SCIENCE

Part - I

Grade 9

Educational Publications Department

First Print 2017

Second Print 2018

Third Print 2019

ISBN 978-955-25-0162-3

Published by Educational Publications Department
Printed by PrintXcel Private Limited
164/4/A, Bakmeegahawewa Road, Pore,
Athurugiriya.

The National Anthem of Sri Lanka

Sri Lanka Matha
Apa Sri Lanka Namo Namo Namo Namo Matha
Sundara siri barinee, surendi athi sobamana Lanka
Dhanya dhanaya neka mal palaturu piri jaya bhoomiya ramya
Apa hata sepa siri setha sadana jeewanaye matha
Piliganu mena apa bhakthi pooja Namo Namo Matha
Apa Sri Lanka Namo Namo Namo Namo Matha
Oba we apa vidya
Obamaya apa sathya
Oba we apa shakthi
Apa hada thula bhakthi
Oba apa aloke
Apage anuprane
Oba apa jeevana we
Apa mukthiya oba we
Nava jeevana demine, nithina apa pubudukaran matha
Gnana veerya vadawamina regena yanu mana jaya bhoomi kara
Eka mavakage daru kela bevina
Yamu yamu vee nopama
Prema vada sema bheda durerada
Namo, Namo Matha
Apa Sri Lanka Namo Namo Namo Namo Matha

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Being innovative, changing with right knowledge,
Be a light to the country as well as to the world.

Message from the Hon. Minister of Education

The past two decades have been significant in the world history due to changes that took place in technology. The present students face a lot of new challenges along with the rapid development of Information Technology, communication and other related fields. The manner of career opportunities are liable to change specifically in the near future. In such an environment, with a new technological and intellectual society, thousands of innovative career opportunities would be created. To win those challenges, it is the responsibility of Sri Lankan Government and myself, as the Minister of Education, to empower you all.

This book is a product of free education. Your aim must be to use this book properly and acquire the necessary knowledge out of it. The government in turn is able to provide free textbooks to you, as a result of the commitment and labour of your parents and elders.

Since we have understood that the education is crucial in deciding the future of a country, the government has taken steps to change curriculum to suit the rapid changes of the technological world. Hence, you have to dedicate yourselves to become productive citizens. I believe that the knowledge this book provides will suffice your aim.

It is your duty to give a proper value to the money spent by the government on your education. Also you should understand that education determines your future. Make sure that you reach the optimum social stratum through education.

I congratulate you to enjoy the benefits of free education and bloom as an honoured citizen who takes the name of Sri Lanka to the world.

Akila Viraj Kariyawasam
Minister of Education

Foreword

The educational objectives of the contemporary world are becoming more complex along with the economic, social, cultural and technological development. The learning and teaching process too is changing in relation to human experiences, technological differences, research and new indices. Therefore, it is required to produce the textbook by including subject related information according to the objectives in the syllabus in order to maintain the teaching process by organizing learning experiences that suit to the learner needs. The textbook is not merely a learning tool for the learner. It is a blessing that contributes to obtain a higher education along with a development of conduct and attitudes, to develop values and to obtain learning experiences.

The government in its realization of the concept of free education has offered you all the textbooks from grades 1-11. I would like to remind you that you should make the maximum use of these textbooks and protect them well. I sincerely hope that this textbook would assist you to obtain the expertise to become a virtuous citizen with a complete personality who would be a valuable asset to the country.

I would like to bestow my sincere thanks on the members of the editorial and writer boards as well as on the staff of the Educational Publications Department who have strived to offer this textbook to you.

W. M. Jayantha Wickramanayaka,
Commissioner General of Educational Publications,
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2019.04.10

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Introduction

This textbook was compiled by the Educational Publications Department in accordance with the syllabus prepared by the National Institute of Education for the use of Grade 9 students in the Sri Lankan school system with effect from 2018.

An effort has made here to arrange the subject content to suit the national educational goals, common national competencies, the objectives of teaching science and the content of the syllabus.

The subject of science directs the student towards a more active learning process in a manner as to develop knowledge, skills and attitudes needed for a developmental scientific thought.

In the compilation of this textbook, subject content is largely arranged based on experiences of daily life. It has contributed to prove the fact that the subject of science is very much closer to the day to day life.

The compilation of this textbook based on activities is a distinctive feature. The activities are prepared based on the scientific method in order to develop knowledge, skills and attitudes. Activities that can be performed individually at home as well as in school are incorporated here. We believe that learning through activities would contribute to create a liking and an interest in the child towards learning science.

At the end of each chapter, a summary, a series of exercises and a glossary were included. It enables the student to identify the important details of the chapter as well as to self evaluate the achievement of learning outcomes.

For the purpose of directing the student to study further about the subject matter, more information is included in the "For extra knowledge". It is given only to broaden the subject area of the child and certainly not to ask questions at term tests.

Assignments and projects are given with the purpose of directing the student towards an explorative study. It enables the students to develop the higher order skills such as application, analysis and synthesis of the concepts achieved from the lesson.

We strongly believe that the duty of the teachers who teach science is to direct the student for self learning instead of teaching the student using traditional teaching methods. This textbook can be utilized by the teachers as a learning tool to execute their teaching role properly.

We would like to bestow our sincere thanks on Chief project officer D. M. Wijesinghe and science teacher (Visakha Vidyalaya) S. M. Sanjeewa.

We kindly request you to forward your comments and suggestions on this textbook to the Educational Publications Department.

Board of Writers and Editors

Contents

Cover Page :- Human heart and a magnified DNA helix.

1 Applications of Micro-organisms

1.1 Micro-organisms

Recall what you have learnt about micro-organisms in grade 8. You have learnt micro-organisms are unicellular or multicellular organisms which cannot be seen clearly with the naked eye. Do assignment 1.1 using the previous knowledge.

Assignment 1.1

- Prepare a list of the groups of micro-organisms you know and write names of micro-organisms belong to each group.

Micro-organisms live in our environment as well as in our body.

Most micro-organisms are favourable to humans and other living beings, but some are harmful.

Micro-organisms are a wide spread and common species category of living organisms on Earth. They are a group of living organisms with a simple structure. They grow fast and have high rate of reproduction.

Micro-organisms have the ability to adapt for different environmental conditions and modes of nutrition.

Unicellular and some of the multicellular organisms can be seen in micro-organism category.

These micro-organisms can be categorized into groups as bacteria, fungi, algae and protozoa. Viruses which are a group in between the living and non-living are also studied under micro-organisms.

Let us study table 1.1 to know about the categories of micro-organisms.

Table 1.1 - Characteristics of different micro-organism categories and examples for them

Category of micro-organisms	Characteristics	Examples
Bacteria	• Unicellular and microscopic • Different body shapes • Widely spread in every type of environment on Earth	• Milk and products related to milk - *Lactobacillus bulgaricus* • Anthrax disease - *Bacillus anthracis* • Bacteria used in Vinegar production - *Acetobacter aceti* • Cholera disease - *Vibrio cholerae*
Fungi *Mucor* *Saccharomyces*	• Unicellular or multicellular • Reproductive organs of some fungi can be seen with naked eye e.g. mushroom • Thrive on moist surfaces (substrate)	• Fungi on bread - *Mucor* • Yeast - *Saccharomyces*
Protozoa *Amoeba* *Paramecium* *Euglena* Red blood cells infected by *Plasmodium*	• Unicellular and microscopic • Use structures such as cilia, pseudopodia and flagella for locomotion • Live in aquatic environments as well as in other living organisms	• *Amoeba* • *Paramecium* • *Euglena* • *Plasmodium*

Algae *Chlamydomonas* *Spirogyra* Diatoms	• Unicellular or multicellular • Filamentous or thallus body forms • Microscopic alga floating on the water surfaces are called phytoplanktons • Possess chlorophyll and have the ability of photosynthesis • Algal varieties such as *Ulva* are visible to the naked eye	• *Chlamydomonas* • *Spirogyra* • Diatoms
Viruses	• Electron microscopic • Display both living and non-living characteristics • Multiply only inside the living cells • No cellular organization • They do not show the living characteristics such as respiration and growth	• Influenza virus • HIV • Ebola virus • Dengue virus

* Several enlarged diagrams of microbes are given in the above table. Memorization of the scientific names is not needed.

1.2 Environments and substrates of micro-organisms

Micro-organisms live within all the eco systems on the Earth where other living organisms survive. Microbial world spreads among soil, water and for about up to 6 km of the atmosphere. These organisms survive even on and within the body of plants and animals. Meat, fish, fruits, vegetables, human skin, mouth, alimentary canal and urinary tract are some specific substrates that micro-organisms grow.

