

Step 2

4. Give reason.

a. Carbon is called non-metal.

b. Aluminium is used to make cooking pots.

c. Non-metals cannot be used to make wires.

d. Zinc is an important diet for children.

e. Mercury is harmful.

f. The bell at school is made of metal.

5. Differentiate between the following.

a. Metals and non-metals

b. Role of iron and role of zinc in the human body

Step 3

6. Answer the following questions.

a. What metals and non-metals are present in the human body?

b. Write any four physical properties of metals.

c. Write any four physical properties of non-metals.

d. Write any three chemical properties of metals.

e. What happens to us due to a lack of iron ions in the body?

f. List the effects of lack of potassium in the body.

g. What are the effects of lack of zinc in our body?

Step 4

7. Long question answers.

a. Describe the role of zinc in the human body in brief.

b. Write any three negative impacts of mercury and lead on the human body.

c. Write a short note about biological inorganic substances.

d. Metal radicals have very important roles to operate our body. List some of them.

e. The handle of the spoon kept in hot soup also becomes hot. What might be the reason?

UNIT

18

CARBON AND ITS COMPOUNDS

ESTIMATED TEACHING PERIODS

TH	PR
4	2

Friedrich Wöhler
(1800-1882)

Curriculum issued by CDC

- Introduction, source and nature of carbon
- Physical and chemical properties of carbon
- Introduction of organic and inorganic compounds
- Differences between organic and inorganic compounds
- Use of organic compounds in daily life

Learning outcomes

After completion of this unit, students will be able to:

- describe source, nature, chemical properties and physical properties of carbon.
- differentiate between organic compounds and inorganic compounds.
- state the usefulness of organic compounds in our daily life.

Terms and terminologies

1. Catenation: The property of carbon which allows carbon to join with each other to form a long carbon chain is called the catenation property of carbon.
2. Allotropes: The different forms of an element have similar chemical properties but different physical properties are called allotropes.
3. Allotropy: The characteristic by which carbon exists in various forms in nature is called allotropy.
4. Water-gas: A mixture of carbon monoxide and hydrogen gas is called water gas.

5. Organic compounds: The compounds formed by the covalent bonding of carbon with elements like hydrogen are called organic compounds.

6. Organic chemistry: The branch of chemistry in which we study organic compounds is called organic chemistry.

7. Inorganic compounds: The compounds which are derived from minerals are called inorganic compounds.

8. Inorganic chemistry: The branch of chemistry in which we study inorganic compounds is called inorganic chemistry.

Introduction

Carbon is one of the most important and unique non-metallic elements. The word carbon has been derived from the Latin word 'carbo', which means shoot or charcoal. Carbon is widely distributed on the earth in free as well as in the combined state. In a free state, it is present in diamond, graphite, charcoal, coal, etc. whereas, in a combined state, it is present in carbon monoxide, carbon dioxide, carbonates, carbohydrates, proteins, fats, nucleic acids, petroleum, natural gas, etc. The bodies of living beings contain carbon and its compounds in abundance. When we burn these carbon-containing compounds, we get black shoots, smoke, charcoal, etc.

Memory Note

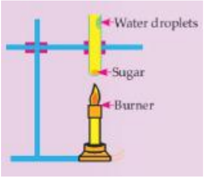
Nearly 20% of your body is carbon.

Activity

Objective: To prove sugar contains carbon.

Materials required: Sugar, hard glass test tube, and source of heat (Bunsen burner)

Procedure: Keep some sugar in the hard glass test tube and heat it with the help of a Bunsen burner.



Observation

1. Initially at about 186°C sugar melts and gives yellowish syrup.
2. On further heating, it turns into a brownish mass with a good smell which is called caramel.
3. At the final stage, the mass is converted into black matter called charcoal, i.e. carbon.

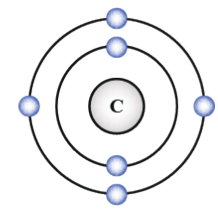
Conclusion: The above activity shows that sugar contains carbon.

Structure of Carbon Atom

Symbol = C

Atomic number = 6

Atomic mass = 12



Carbon Atom

Electronic configuration

Shell	K	L
No. of electrons	2	4

Position in periodic table: Period – 2, Group – IVA

Source of carbon

Carbon occurs in different forms in nature. The major sources of carbon are as follows:

i. All organic compounds which are obtained from living organisms contain carbon.

ii. Rocks containing carbonate, minerals, petrol, natural gases contain carbon as one of the constituents.

iii. Carbon monoxide, carbon dioxide, etc. contain carbon as one of the elements.