Microbes can survive even under extreme environmental conditions. Hot water springs, salt marshes, liquids such as petrol and diesel are some such environments.

1.3 Effects of micro-organisms

Micro-organisms have been used in different industries by human from the past. Micro-organisms are beneficial for the environmental equilibrium. But, they can also be harmful to human because some of them act as pathogens and spoil food.

1.3.1 Beneficial effects of micro-organisms

Micro-organisms are used in agriculture, medicine, conservation of environment and in different kinds of industries in seek of economical advantages and for research purposes. Here we will investigate how they are being used in different fields.

Applications of micro-organisms in agriculture

- **Gene technology**

In agriculture, crop harvest is enhanced and enriched by producing drought-resistant and pest-resistant crops and crops with high nutrients and taste, with the aid of micro-organisms. Further, biological pesticides and weedicides are developed using micro-organisms.

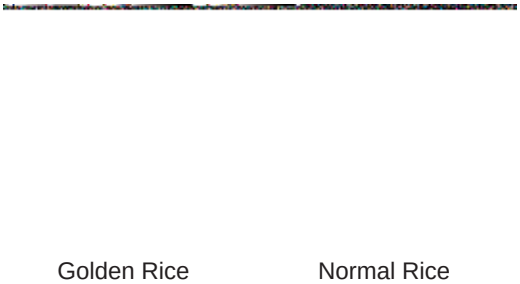


Figure 1.1

Genes of the bacterium *Erwinia uredovora* is used in developing golden rice enriched with vitamin A (figure 1.1).

Genes of the bacterium *Bacillus thuringiensis* is muted in *Zea maize* genome to produce toxins to crop pests.

- **Nitrogen fixation**

Even though 78% of Nitrogen exists naturally in the atmosphere, plants have a limited ability to absorb it directly. But *Rhizobium*, a type of bacteria that lives in the nodules of legumes such as beans and peas has the ability to absorb atmospheric Nitrogen directly. This process is known as **Nitrogen fixation**. Commercially produced *Rhizobium* is used in cultivation lands in order to increase the yield of legumes.

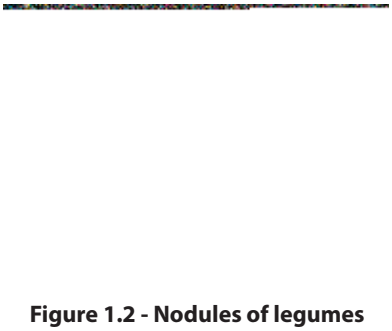


Figure 1.2 - Nodules of legumes

Azotobacter, a free living Nitrogen fixing bacteria, is directly added to the cultivation lands. They are known as **bio fertilizers**. Bio fertilizers are the substances which make the soil rich with nutrients by using micro-organisms.

• Producing compost

Compost is prepared by rapid decomposition of organic matter by micro-organisms. Compost adds mineral to the soil systematically and makes favourable conditions for plants to grow. The organic matter in compost are often decomposed by bacteria and fungi.

Figure 1.3 - Producing compost by using organic matter

• Bio-pesticides

Some of the micro-organisms can be used as **bio pesticides** to control insect pests that cause damage to the crops.

e.g. The fungus *Alternaria* is used to combat the aquatic weed, salvinia.

Applications of micro-organisms in medicine

Use of micro-organisms to treat the diseases caused by another micro-organism is very common in medicine. Micro-organisms are used to produce antibiotics, vaccines and anti-toxins.

• Producing antibiotics

Chemicals produced in the body of a microbe to destroy or sabotage another micro-organism are known as antibiotics.

Fungi and bacteria are used to produce antibiotics. Antibiotics can kill bacteria and fungi but they do not fight against infections caused by viruses.

Figure 1.4 - Some antibiotics

Although, antibiotics are not much harmful to human they can cause side effects if used without medical advice.

Penicillin, Amoxicillin, Tetracycline and **Erythromycin** are used against bacterial infections while **Griseofulvin** is used against fungal infections.

For extra knowledge

- The antibiotic Penicillin was discovered by the Scottish scientist Alexander Fleming.
- It is produced using the fungus *Penicillium notatum*.

Alexander Fleming

• Producing vaccines

A vaccine typically contains an agent that resembles a disease causing micro-organism; and is often made from weakened or killed forms of the microbe or from its toxins.

- Vaccines made from weakened microbes
  e.g. Polio, Tuberculosis, Measles
- Vaccines made from killed microbes
  e.g. Cholera, Influenza, Typhoid
- Vaccines made from toxins of microbes
  e.g. Tetanus, Diphtheria
- Vaccines made from body parts of microbes using genetic engineering
  e.g. Hepatitis B

Assignment 1.2

Collect information about the immunization programmes conducted in Sri Lanka.

Display the collected information in a wallpaper in the classroom.

• Producing anti toxins

Bio-chemical substances produced by pathogenic bacteria which harm the host's activity are known as **toxins**. Anti-toxins are synthesized using these toxins by removing its toxic components.

e.g. Tetanus vaccine

Applications of micro-organisms in industries

Various strains of microbes are used for research and economic benefits. Using micro-organisms in industrial activities for economic benefits is known as **Industrial Microbiology**.

Micro-organisms are commonly used in following large scale and small scale industries.

- Producing dairy products (yoghurt, curd, cheese, butter)
- Producing biogas
- Metal extraction
- Products based on plant fibres
- Producing alcohol
- Producing vinegar
- Bakery industry

For extra knowledge

Industry	Micro-organisms used
Producing alcohol	*Saccharomyces cerevisiae*
Producing vinegar	*Acetobacter aceti*
Bakery industry	*Saccharomyces cerevisiae*
Producing dairy products (yoghurt, curd, cheese, butter)	*Lactobacillus bulgaricus* *Streptococcus thermophilus*
Producing biogas	*Methanococcus, Methanobacterium*
Products based of plant fibres	*Bacillus corchorus, Bacillus comesii*
Metal extraction	*Acidithiobacillus ferrooxidans* *Thiobacillus ferrooxidans*

• Producing biogas

A mixture containing organic materials such as straw, cow dung and water is used to produce biogas. Anaerobic bacteria such as *Methanococcus* react on these organic surfaces and produce biogas. Biogas mainly consists of Methane gas. Therefore, it can be used as an energy source.

Figure 1.5 - Producing biogas

• Metal extraction

The most simple and effective technology used for the metal extraction from low grade ores, by the use of microbes, is known as **bio-leaching**. Uranium and Copper are such two metals that are extracted by bio-leaching.

• Milk based products

Let us do activity 1.1 to demonstrate the production of yoghurt.

Activity 1.1

You will need :- Pure cows' milk, yoghurt sample for culture, sugar, gelatin, a pan to boil milk, some plastic cups, a thermometer

Method :-

- Heat cows' milk for 15-30 minutes in a temperature between 88 ^{0}C - 95 ^{0}C.
- Remove the cream.
- Add sugar and gelatin as required.
- Add culture youghurt sample to the milk in small amount in 60 ^{0}C temperature and mix well.
- Put the mixture into plastic cups.
- Keep the mixture for 6 - 7 hours in the temperature between 40 ^{0}C - 45 ^{0}C.
- Cover the cups and keep in the refrigerator (under 4 ^{0}C).

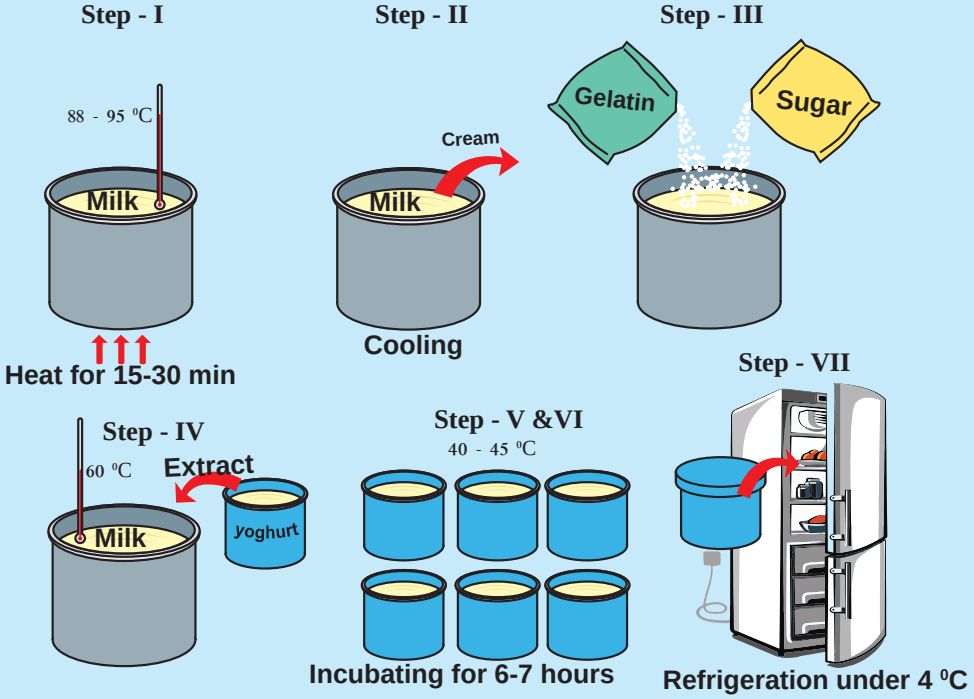


Figure 1.6

When boiling, unfavourable bacteria in milk get destroyed. *Lactobacillus* and *Streptococcus* are used as culture in producing yoghurt. They turn Lactose into Lactic acid. Since it creates an acidic medium, growth of other micro-organisms get retarded and enhance preservation. Refrigerating further retards bacterial growth.

Figure 1.7 - Dairy products (yoghurt, curd, cheese, butter)

- **Products based on plant fibres**

Plant fibres are used for various products and these fibres are separated by using bacteria. Coconut, hemp, palmyrah and agave plants are used to get fibre. The compound pectate which is among the fibres keep them bound together. The Pectinase enzyme which is produced by the relevant bacteria helps to separate these fibres by digesting pectate.

Figure 1.8 - Crushing coconut husks

Applications of micro-organisms in environmental conservation

Micro-organisms are commonly used for environmental conservation. The technology used to remove environmental pollutants using micro-organisms is known as **bio-remediation**.

Following are some instances where bio-remediation is applied.

- Microbes are used to decompose the organic waste matter in polluted water.
- *Pseudomonas*; a kind of a bacteria which is released on to the ocean water for the decomposition of oil layers on the ocean. An enzyme released by these micro-organisms decomposes the hydrocarbons in oil.
- Heavy metals such as Chromium (Cr), Lead (Pb) and Mercury (Hg) are released to the environment from different industries. This polluted water is sent through a tower which contains bacteria to remove these toxic heavy metals from water.
- In producing bio-degradable plastics (plastics that are decomposed by bacteria)

We have discussed the favourable impacts of micro-organisms. Based on the following features, micro-organisms are used in economically important large-scale productions.

- Their biological processes occur very rapidly as their growth rate and metabolic rate is high.
- Various strains/varieties of microbes exist that are capable of acting and multiplying on various substances.
- Since micro-organisms possess simple genes, they can be easily used for genetic engineering. Hence, microbes are often used for modern genetic engineering.
- The majority of micro-organisms can be obtained at very low rates or free of charge from the environment to use in industries.
- Though, large amount of energy is required for other industries, a small amount of energy is required for industries using microbes.
- Though, most of the industries cause heavy environmental pollution and serious environmental deterioration, the industries with microbes cause minimal environmental damages.

Assignment 1.3

Gather information regarding the applications of micro-organisms in environmental conservation. Prepare an article to present in the wallpaper.

1.3.2 Adverse effects of micro-organisms

Causing diseases for man, plants and animals that are economically important for man, food spoilage and economical damage to non-living surfaces are several adverse effects of microbes. Biological weapons are another instance where man uses microbes adversely.

Causing diseases

Bacteria, viruses, fungi and protozoa are the groups of micro-organisms that cause diseases. A micro-organism that has the potential to cause a disease is called a **pathogen**. Mosquitoes and flies are **vectors** which carry the pathogen to the host. **Host** is an organism, who provides its body inside or outside as the substrate to growth of the pathogen.

e.g. Viruses act as the pathogen for Dengue disease, while mosquitoes are the vectors. Symptoms appear on man, who is the host.

• Diseases caused by micro-organisms to human

Microbial infections spread by air, water, food, contact, vectors etc. Pathogenic micro-organisms cause different infections to human beings through various methods. Information of such infections is given in table 1.2.

Table 1.2 - Information of diseases caused by micro-organisms to human

Pathogen	Disease	Method of spread	Way the pathogen enters the body
Viruses	Cold	Air	Through respiratory system
	Dengue	Mosquito vectors	Through the skin by mosquito bites
	AIDS	Blood and other fluids of an infected person	Through sexual contacts or blood transfusion
Bacteria	Tuberculosis	Air	Through respiratory system
	Typhoid fever	Polluted food and vectors such as housefly	Through digestive system with food
Protozoa	Malaria	Mosquito (vectors)	Through the skin by mosquito bite
	Amoebic dysentery	Polluted water and food	Through digestive system
	Leishmaniasis	Vectors such as sandfly	Through open wounds on the skin
Fungi	Pityriasis	Contact of an infected person or through clothes of an infected person	Through skin
	Rashes		

* The bacterium *Bacillus thuringiensis* is used as a biological control to destroy the larval stages of dengue mosquitoes.

For extra knowledge

Leishmaniasis is a disease caused by a protozoan. It is spread by the bite of Sandfly which acts as the vector. The protozoan can enter through skin ulcers. Then, it infects the skin, mouth and nasal path. Skin ulcers, fever, reducing red blood cells and enlarging liver are symptoms of leishmaniasis.

• Diseases caused by micro-organisms to plants

Some of the diseases caused by micro-organisms to plants are given below.

Powdery mildew disease

Powdery mildew is a disease caused by a fungus. The leaves, stem, flowers and fruits of the plant are affected by this disease. Appearing of white or gray colour powdery material is the main symptom of infected parts. This disease can damage every part of the tree (figure 1.9).

Late blight

Potato plant is commonly affected by this disease which is caused by a fungus. Brown spots can be seen on the leaves and later they turn into black. Then, the whole tree gets affected by the disease (figure 1.10).

Wilting

Fungi or bacteria cause this disease. The xylem of the plants which transports water throughout the tree gets affected from this disease. Later the xylem does not function properly due to damage. Therefore, the whole plant gets withered due to poor supply of water (figure 1.11).

Figure 1.9 - Grapes with powdery mildew disease

Figure 1.10 - Potato plant with late blight

Figure 1.11 - Tomato plant with bacterial wilt

Food spoilage caused by micro-organisms

Micro-organisms multiply on food as food has the necessary factors for the growth of micro-organisms. Micro-organisms convert the components of the food into unfavourable materials or they add toxic materials to food. Due to this reason the nature of the food is changed. The change of physical and chemical nature of food makes the food unfit for consumption. This process is known as food spoilage.

(You have learnt about food spoilage such as fermentation of carbohydrates, putrefaction of proteins and rancidity of lipids in grade 8).

Figure 1.12 - Food spoilage caused by micro-organisms

For extra knowledge

Changes in food when spoiled

Physical changes
- Food becomes soft
- Change of the colour
- Change of the taste
- Change of the odour

Chemical changes
- Fermentation of Carbohydrates
- Putrefaction of Proteins
- Rancidity of Lipids

Factors affecting food spoilage

Internal factors
- Amount of nutrients
- Moisture
- Biological structure of the food

External factors
- Environmental temperature
- Environmental humidity
- Gases available in the atmosphere

Applications of micro-organisms as biological weapons

The toxins produced by micro-organisms or harmful pathogenic bacteria or viruses which, are used for military purposes, are known as **biological weapons**.

Bacillus anthracis, the causative agent of Anthrax disease, is considered as the most harmful biological weapon at present. These biological weapons are very much harmful to human, other animals and plants.

Assignment 1.4

Conduct a debate under the following topic regarding micro-organisms

- **Proposing team -** Micro-organisms are mostly useful to the living beings.
- **Opposing team -** Micro-organisms are mostly harmful to the living beings.

Summary

- Micro-organisms are unicellular or multicellular organisms which cannot be seen clearly with the naked eye.
- The main micro-organism categories are bacteria, fungi, algae and protozoa.
- Viruses have living and non-living characteristics but, they are also studied in microbiology.
- Micro-organisms live within all the eco-systems with favourable environmental conditions and even under the extreme environmental conditions.
- Micro-organisms are used in various fields such as agriculture, medicine, industries and for environmental conservation as well.
- Food spoilage, diseases, damage done to the economically important surfaces and use of micro-organisms as biological weapons are some adverse effects of micro-organisms.