The various forms (sources) of carbon in the form of an element, compound, and gas are given below:

Carbon as an element	Carbon as an organic compound	Carbon as an inorganic compound	Carbon as a gas
Coal	Carbohydrate	Carbonate	Carbon dioxide
Coke	Protein	Bicarbonates	Carbon monoxide
Charcoal	Ghee and oil	Carbides such as CaC_2	Methane, ethane
Graphene	Petrol and diesel	Rocks	LPG
Diamond	Silk, paper, soap	Minerals	Water gas

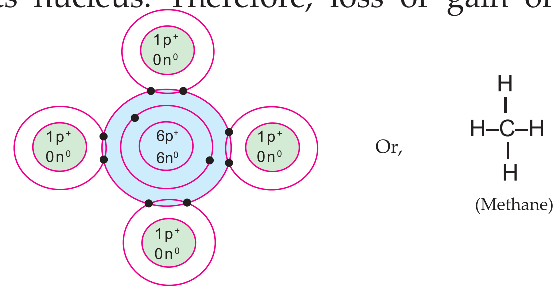
Memory Note

Carbon helps us to determine the age of the object.

Nature of carbon

Carbon has four electrons in its valence shell.

The carbon atom has a small atomic size and more electronegativity. So, it attracts electrons strongly towards its nucleus. Therefore, loss or gain of four electrons by carbon atom is not possible. As a result, carbon shares its valence electrons with other atoms to attain a stable electronic configuration. Hence, it forms four covalent bonds as shown in the given structure.



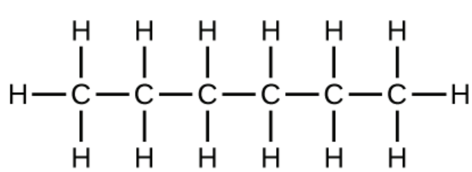
Molecular structure of Methane

Activity

Make a model of the atomic structure of the carbon atom.

a. Catenation

Carbon shows the mutual sharing of its four electrons with other carbon atoms or atoms of other elements to form a large number of covalent compounds. Carbon is one of the unique elements which can join with each other to form a long carbon chain which is called the catenation property of carbon. Due to this property of carbon, a large number of carbon compounds are found in nature. The number of carbon compounds is more than the number of compounds formed from other elements. This is the reason why we have a separate branch of chemistry to study carbon compounds or hydrocarbons which is called organic chemistry.



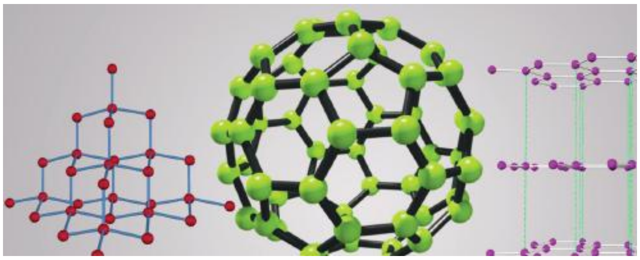
Fact and Reason

Why do carbons make a covalent bond?

There are four valence electrons in carbon. Due to its small atomic size, it can neither lose four electrons nor gain four electrons to be stable. So, it forms a covalent bond by sharing electrons.

b. **Allotropy of Carbon**

The different forms of an element with similar chemical properties but different physical properties are called allotropes.



Diamond *fullerene* *graphite*

Carbon occurs in different forms with different physical properties which are called allotropes. The characteristic by which carbon exists in various forms in nature is called allotropy. Diamond is one of the hardest allotropes which is transparent, brilliant, and precious whereas graphite is another soft, slippery, black, and greasy allotrope of carbon.

The diamond is hard, compressed carbon. Each of its valence electron is bonded. It does not have free electron and cannot pass electricity. The graphite is soft, black carbon. It has a free valence electron and can pass electricity.

Memory Note

Lampblack is the form of carbon that can be obtained from the flame of the kerosene lamp. It is used to make black ink. Similarly, it is also used as collyrium (gajal).

Coke is a fuel with few impurities and high carbon content. Usually, it is made from coal. It is used as fuel.

Activity

Collect samples of different allotropes of carbon.

Carbon is a non-metallic element that occurs in different physical forms. Among them, some exist in crystalline forms like diamond and graphite and some in amorphous forms like coal, charcoal, coke, etc.

Allotropes of Carbon

- Crystalline forms
  - Diamond
  - Graphite black lead
  - Fullerene
- Amorphous forms
  - Coal
  - Coke
  - Charcoal
  - Lampblack

Physical properties of carbon

i. It is present in amorphous and crystalline solids.

ii. It is a non-metallic element.

iii. It shows different allotropes.

iv. It does not dissolve in water.

v. Carbon is black.

vi. At high temperatures carbon changes from solid to liquid.

Chemical properties of carbon

i. Combustion in air

Carbon burns in excess air to give carbon dioxide gas.

$$C + O_2 \rightarrow CO_2$$

If the amount of oxygen is insufficient, it forms carbon monoxide.

$$2C + O_2 \rightarrow 2CO$$

ii. Reducing nature of carbon

Carbon is a good reducing agent. It reduces less reactive metallic oxides into free metal.

$$PbO + C \xrightarrow{\Delta} Pb + CO$$

$$ZnO + C \xrightarrow{\Delta} Zn + CO$$

Fact and Reason

Carbon is called a reducing agent. Why?