Exercise

01) Select the correct or most suitable answer.

1. A group of autotrophic micro-organisms is,
   1. viruses 2. fungi 3. algae 4. protozoa
2. Toxic chemicals produced in the body of a microbe to destroy or sabotage an another micro-organism is called as,
   1. antibodies 2. anti nutrients 3. antiseptics 4. antibiotics
3. Some characteristics of viruses are given below.
   a. No cellular organization
   b. Multiply only in living cells
   c. Do not show the living characteristics such as respiration and growth
   The correct statements of the above are;
   1. a and b 2. a and c 3. b and c 4. a, b and c
4. A disease caused by bacteria is,
   1. Malaria 2. Tuberculosis 3. Rabies 4. Ebola
5. The technology used to remove the environmental pollutants by applying micro-organisms is known as,
   1. bio-control 2. bio-degradation
   3. bio-remediation 4. bio-leaching

02) State whether the following statements are true (√) or false (x).

1. Antibiotics are any chemical substance that is used to destroy or deactivate micro-organisms. ( )
2. The vaccine given for tetanus contains weakened bacterial toxins. ( )

3. Viruses are pathogens that display both living and non-living characteristics. ( )
4. Most microbes in the environment are unfavourable to living beings. ( )
5. *Rhizobium* bacteria found in the root nodules of legume plants fix atmospheric nitrogen. ( )

03) Answer the following questions.

1. Name three industries based on microbial activity.
2. Explain two instances where micro-oraganisms are used in the medical field.
3. Mention three instances where microbes are used in environmental conservation.
4. Write three good health habits that could minimize infections caused by micro-organisms.
5. State three strategies used in agriculture to minimize infections caused by micro-organisms.

Technical Terms

Micro-organism	- ක්ෂුද්‍ර ජීවියා	- நுண்ணங்கி
Microbiology	- ක්ෂුද්‍ර ජීව විද්‍යාව	- நுண்ணுயிரியல்
Substrate	- උපස්තරය	- கீழ்ப்படை
Industrial microbiology	- කාර්මික ක්ෂුද්‍ර ජීව විද්‍යාව	- கைத்தொழின்முறை நுண்ணுயிரியல்
Nitrogen fixation	- නයිට්‍රජන් තිර කිරීම	- நைதரசன் பதித்தல்
Organic food	- කාබනික ආහාර	- சேதன உணவு
Bio pesticides	- ජෛව පළිබෝධනාශක	- உயிரியற் பீடை நாசினிகள்
Antibiotics	- ප්‍රතිජීවක	- நுண்ணுயிர்க் கொல்லிகள்
Biogas	- ජීව වායුව	- உயிர் வாயு
Bio-leaching	- ජෛව ක්ෂීරණය	- உயிரியல் நீர்முறையரிப்பு
Bio-remediation	- ජෛව ප්‍රතිකර්මණය	- உயிரியல் பரிகரிப்பு
Food spoilage	- ආහාර නරක් වීම	- உணவு பழுதடைதல்
Biological weapons	- ජෛව රසායනික අවි	- உயிரியல் ஆயுதங்கள்
Immunization	- ප්‍රතිශක්තිකරණය	- நீர்ப்பீடனமாக்கல்
Genes	- ජාන	- பரம்பரையலகுகள்
Antitoxins	- ප්‍රතිවිෂ	- தொட்சினெதிரி
Bio-degradation	- ජෛව හායනය	- உயிரியல் ரீதியாக பிரிந்தழிகையடைக்கூடிய
Pathogen	- ව්‍යාධිජනකයා	- நோயாக்கி
Vector	- වාහකයා	- நோய்க் காவி
Host	- ධාරකයා	- விருந்து வழங்கி

2 Eye and Ear

Our environment is subjected to frequent changes. Our eyes, ears, nose, tongue and skin perceive these changes that occur in our environment. Let us study about the structure and functions of the eye and the ear.

2.1 Structure and function of the human eye

The eye is the optical sensory organ in our body. Let us take a look at the structure of the eye to study how we see things.

Activity 2.1

You will need :- A model of the eye in the laboratory or a diagram

Method :-

- Observe the eye model or the diagram well.
- Identify the parts of the eye.
- Get the help of a labelled diagram of the eye.

Figure 2.1 - A model of the eye

A cross section of human eye is given in the figure 2.2.

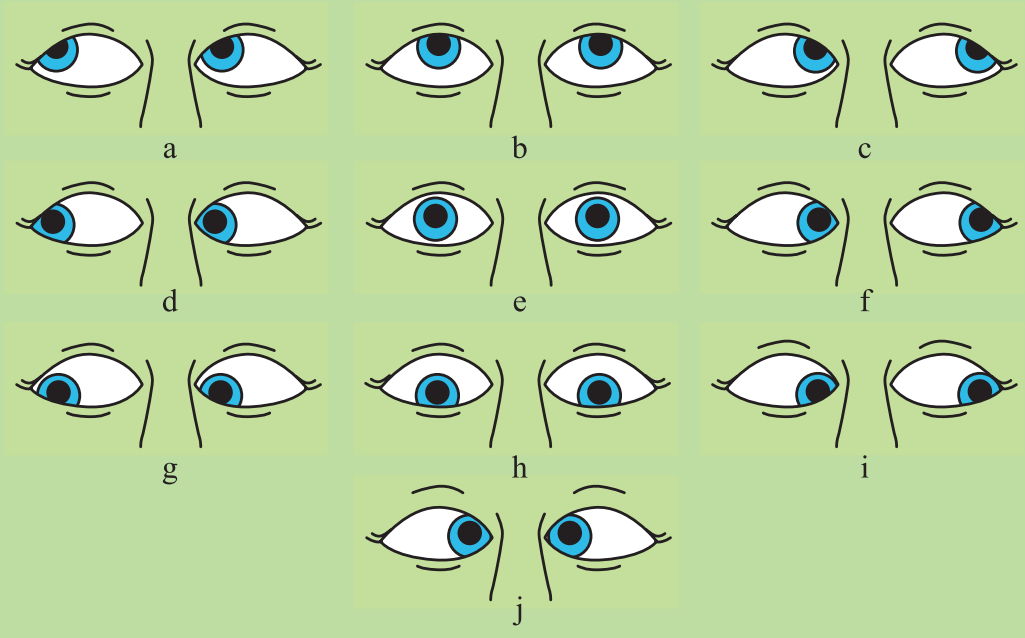
Figure 2.2 - A cross section of human eye

Eyes are located inside the orbits in the skull (figure 2.3). Eye is fixed with six eye muscles in to the orbit (figure 2.4).

Figure 2.3 - Location of eye inside the orbit **Figure 2.4 - Connection of eye with eye muscles**

Therefore, eye ball can move in vertical plane, horizontal plane and circular plane.

For extra knowledge



In b, e, h instances - eye ball can be moved in vertical plane.
In d, e, f instances - eye ball can be moved in horizontal plane.
In a, d, g, h, i, f, c, b, j instances - eye ball can be moved in circular plane.

Hence, human eye has gained the ability of seeing a broad area. This is called as **"widening of the optic region."**

The table 2.1 shows the information about the main parts of the eye.

Table 2.1 - Information about the major parts of the human eye

Structural Part	Information
Sclerotic layer	▪ Tough, white outer most layer of the eye ▪ Light do not penetrate through it.
Cornea	▪ The sclerotic layer in front of the iris becomes thin, transparent and forms the cornea
Choroid	▪ Inside the sclerotic layer is the choroid ▪ Supplies blood to the eye
Retina	▪ Inside the Choroid layer is the retina ▪ The light sensitive rod cells and cone cells are located in this layer.
Aqueous humour	▪ A transparent watery liquid. ▪ Fills the space between the lens and cornea.
Lens	▪ Transparent biconvex lens that has the ability to change its curvature ▪ Focuses the images on retina.
Iris	▪ Controls the amount of light entering the eye
Pupil	▪ The hole in the centre of the iris. ▪ It allows light to enter and pass through the lens.
Ciliary muscle	▪ Supports to hold the lens ▪ Helps to change the curvature of the lens, when necessary.
Vitreous humour	▪ A transparent Jelly-like substance, which fills the rear cavity of the lens. ▪ Helps to maintain the spherical shape of the eye.
Fovea/Yellow spot	▪ The sensitive part of the retina, where the sharp images formed.
Blind spot	▪ The area of the retina, where light sensitive cells are not located. ▪ Though, light is focused no vision is possible.
Optic nerve	▪ The nerve that connects the eye and the brain. ▪ Convey the visual stimulus from the retina to the brain for the interpretation of the image.