Carbon is called a reducing agent because it reduces less reactive metal oxide into free metal.

iii. Reaction with steam

When carbon is strongly heated with steam at about 900–1000°C, a mixture of carbon monoxide and hydrogen gas is obtained which is called water gas.

$$C + H_2O \xrightarrow{900 - 1000°C} CO + H_2 \text{ (water gas)}$$

Memory Note

The mixture of carbon monoxide and hydrogen ($CO + H_2$) is called water gas. It is used in industries as a source of heat.

iv. Reaction with calcium oxide (CaO)

When carbon reacts with calcium oxide or lime, it gives calcium carbide and carbon monoxide.

$$3C + CaO \rightarrow CaC_2 + CO \text{ (Calcium carbide)}$$

v. Reaction with metal

Carbon reacts with calcium and forms calcium carbide.

$$2C + Ca \rightarrow CaC_2 \text{ (Calcium carbide)}$$

Organic and inorganic compounds

Organic compounds

In ancient times, scientists believed that organic compounds were produced within the body of living beings by the natural processes. They also believed that the formation of organic compounds took place under the influence of vital force and they could not be prepared in the laboratory. But in 1828 AD, German chemist Friedrich Wohler synthesised urea in the laboratory by heating ammonium cyanate.

$$\underset{\text{(Ammonium cyanate)}}{NH_4CNO} \xrightarrow{\Delta} \underset{\text{(Urea)}}{NH_2 - CO - NH_2}$$

Here, ammonium cyanate is an inorganic compound whereas urea is an organic compound. This experiment displaced the vital force theory of organic compounds. Thereafter many organic compounds were synthesised artificially in the laboratory. The compounds formed by the reaction of carbon with elements like hydrogen, oxygen, nitrogen, etc are called organic compounds. Examples: Methane, ethane, propane, butane, alcohol, ether, glycerol, etc. The branch of chemistry in which we study organic compounds is called organic chemistry.

Properties of organic compounds

i. They have a covalent bond.
ii. They have a low melting point and low boiling point.
iii. They do not ionise in water.
iv. They burn easily.

Inorganic compound

The compounds which are derived from minerals are called inorganic compounds. They contain other elements except for hydrocarbon. For example, water, sodium chloride, calcium carbonate, hydrochloric acid, etc. The branch of chemistry in which we study inorganic compounds is called inorganic chemistry.

Memory Note

There are certain compounds like CO_2 and CO that contain carbon but are traditionally called inorganic compounds. Compounds like $CaCO_3$, Na_2CO_3 etc. also contain carbon atoms but they have an electrovalent bond and they do not have hydrogen. So, these compounds are called inorganic compounds.

Fact and Reason

Why does oil boil earlier than water?

Oil boils earlier than water because oil is an organic compound with a low boiling point whereas water is an inorganic compound with a high boiling point.

Properties of inorganic compounds

i. They have an electrovalent bond.

ii. They have high melting and boiling points.

iii. They ionise in water and can pass electricity.

iv. They do not burn.

Memory Note

Organic compounds are usually soluble in organic solvents, such as ether, alcohol, benzene, etc. and insoluble in water. Whereas inorganic compounds are soluble in water but insoluble in organic solvents.

Differences between organic and inorganic compounds

SN	Organic compound	SN	Inorganic compound
1	Carbon-containing compounds are called organic compounds.	1	Compounds of elements other than hydrocarbon are called inorganic compounds.
2	They have a covalent bond. So, they are called covalent compounds.	2	They have an electrovalent bond. So, they are called electrovalent compounds.
3	They have low melting and boiling points.	3	They have high melting and boiling points.
4	They are soluble in organic solvents like ether, benzene, etc.	4	They are soluble in water.
5	They burn easily.	5	They do not burn easily.
6	Organic compounds are generally covalent compounds and do not ionise when they are dissolved in water.	6	Many inorganic compounds are electrovalent and usually ionise in water.

Uses of organic compounds in our daily life

i. Organic compounds are used for manufacturing different kinds of organic materials such as dyes, detergents, soap, fuel, etc.

ii. They are used to make plastic, rubber, pesticides, and fertilizer.

iii. They are used to make cosmetic items and pharmaceutical goods.

iv. Certain organic compounds are used to treat diseases.

v. Organic compounds such as oil, sugar, ghee, etc. are food materials.

vi. Some organic compounds are used as laboratory reagents.

vii. Fossil fuels, firewood, and gobar (animal dung) gas are organic compounds.

viii. Clothes are made up of fibres which are organic compounds.

Answer writing skill

1. In which group and period of modern periodic table does carbon atom belong?

Group of carbon – IV A and Period of carbon – 2nd period.

2. Name any two organic sources of carbon.

Carbohydrates and protein are two organic sources of carbon.

3. Why is methane called an organic compound?

The methane is called an organic compound because it is formed by covalently bonded carbon and hydrogen.