Let us see how the eye perceives visionary senses.

Let us inquire the way that our eye functions to give us sight. To see an object clearly, light rays must be entered to the eye from the object. The rays refract through the lens and converge on to the retina, forming an inverted image. Then, the nerve endings on the retina get stimulated and send the message about the image to the brain through optic nerve. Optical area of brain interpret it as an upright image.

Eye lens is convex. Let us engage in the activity 2.2 to study the refraction of light through convex and concave lenses.

Activity 2.2

You will need :- A convex lens, a concave lens, a parallel beam of light made by using a torch or by reflecting the sunlight using a mirror, a comb

Method :-

- Let the parallel beam of light fall on the convex lens and observe the refracted rays.
- Let the parallel beam of light fall on the concave lens and observe the refracted rays.
- Draw the path of the light in both situations in your note book.

The path of a parallel beam of light directed towards a convex lens after refracting through the lens is depicted in the figure 2.5. After refraction the light rays get converged to a point.

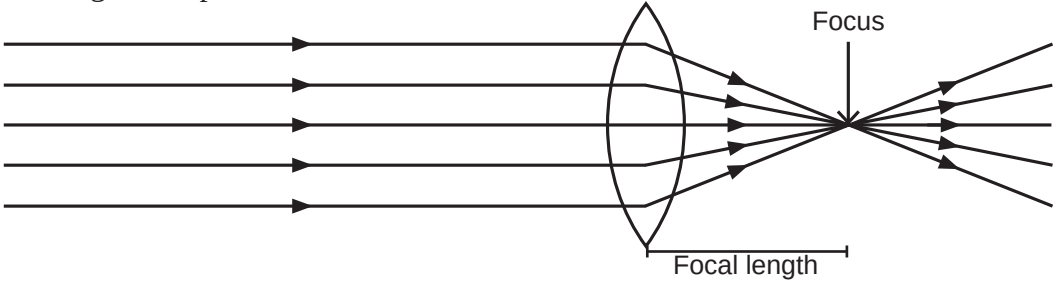


Figure 2.5 - Refraction of parallel beam of light through convex lens

The point that collects light rays in front of a convex lens is called the focal point of the lens. The distance between lens and focus is **focal length.**

A parallel beam of light falls on a concave lens after refraction through the lens get diverged as in the figure 2.6.

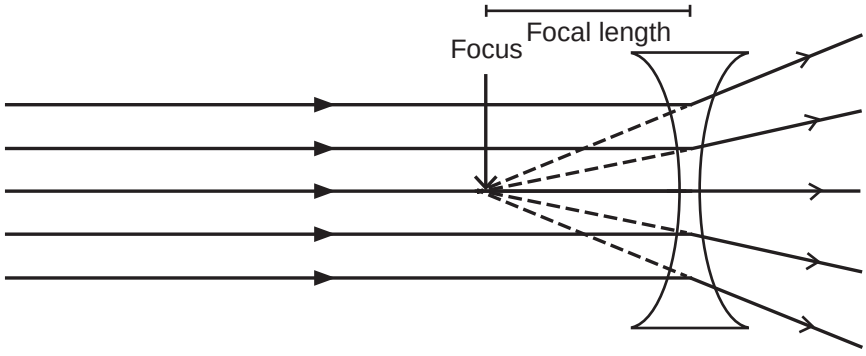


Figure 2.6 - Refraction of parallel beam of light through concave lens

After the refraction, the light rays can be observed to be diverged, as shown in figure 2.6. Here the rays after refraction appear to come from a point called focus.

An image of an close object forms far from the convex lens, while far object forms an image, close to the lens. Let us engage in activity 2.3 to study this concept.

Activity 2.3

You will need :- A convex lens, a candle, a box of matches, lens holder, a screen (you can prepare a screen by covering a lens holder or a small box with a white paper)

Method :-

- Fix the convex lens to the lens holder. Using the lens get a clear image of a distant object on the screen.
- Light the candle in front of the lens and get a clear image on the screen.
- Measure the distance between the lens and the image (image distance) in both cases, and compare.

You can confirm that the image distance is more when the object is located close by than it is located far away.

But, considering the eye, the distance from the lens to the retina (image distance) cannot be changed. Then, how can we clearly see the objects close by and far away? The lens of the eye has the ability to increase or decrease its curvature to the required size.

Let us do the activity 2.4 to study about the image formation of a distant object and nearby object without changing the image distance.

Activity 2.4

You will need :- A convex lens with a less curvature, another convex lens with a higher curvature, candle, lens holder, screen

Method-

- Fix the convex lens with less curvature to the lens holder and get a clear image of a distant object on to the screen (figure 2.7 a).
- Fix the convex lens with a higher curvature to the lens holder without changing the distance between the lens and the screen. Now get a clear image of the lit candle on to the screen (figure 2.7 b).

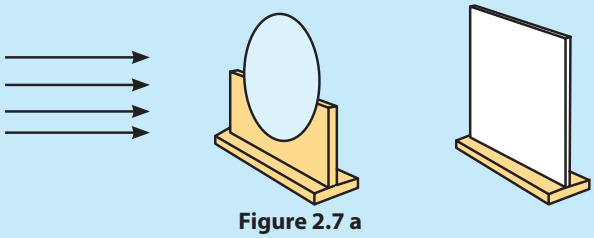


Figure 2.7 a

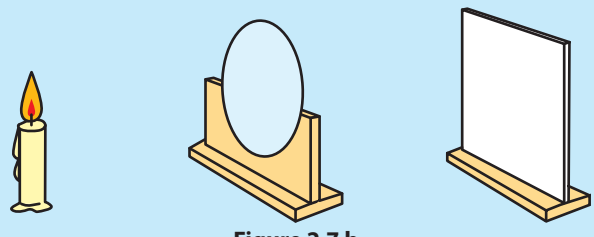


Figure 2.7 b

The focal length is comparatively high in low-convex lenses (lens with a less curvature) while the focal length is relatively low in higher convex lenses (lenses with a higher curvature).

Figure 2.8 a - Convex lens with less curvature

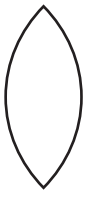


Figure 2.8 b - Convex lens with high curvature

Figure 2.8

According to the activity 2.4 it can be concluded as follows.
To get a clear image without changing the image distance,

- The curvature of the eye lens should be reduced for a distant object.
- The curvature of the eye lens should be increased for a close object.

Assignment 2.1

Make a water lens using necessary items.

By increasing or decreasing the curvature of the lens, get clear images of a lit candle placed in different places, without changing the image distance.

- **Ray diagram for an image formed from a far object on the retina of eye (figure 2.9).**

The rays that reach from the far object, can be considered as parallel rays.

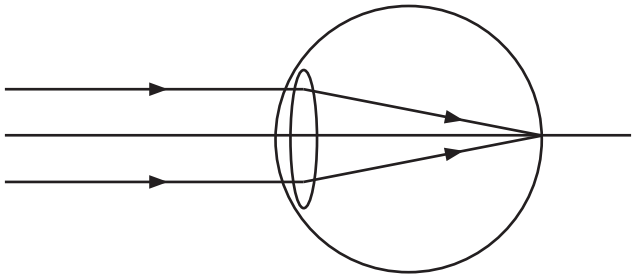


Figure 2.9

The rays that reach the eye from the far object, get refracted through the lens and converged onto the retina making an image on it.

- **Ray diagram for an image formed from a close object on the retina of eye (figure 2.10).**

The rays that reach from the close object, can be considered as diverged rays.

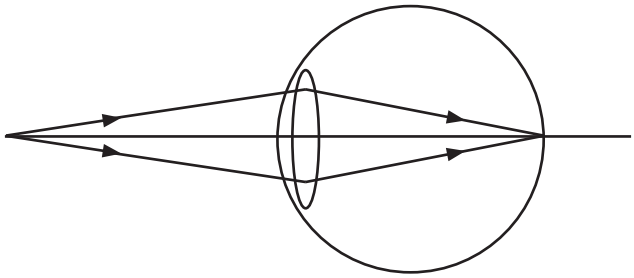


Figure 2.10

The rays that reach the eye from the close object, get refracted through the lens and converged onto the retina making an image on it.

2.2 Defects of vision

Two eye defects can be identified in vision, when the eye ball becomes short or long and when eye is unable to adjust the focal length of its lens to the desired level.

- Long sight (hypermetropia)
- Short sight (myopia)

Long sight (hypermetropia)

A person having this defect is able to see far objects clearly, but close objects become unclear. This happens because of the inability to increase the curvature of the eye lens or the eye ball being too short. This defect can be corrected by using a convex lens.

Let us look at how the vision of a person suffering from long sight takes place.

- The person can focus the rays coming from a distant object on the retina to form a sharp image. So, that he can see distant objects clearly (figure 2.11).

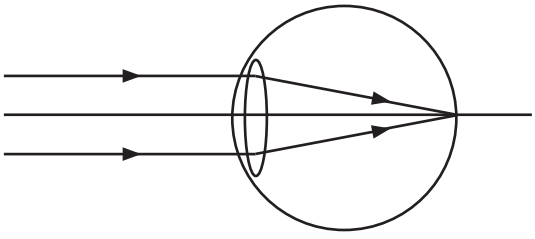


Figure 2.11

- The light rays from the nearby object cannot be brought to focus on the retina to give a distinct image. In this case the image is formed behind the retina, as the rays get focused behind the retina (figure 2.12).

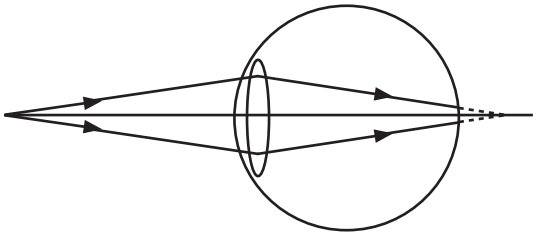


Figure 2.12

Correcting the long sight

- This defect can be corrected by using a convex meniscus lens. The convex meniscus lens receives the light rays and converge them. The eye lens converges the rays again to focus the image at the retina.

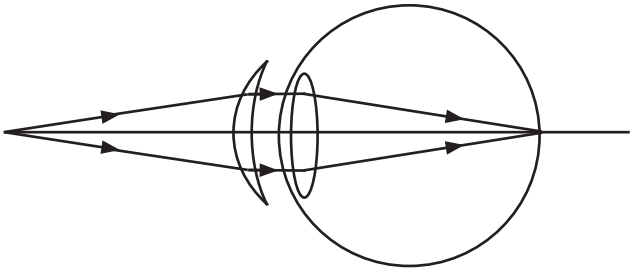


Figure 2.13 - Long sight and its correction

Let us do the activity 2.5 to understand what happens after long sight is corrected.

Activity 2.5

You will need :- Two convex lenses, a candle, a screen

Method :-

- Using one convex lens get a clear image of a distant object on the screen.

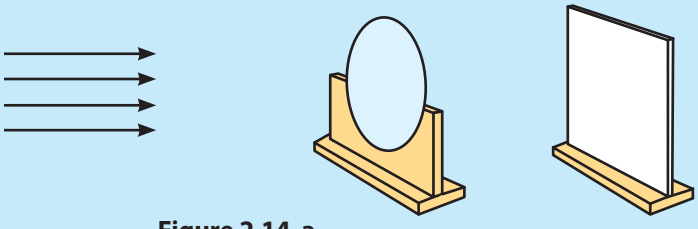


Figure 2.14 a

- Get a clear image of a somewhat far object on the screen.

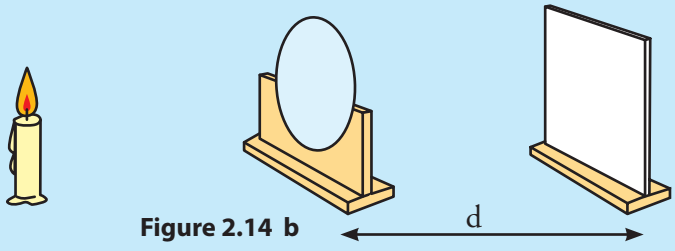


Figure 2.14 b

- Light the candle in front of the lens **without changing the distance between the lens and the screen.** Observe the blurred image.

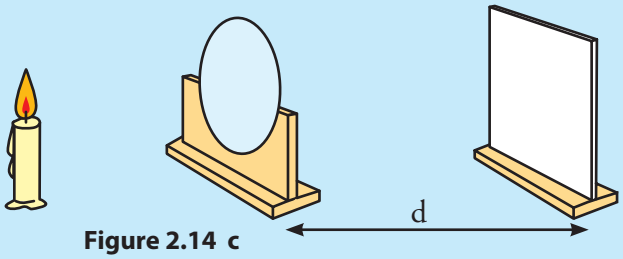


Figure 2.14 c

- Place the other convex lens between the first lens and the screen. Move it until a clear image of the candle is focused on the screen.

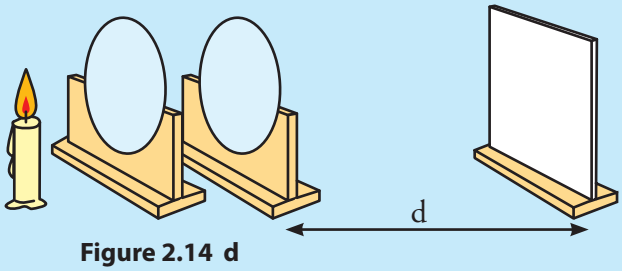


Figure 2.14 d

From the activity 2.5 you can understand that, when nearby objects cannot be seen clearly, convex lenses can be used to make the image clear.

Short sight (myopia)

A person sees nearby objects clearly while distant objects appear blurred. This defect arises because of the inability to reduce the curvature of the eye lens or due to the elongation of the eye ball. This defect can be corrected by using a concave lens.

Let us look at how the vision of a person suffering from short sight takes place.

- The rays coming from close objects can be focused on the retina. So, the close objects can be seen clearly (figure 2.15).

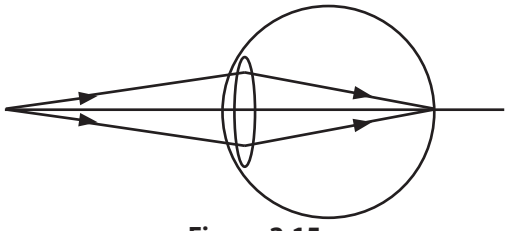


Figure 2.15

- The rays coming from distant objects are focused in front of the retina. So, the image of a distant object is formed in front of the retina and cannot be seen clearly (figure 2.16).

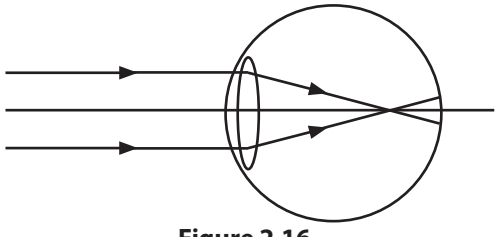


Figure 2.16

Correcting the short sight

- This defect can be corrected by using concave meniscus lenses. The rays from the object are diverged through the concave meniscus lens and the eye lens converge them to a point on retina to make the image clear.

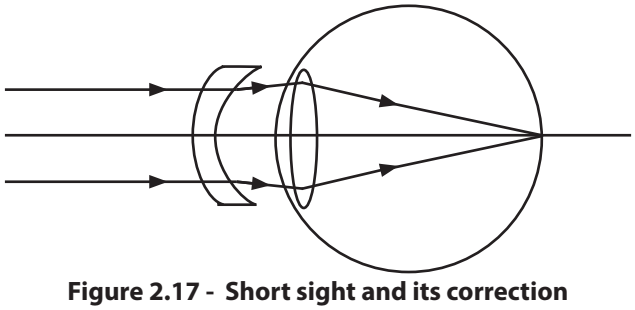


Figure 2.17 - Short sight and its correction

Let us do the activity 2.6 to understand what happens after correcting the short sight.

Activity 2.6

You will need :- A convex lens, a concave lens, candle, screen

Method :-

- Light the candle in front of the convex lens and get a clear image of it on the screen.

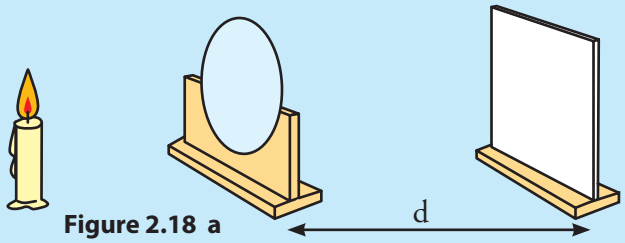


Figure 2.18 a

- When the candle is kept far away without changing the distance between the lens and the screen (distance "d"), we can get a blurred image of a distant object on the screen.