4. Differentiate between diamond and graphite.

Differences between diamond and graphite are:

SN	Diamond	SN	Graphite
1	Diamond is insulator.	1	Graphite is conductor.
2	Diamond is hard rock.	2	Graphite is soft.

5. What are the physical properties of carbon?

The physical properties of carbon are:

i. It is present in amorphous and crystalline solids.

ii. It is a non-metallic element.

iii. It shows different allotropes.

iv. It does not dissolve in water.

6. When firewood burns with enough air, the eye does not burn but if firewood is wet or if the air is less, then smoke burns our eye? Explain the chemistry behind it with a balanced chemical equation.

When firewood burns with enough air, there is enough oxygen, so carbon dioxide is produced during the reaction. Carbon dioxide does not burn the eyes.

$C + O_2 \rightarrow CO_2 + \text{heat}$

When firewood burns with less amount of air, there is less oxygen, so carbon monoxide is produced which burns the eye.

$2C + O_2 \rightarrow 2CO + \text{heat}$

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. What is the atomic number of the carbon?
   i. 6   ii. 7
   iii. 8   iv. 9

b. What is the property of carbon that allows it to form a very long chain of multiple carbon atoms?
   i. catenation   ii. allotropy
   iii. ionisation   iv. none

c. Which one is the crystalline allotrope of carbon?
   i. diamond   ii. coal
   iii. coke   iv. charcoal

d. Which one is not an organic compound?
   i. oil   ii. coal
   iii. sugar   iv. table salt

e. Which one is an organic compound?
   i. table salt   ii. water
   iii. quick lime   iv. urea

2. Define the following, with examples.

a. Catenation   b. Allotropes
c. Allotropy   d. Organic chemistry
e. Hydrocarbon   f. Inorganic chemistry

3. Short question answers.

a. What are the sources of carbon?
b. Name two crystalline allotropes of carbon.
c. What is the valency of carbon?
d. What is water gas?

e. What is the reducing property of carbon?
f. It is risky to make fire inside enclosed room in winter.
g. What type of bond is present in organic compounds?

Step 2

4. Give reason.

a. Methane is called an organic compound.
b. Carbon forms a covalent compound.
c. There are a very large number of carbon compounds.
d. It is risky to make fire inside enclosed room in winter.
e. Organic compound melts faster than inorganic compound.

5. Differentiate between the following.

a. Organic compound and inorganic compound
b. Diamond and graphite

Step 3

6. Answer the following questions.

a. How is water gas produced?
b. Draw the atomic structure of carbon. Show its electronic configuration.
c. Write any three physical properties of carbon.
d. Describe the bonding nature of carbon in brief.
e. Mention any three characteristics of an organic compound.
f. What are the characteristics of the inorganic compound?

Step 4

7. Long question answers.

a. Sugar is a carbon containing compound. Experiment to show that sugar contains carbon. Write a report.
b. What happens when carbon is heated with lead oxide?
c. What happens when carbon reacts with lime?
d. Lets suppose you have certain substance such as pencil, salt, lemon, pebble etc. How can you know if it is an organic or inorganic matter? Suggest the ways to test them.
e. Let's suppose our dress got greased. When we tried to wash it by soap, stain remained. Then someone suggested to wash it by kerosene and it worked. Discuss the reason.

UNIT

19

MATERIALS USED IN AGRICULTURE

ESTIMATED TEACHING PERIODS

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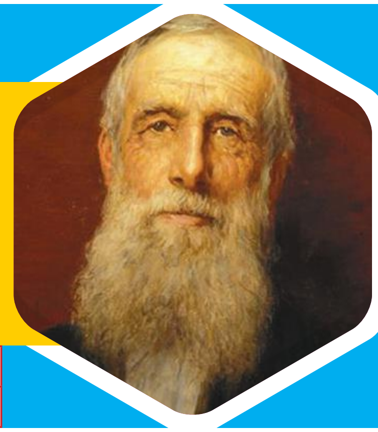

Sir John Bennet Lawes
(1814-1900)

Curriculum issued by CDC

- Introduction to plant nutrients
- Effects of deficiency of macro nutrients (N, P, K) in the plants
- Introduction of organic fertilizer and their advantages
- Methods of composting
- Introduction of chemical fertilizers and pesticides and their importance
- Harmful effects of chemical fertilizers and insecticides and their biological alternatives

Learning outcomes

After completion of this unit, students will be able to:

- introduce the nutrients essential for plants.
- identify the effects of deficiency of nitrogen, phosphorus and potassium in plants.
- introduce organic manure and mention its formation and advantage.
- introduce chemical fertilizer and pesticides.
- describe importance, effects and alternatives of chemical fertilizer and pesticides.
- describe the measures for conservation of soil quality.

Terms and terminologies

1. Primary nutrient: The nutrients required for plants in the largest amount is called primary nutrient.
2. Secondary nutrients: The nutrients that are usually needed in moderate amounts compared to the primary nutrients are called secondary nutrients.
3. Fertilizers: Fertilizers are those water-soluble substances that are used in the soil to increase crop production by supplying essential nutrients.

4. Organic fertilizers:	Fertilizers that are obtained from dead, decayed and decomposed parts of animals and plants or their waste products are called organic fertilizers or manure.
5. Complete fertilizers:	The fertilizers that contain nitrogen, phosphorus, potassium, and every other nutrient required for plants are called complete fertilizers.
6. Green manures:	Green manures are the green plants that are grown, ploughed, and mixed in the soil to provide essential nutrients to the growing plants.
7. Compost manure:	Compost manure is an organic fertilizer that is made from dead, decayed, and decomposed parts of animals and plants or their waste products.
8. Chemical fertilizers:	The man-made chemical substances that are added to the soil to increase crop production by supplying essential elements are called chemical fertilizers.
9. Nitrogenous fertilizers:	Fertilizers that contain nitrogen are called nitrogenous fertilizers.
10. Phosphorus fertilizers:	Fertilizers that contain phosphorus are called phosphorus fertilizers.
11. Potassium fertilizers:	Fertilizers that contain potassium are called potassium fertilizers.
12. Insecticides:	Chemical compounds that are used to kill or control harmful insects are called insecticides.
13. Bioinsecticides:	The pesticides made from natural materials that are meant to kill or control insects are called bioinsecticides.
14. Chemical insecticides:	The Man-made poisonous chemical compounds that are used to kill or control harmful insects are called chemical insecticides.
15. Organic insecticide:	The carbon-containing man-made chemical compounds that are used to kill or control harmful insects is called organic insecticide.
16. Inorganic insecticide:	Insecticides that are made from minerals are called inorganic insecticides.

Introduction


crops in fields

Food is essential for living things. It is the only source of energy for us. We obtain food from plants. We grow crops, fruits, and vegetables in the fields. They obtain nutrients from the soil. If the land lacks nutrients agricultural production decreases.

We are supposed to use fertilizers to increase agricultural production.

Various germs, bacteria, fungus, and viruses are harmful to plants. We should use pesticides, fungicides, and insecticides to get rid of them.

Necessary nutrients for plants

Fertilizers enhance the growth and development of plants. Plants need three main macronutrients, viz. Nitrogen (N), Phosphorus (P), and Potassium (K), three secondary macronutrients, viz. calcium (Ca), magnesium (Mg) and sulphur (S), and some micronutrients like copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), boron (B), etc. These macronutrients and micronutrients are found in soil which is absorbed by the roots of green plants.

a. Primary nutrients

The nutrients required for plants in the largest amount are called primary nutrients. Nitrogen, phosphorus, and potassium are the three main nutrients necessary for the growth and development of the plant.

b. Secondary nutrients

The nutrients that are usually needed in moderate amounts compared to the primary nutrients are called secondary nutrients. Calcium, magnesium, sulphur, etc. are some secondary nutrients.

Fertilizer

chemical fertilizer

Farmers use a variety of organic and inorganic substances to increase the fertility of the soil. These substances are called fertilizers. These substances supply nutrients which are essential for the growth and development of plants. Fertilizers are water-soluble substances used in the soil to increase crop production by supplying essential nutrients. A good fertilizer or complete fertilizer always provides essential elements to the growing plants as well as nourishes the micro-organisms.

Memory Note

Fertilizers account for 50% of global food production consumed by both animals and humans.

Fact and Reason

It is necessary to use fertilizers in the soil, why?

When the same types of plants are grown for a long time, the fertility of soil decreases. So, for continuous use of soil and to maintain crop production, it is necessary to use fertilizers.

Activity

Visit a nearby vegetable garden with your guardian. Why do the gardeners use fertilizer? Ask them.

The population of the world is increasing at a high rate but the productivity of crops is decreasing which will result in a food crisis. Therefore, a variety of fertilizers should be used to increase the productivity of crops.

1. Organic Fertilizers

Fertilizers that are obtained from dead, decayed and decomposed parts of animals and plants or their waste products are called organic fertilizers or manure. Organic fertilizers are soil suitable fertilizers. Organic fertilizers are complete fertilizers because they contain nitrogen, phosphorus, potassium, and every other nutrient. There are two types of organic fertilizers or manures.

a) **Green manure:** Green manures are the green plants that are grown, ploughed, and mixed in the soil to provide essential nutrients to the growing plants. Green manures supply essential elements which are required for growing plants and also checking soil erosion. The

green manure

leguminous and non-leguminous plants are grown, ploughed, and decomposed to get organic matter which is also called humus.

b) **Compost manure:** Compost manure is an organic fertilizer that is made from dead, decayed, and decomposed parts of animals and plants or their waste products. To prepare compost manure, a mixture of dead plants, animals, or their waste products is kept in a pit with altering layers of soil. Sometimes, a little amount of lime is also added to the mixture. Due to microbial action, the mixture gets decomposed into compost manure. It is used in the soil to provide essential elements for growing plants.

compost

compost pit

Memory Note

Organic fertilizer is a biodegradable fertilizer. So, natural fertilizer (organic fertilizer) does not pollute the environment.