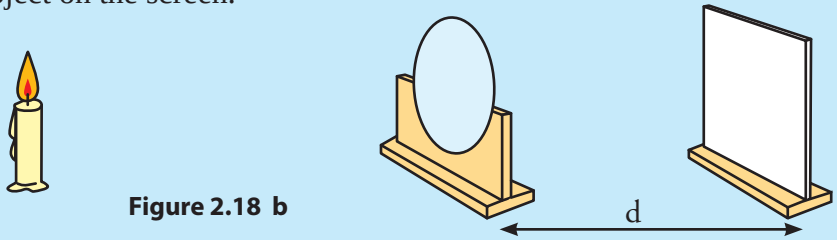


Figure 2.18 b

- Place a concave lens in front of the convex lens and move it till a clear image of the candle is formed on the screen.

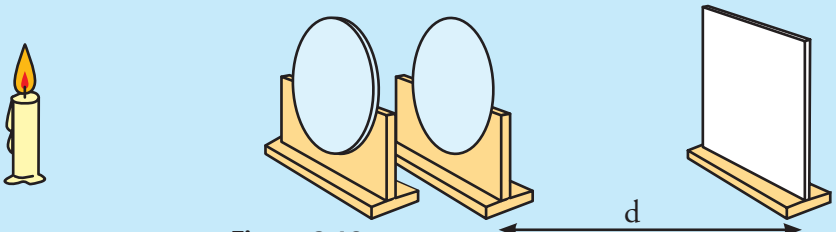


Figure 2.18 c

From the activity 2.6 it can be understood that when distant objects cannot be seen clearly, concave lenses can be used to get a clear image of a distant object.

Binocular vision and stereoscopic vision

The eyes of human, monkey, 'Rilava'/'Mandi', chimpanzee, gorilla and loris are located in front position of the skull (figure 2.19). So, there is a greater chance of seeing the same area with both eyes.

Human Monkey 'Rilava' / 'Mandi'

Chimpanzee Gorilla Loris

Figure 2.19

Mammals such as cattle, dog, tiger have no ability to look at the same area using both eyes (figure 2.20). But, they have the ability to look more areas separately using the each eye.

Cattle Dog Tiger

Figure 2.20

The ability to maintain visual focus on an object with both eyes creating a single visual image, is known as **binocular vision.** The human has a broader range of a binocular vision.

The range of binocular vision of man The range of binocular vision of dog

Figure 2.21

Let us do the activity 2.7 to identify your range of binocular vision.

Activity 2.7

Method :-

- Keep the face straight and look forward.
- Do the following things without moving the face.
- Stretch your hands and fold your fingers.
- Straighten the thumb right upwards.
- Close your left eye and move your left hand in the horizontal plane to the left until you cannot see the thumb.
- Keep the left hand in the same position and close your right eye. Now move your right hand in the horizontal plane to your right until you can't see the thumb.
- Now look at both thumbs using the both eyes.

Your eyes can see the objects which lie in the range of the stretched hands. It is your binocular range. But, when both eyes are open, the objects seen to the left of the left hand can be seen only by the left eye. Similarly the objects to the right of the right hand can be seen only by the right eye.

Due to the binocular vision human has got the **stereoscopic vision** and the ability to determine the distance of an object. stereoscopic vision means the ability of eye to determine the depth of an object or the height of it. Let us do the activity 2.8 to study this further.

Activity 2.8

You will need :- A ball point pen

Method :-

- Hold the clip of the pen keeping its hole upwards in a distance when you stretch the hands to your front.
- Close one eye and insert the pen into the clip.
- Insert the pen again into the clip using both eyes.
- Compare the difference of ease, in both situations.

It is easier to insert the pen into the clip by seeing through both eyes rather than seeing through one eye. This is because of the stereoscopic vision of the eye.

2.3 Eye diseases

Two common eye diseases identified at present are;

- Cataract
- Glaucoma

Cataract

A cataract is a cloudiness or opacity in normally transparent crystalline lens of the eye. It happens because of the denaturing of proteins in the eye lens. Then, eye lens turns in to milky colour.

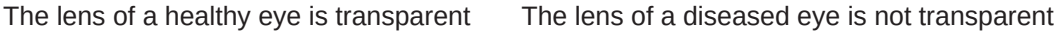


Figure 2.22

Cataract prevents the light rays coming from an object focusing properly on the retina. Then, all the objects are seen blurred.

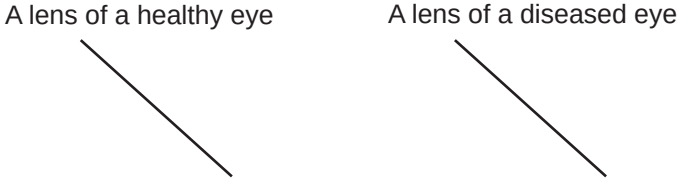


Figure 2.23

A healthy eye sees an object clearly The diseased eye sees the objects blurred

Figure 2.24

Generally, cataract may occur with age and genetic factors. It is believed that ultra violet rays reach the Earth through holes of the ozone layer affect towards the occurrence of cataracts in eye.

Glaucoma

Glaucoma is a disease that gradually reduces the visual range of the eye and leads to blindness due to the damage of the optic nerve. By detecting at the first stage further increase of glaucoma can be controlled. Glaucoma is usually the result of high blood pressure inside the eye. A person with diabetes has an increased risk of developing glaucoma. The damage caused to the eye from this disease cannot be reversed again.

The figures A, B, C and D shows how a glaucoma patient loses his vision gradually.

A B

C D

A - healthy eye sees the objects clearly

B - first stage of glaucoma

C - middle stage of glaucoma

D - final stage of glaucoma (leads to vision loss or blindness)

Figure 2.25

Eye infections

In addition to above mentioned diseases, eyes can be infected by viruses. Reddening of eye and secretion of tears are the symptoms. The disease spreads through insects ('Konduruwa') and by contact. This condition is known as "sore eyes". It can be cured by medical treatments (figure 2.26).

Precautionary measures should be followed to prevent health problems and possible defects of the eye. Such precautions are given below.

Figure 2.26

- Protect your eyes from harmful light rays
- Do not look at the sun directly at a solar eclipse and necessary safety methods should be used to look at the sun in such situations
- Be sure to wear safety glasses when do welding
- Do not use eye drops or any other liquids into the eye without medical advice
- Do not use someone else's spectacles
- When using sun glasses follow medical advices
- Should care for personal hygiene
- Do not watch television or use computers continuously and follow relevant precautionary measures.

2.4 Structure and function of the human ear

Audio sensory organ of the body is the ear. Let us take a look at the structure of the ear.

Activity 2.9

You will need :- A model of the human ear in the laboratory or a diagram

Method :-

- Observe the model or the diagram well.
- Identify the parts of the human ear.
- Get the help of a named diagram of the human ear.

Figure 2.27 - A model of the human ear

A diagram of the human ear is given by figure 2.28.

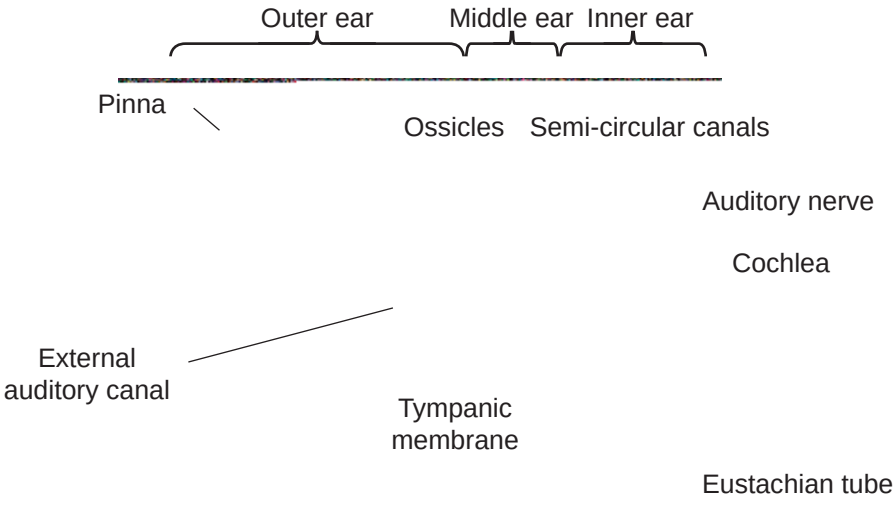


Figure 2.28

Information about the major parts of the human ear is given in the table 2.2.