Advantages of Organic Fertilizer

The main advantages of organic fertilizer are given below:

i. It increases the fertility of the soil.

ii. It increases the water-retaining capacity of the soil.

iii. It helps to control soil erosion.

iv. It helps to control environmental pollution.

v. It does not affect the quality of the soil.

Disadvantages of Organic Fertilizer

The major disadvantages of organic fertilizer are as follows:

i. It takes a long duration to work.

ii. It contains little quantity of nutrients required for plants.

Fact and Reason

Organic fertilizers are soil suitable fertilizers, why?

Organic fertilizers are soil suitable fertilizers because they provide all the essential elements to the growing plants without changing the composition of the soil.

Activity

Compost is a complete fertilizer. It contains every nutrient necessary for plants. However, it works slower than chemical fertilizer. Take two flower pots with sand and grow a flower in both. Use chemical fertilizer in the first one and compost in the second one. Observe the differences in their growth.

2. Inorganic Fertilizers or Chemical Fertilizers

The man-made chemical (or inorganic) substances which are added to the soil to increase crop production by supplying essential elements are called chemical fertilizers. Chemical fertilizers (or inorganic fertilizers) supply mostly Nitrogen (N), Phosphorus (P), and Potassium (K) as the chief elements. They are needed for growth, development, and seed production. Based on the elements present, there are three types of chemical fertilizers.

They are:

i. Nitrogenous fertilizers
ii. Phosphorus fertilizers and
iii. Potassium fertilizers

The fertilizer that contains nitrogen, phosphorus, and potassium is also called NPK fertilizer.


nitrogenous fertilizer


potassium fertilizer


phosphorus fertilizer

a. **Nitrogenous fertilizers:**

Fertilizers that contain nitrogen are called nitrogenous fertilizers.

For example,

i. Urea [NH_2CONH_2]

ii. Ammonium sulphate [$(NH_4)_2SO_4$]

iii. Ammonium nitrate [NH_4NO_3]

iv. Calcium cyanide [$Ca(CN)_2$]

Importance of nitrogen (Nitrogenous fertilizer)

Nitrogen helps in the formation of protein, protoplasm, and chlorophyll in plants. It is a single fertilizer. It contains only one nutrient. It is essential for rapid growth and to yield more crops. Deficiency of nitrogen results in poor development of flowers, fruits, and seeds. Leaves become yellow and flowers do not bloom properly.

Memory Note

Nitrogenous fertilizer is necessary for plants if the leaves are yellow and the flower does not bloom properly.

Fact and Reason

Why does wind break down maize plants if too much urea is used in the fields?

If too much urea is used in the fields, then only the shoot system will grow faster whereas roots remain weak due to the lack of phosphorus. As a result, the maize plant breaks when the wind blows.

b. **Phosphorus fertilizers:**

Fertilizers that contain phosphorus are called phosphorus fertilizers.

For example,

i. Ammonium phosphate [$(NH_4)_3PO_4$]

ii. Calcium superphosphate [$Ca(H_2PO_4)_2.2CaSO_4$]

iii. Triple superphosphate [$3Ca(H_2PO_4)_2$]

iv. Bone meal

Importance of phosphorus (Phosphorus fertilizer)

Phosphorus helps in the ripening of fruits and the development of seeds. It is also important in the synthesis of protein, cell division, and growth

> **Memory Note**
>
> *If plants have poorly developed roots, then phosphorous containing fertilizer is necessary for these plants.*

> **Fact and Reason**
>
> **Why is bone used to make fertilizer?**
>
> Bone is a tissue present in the animal's body. It is very rich in salts of calcium and phosphorus. Since bone can supply calcium and phosphorus to the plants, it is used as a fertilizer.

c. Potassium fertilizers:

Fertilizers that contain potassium are called potassium fertilizers.

For example,

i. Potassium chloride (KCl)
ii. Potassium nitrate (KNO_3)
iii. Potassium sulphate (K_2SO_4)
iv. Potassium carbonate (K_2CO_3)

Importance of potassium (Potassium fertilizer)

Potassium helps in the photosynthesis and growth of flowers. It also helps in protein synthesis, cell division, food production, etc. Due to deficiency of potassium, leaves, and buds wither and immunity is also reduced.

Advantages of Inorganic (Chemical) Fertilizers

The major advantages of chemical fertilizers are as follows:

i. Chemical fertilizers are easy to collect and transport from one place to another.
ii. They contain most of the nutrients essential for the growth and development of plants.
iii. They are water-soluble. So, they can be absorbed by plants easily.
iv. Different single fertilizers can be mixed and used according to the need.

Memory Note

Chemical fertilizers are good for immediate results in the growth, development, and productivity of plants.

Fact and Reason

Despite the harmful effects, chemical fertilizers are widely used.

The chemical fertilizers are harmful but they are widely used because they are easily dissolved in water and absorbed by plants.

Disadvantages of Chemical Fertilizers

i. Chemical fertilizers cause environmental pollution.

ii. They increase the acidity or alkalinity of the soil.

iii. They affect the quality of the soil.

Activity

- Pay a visit to farmers in your locality.
- Ask the technique of making compost manure and green manure to the farmers.
- Prepare a short report and submit it to your science teacher.
- Also, prepare a list of inorganic or chemical fertilizers that are used in your locality.

Conservation of soil quality

Plants grow well in fertile soil. Soil loses its quality due to erosion, sewage, chemical fertilizers, and unscientific agriculture. We can conserve the quality of soil by following methods.

terrace farming

i. Plant trees

The plants prevent soil erosion and landslide. They prevent decrease in the quality of the soil.

ii. Build terrace

The terrace reduces speed of running water. It prevents soil erosion.

iii. No-till farming

Avoid till farming because it kills earthworms and soil loses organic materials.

iv. Contour ploughing

Contour ploughing is the method of ploughing across the contour lines of the slope. This method helps in slowing the water and preventing erosion.

contour ploughing

v. Crop rotation

Continuous cultivation of the same crop imbalances the fertility of the soil. Crop rotation is the method of growing a series of dissimilar crops in the area. It helps to improve soil structure and make it fertile.

vi. Maintain soil pH

Plants grow well on soil with suitable pH. We should test the pH of the soil. It allows us to know the missing nutrients from the soil. We can treat the acidity or alkalinity of soil by using suitable chemicals.

vii. Water the soil

Proper irrigation prevents soil erosion.

Insecticides

The chemical compounds that are used to kill or control harmful insects are called insecticides. In our surroundings, several insects and pests are present. Among them, some are beneficial, whereas some are harmful. Some insects harm plants, crops, domestic animals, human beings, etc. Therefore, poisonous chemicals are manufactured to control them. Those chemicals either kill or disturb the life cycle of harmful insects and decrease their number.

Memory Note

The most commonly used insecticide is malathion. It is an insecticide against mosquitoes.

Types of insecticides

Insecticides are classified as bio-insecticides and chemical insecticides.

a. Bioinsecticides

The pesticides made from natural materials that are meant to kill or control insects are called bioinsecticides. They may be prepared from animals, plants, bacteria, or minerals. They control insects by non-toxic mechanisms. Bioinsecticides are less toxic. They decompose quickly. They do not pollute the environment. They do not kill good insects and earthworms. They are usually made from plant parts.

Memory Note

Bioinsecticides are good insecticides. The insecticides that are less toxic, degradable and do not pollute the environment.

b. Chemical insecticides

Man-made poisonous chemical compounds that are used to kill or control harmful insects are called chemical insecticides. In our surroundings, several insects and pests are present. Some insects harm plants, crops, domestic animals, human beings, etc. Therefore, poisonous chemicals are manufactured to control them. Those chemicals either kill or disturb the life cycle of harmful insects and decrease their number.

Examples: BHC (Benzene hexachloride), DDT (Dichloro diphenyl trichloroethane), Aldrin, Dialdrin, Methoxychlor, etc. are organic chemical insecticides. Calcium arsenate, lead arsenate etc. are inorganic chemical insecticides.

Advantage of insecticides

i. Increased crop production.

ii. Protection from defoliation.

iii. Prevents diseases.

iv. Prevents spoilage of stored food.

v. Controls insects from the crops.

Disadvantage of insecticides

i. Poison can get into food.

ii. They kill good insects such as spiders and earthworms.

iii. They pollute land and water.
iv. They can cause cancer in human beings.
v. They can kill aquatic animals.

Fact and Reason

Why should we not use chemical insecticides?

We should not use chemical insecticides because they kill not only the harmful insects but also the good ones.

Precautions while using insecticides

Since insecticides are poisonous, they should be used with caution:

i. They should be kept in a closed container and labelled properly.
ii. They should be used in the recommended doses.
iii. People using pesticides should fully cover their body and wear a gas mask.
iv. Users should not eat or drink while using pesticides.
v. Fruits should not be plucked and eaten right after using pesticides.

Answer writing skill

1. Name three primary macronutrients important for plants.

Nitrogen, potassium, and phosphorous are the main primary nutrients required for plants.

2. What does it mean to say that fertilizer is nutrient-specific? Give an example.

A fertilizer is nutrient-specific. It means that fertilizer can supply only one kind of nutrient for plants. For example, urea supplies nitrogen only.

3. Organic fertilizer is good for plants but farmers are attracted towards chemical fertilizer, why?

Organic fertilizer is good for plants but farmers are attracted towards chemical fertilizer because:

i. Chemical fertilizer is easily absorbed by plants and immediate result is seen. But organic fertilizer is slowly absorbed by plants and cannot give immediate results.

ii. Chemical fertilizer is available easily in the market but organic fertilizer is not produced on an industrial scale.

iii. Chemical fertilizer is rich in nutrients but organic fertilizer has a low concentration of nutrients.

iv. Different types of chemical fertilizers can be used depending upon the nature of the soil.

4. Differentiate between nitrogenous fertilizer and potassium fertilizer.

Differences between nitrogenous fertilizer and potassium fertilizer are:

SN	Nitrogenous fertilizer	SN	Potassium fertilizer
1	Nitrogenous fertilizer primarily helps to develop shoot system.	1	Potassium fertilizer primarily helps to boost immunity system.
2	It is usually supplied from urea.	2	It is usually supplied from potassium chloride.

5. How do chemical fertilizers pollute the environment?

Chemical fertilizers pollute the environment in the following ways:

i. Chemical fertilizer decreases the population of earthworms and other micro-organisms in the soil.

ii. Chemical fertilizer increases the acidity of soil and decreases agricultural products.

iii. Chemical deposit is found in food products which causes serious health hazard.

iv. Chemicals dissolved in water pollute water resources, drinking water, and kill aquatic life.

6. Farmers complain that if urea fertilizer is used more in fields, plants grow very tall and fall during winds. Explain the possible reason behind it.

If an excess amount of urea is used, plants grow very tall and fall during winds. It is reasonable to complain because urea is not a complete fertilizer. Urea supplies a large amount of nitrogen. So, plants grow rapidly and become very tall. But due to lack of phosphorous, roots become weak and cannot support the weight of the plant. Hence, they fall in wind.

EXERCISE

Step 1

1. Choose the best answer from the given alternatives.

a. Which one is the primary nutrient?

i. nitrogen	ii. boron
iii. zinc	iv. iron

b. Which one is nitrogenous fertilizer?

i. urea	ii. calcium superphosphate
iii. potassium chlorate	iv. bone meal

c. Which activity does not conserve the soil?

i. contour farming	ii. terrace farming
iii. crop rotation	iv. chemical fertilizers

d. What is the chemical that is used to kill insects?

i. fertilizers	ii. compost
iii. green manure	iv. insecticides

e. Which one is an inorganic insecticide?

i. DDT	ii. BHC
iii. aldrin	iv. lead arsenate

2. Define the following, with examples.

a. Primary nutrients
b. Secondary nutrients
c. Fertilizers
d. Chemical fertilizers
e. Potassium fertilizers

3. **Short question answers.**

a. Define single fertilizer and mixed fertilizer.

b. What are NPK fertilizer and complete fertilizer?

c. Define bioinsecticide with an example.

d. What is a chemical insecticide?

e. Name any two primary nutrients and secondary nutrients essential for the growth and development of plants.

Step 2

4. **Give reason.**

a. Farmers should use fertilizers in their fields.

b. Organic fertilizers are better than chemical fertilizers.

c. NPK fertilizer is also called complete fertilizer.

d. Inorganic fertilizers are harmful for ecosystem.

e. We should not use chemical insecticides.

5. **Differentiate between the following.**

a. Organic fertilizer and inorganic fertilizer

b. Green fertilizer and compost manure

c. Nitrogen fertilizer and phosphorus fertilizer

Step 3

6. **Answer the following questions.**

a. Enlist the advantages and disadvantages of organic fertilizer.

b. Mention any three advantages and three disadvantages of inorganic fertilizers.

c. Write down the importance of nitrogen fertilizer, phosphorus fertilizer and potassium fertilizer.

d. What are the two effects of deficiency of nitrogeneous fertilizers, phosphorus fertilizer and potassium fertilizers on plants?

e. A farmer is unable to decide whether s/he should use or not use the chemical fertilizers and pesticides. Give your opinion to s/he in support or against the use of chemical fertilizers and pesticides.

f. What are the alternatives for those farmers who do not want to use chemical insecticides and chemical fertilizers?

g. Use of chemical fertilizers and pesticides is in practice in agriculture. Enlist its harmful effects on human health. Make any two slogans to make a pamphlet.

h. Let's say a farmer is about to use pesticides. What precautions should s/he follow to avoid being poisoned to death?

Step 4

7. Long question answers.

a. Farmers are using chemical fertilizers since last decades which is harmful for the environment. Observe your surroundings and enlist any of its impact on the environemnt.

b. Agricultural fields in terai regions produces large quantity of agricultural residue which is ploughed along with the field by tractors. Discuss the advantages of doing so.

c. Side effects of chemical fertilizer are now easily seen in the fields. Soil is acidic and agriculture production has decreased. What can be done to save the fertility of the soil and increase crop production? Explain.

d. We should use bioinsecticides over chemcial fertilizers. Support the statement.

e. Despite being poisonous and harmful farmers are obliged to use pesticides. What may be the reasons that farmers are not quitting insecticides?

f. If farmers are about to spread chemical fertilizer in their tomato fields, what safety measures should they adopt?