Table 2.2 - Information about the major parts of the human ear

Area	Part of the organ	Information
Outer ear	Pinna/ear lobe	• A cartilaginous organ • Directs sound waves towards the auditory canal
	External auditory canal	• Directs the sound to tympanic membrane
	Tympanic membrane	• Vibrates in response to the sound wave and acquires the auditory senses
Middle ear	Ossicles	• Three bones named malleus, incus and stapes • Transmit sound related vibration to the cochlea
	Eustachian tube	• An open tube connected to pharynx • Controls the pressure on either sides of the tympanic membrane
Inner ear	Cochlea	• The nerve endings of the auditory nerve is connected to cochlea • Transmit auditory senses to the auditory nerve
	Auditory nerve	• Take auditory senses to the relevant part of the brain • That sound is interpreted by the relevant part of the brain
	Semi-circular canals	• Contribute to maintain the balance of body

Let us see how the ear perceives auditory senses.

Do the activity 2.10 to demonstrate how a membrane is vibrated according to a sound.

Activity 2.10

You will need :- Two funnels, sheath of a balloon, 2m length rubber tube, a thread, a tuning folk

Method :-

- Tighten well the balloon sheath to the mouth of a funnel.
- Join the two funnels to the open ends of the 2m length rubber tube.
- Keep the funnel with the balloon sheath to one of the student's ear and vibrate the tuning folk near the other funnel.
- Report your observations.

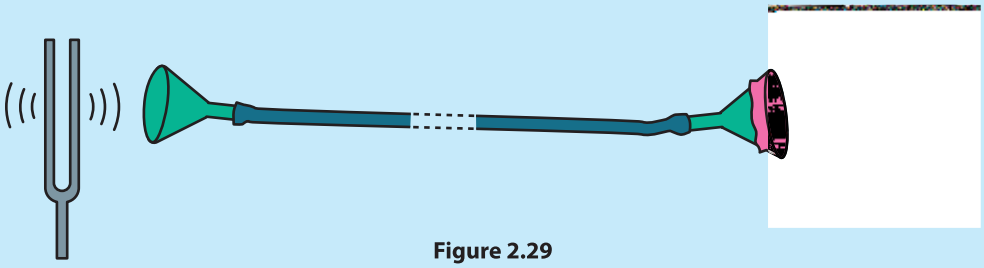


Figure 2.29

When the folk is vibrated the rubber sheath too vibrates and the sound is better heard. Similarly, correspond to the sound wave the tympanic membrane vibrates.

The sound waves created by the vibrations of the objects in the external environment, travels to tympanic membrane along the external auditory canal. The tympanic membrane is vibrated accordingly. The vibrations are then transmitted to cochlea through ossicles. The nerve endings connected to cochlea take the auditory senses to the auditory nerve. The auditory nerve transmits the impulse to the relevant part of the brain. The sound is interpreted by the auditory area of the brain.

2.5 Defects of ear

Disorders such as impaired hearing, deafness, hardening of ossicles may occur in ears while living or from the birth. It is also said that people who are deaf from birth are dumb too. Hearing aids can be used as a remedy for loss of hearing.

You know that 20 Hz - 20 000 Hz is the audible range of the human ear. There is also a limited intensity of sound in this range that the ear can tolerate. Sounds beyond that range can damage the ear.

Necessary precautions should be taken to protect the ear.

- Avoid inserting foreign objects into the ear
- Refrain exposing to loud noises
- Do not put any medicines for the ear without medical advice
- Avoid diving in deep waters without wearing safety equipment (As pressure is very high in deep water)
- Avoid slapping on the ear and dragging by the ear lobe

Figure 2.30

Assignment 2.2

- Using suitable materials, make a model of a stethoscope.

Figure 2.31

Assignment 2.3

- Prepare ten short questions on eye and ear to conduct a quiz competition.

For extra knowledge

	Sound pressure level dB(A)
Jet Engine	Threshold of pain
	Jackhammer
Live rock music	
	Heavy truck
Street Traffic	
	Business office
Conversational speech	
	Living room
Bedroom	
	Woodland

Summary

- Optical sensory organ of the body is the eye.
- Images that are real, inverted and smaller than the object formed on the retina are interpreted by the brain. This is known as vision.
- Binocular vision of human is important to determine the distance of an object and stereoscopic vision.
- The most common defects of vision are long sight and short sight.
- Long sight can be corrected by using a convex lens while short sight can be corrected by using a concave lens.
- Most frequent eye diseases at present are cataract and glaucoma.
- To maintain a healthy vision for a long period of time, necessary precautions should be taken to protect the eye.
- Audio sensory organ of the body is the ear.
- Sound waves vibrate the tympanic membrane and the cochlea in the ear. This results the stimulation of the nerve endings at the cochlea.
- This auditory impulse is carried to the brain by the auditory nerve and the relevant part of the brain interpret the sound. This is known as hearing.
- The semi-circular canals contribute to maintain the balance of the body.
- Hardening of ossicles, impaired hearing and deafness are some disorders of hearing.
- The range of audibility of the human ear is between 20 Hz - 20 000 Hz.
- The sounds of higher intensities may damage the ear.
- Necessary precautions must be followed to protect the ear.

Exercise

01) Select the correct or most suitable answer.

1. The part that an image focuses on the human eye is,
   1. Vitreous humour
   2. Eye lens
   3. Iris
   4. Retina

2. The defect that close objects can be seen clearly, but distant objects can be seen blurred is,
   1. Long sight
   2. Glaucoma
   3. Cataract
   4. Short sight

3. The organ in the ear that maintain the balance of body is,
   1. Cochlea
   2. External auditory canal
   3. Ossicles
   4. Semi-circular canals

4. Following are some statements that a student wrote about the ear and its functions.

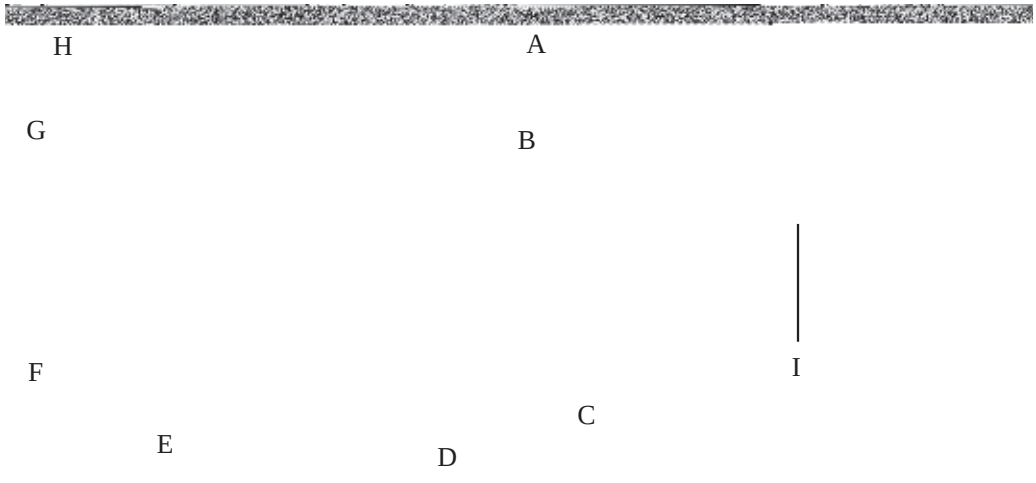
a. Ear lobes are cartilaginous.
b. Cochlea transmits auditory senses to the auditory nerve.
c. Ossicles are located in the external auditory canal.

1. a and b only
2. b and c only
3. a and c only
4. a, b and c all

5. The range of audibility of the human ear is,

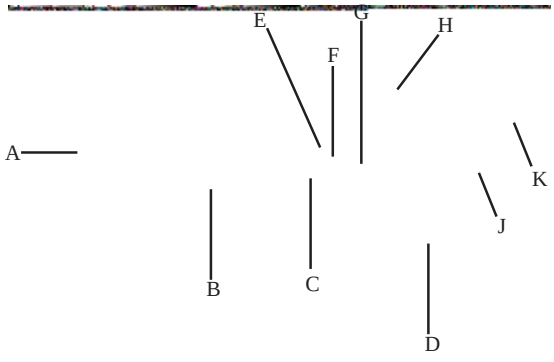
1. **2** Hz - **20 000** Hz
2. **20** Hz - **20 000** Hz
3. **20** Hz - **200 000** Hz
4. **200** Hz - **20 000** Hz

02) Following figure shows the structure of the human eye.



Write down the names and functions of each part in the eye denoted by English letters A to H.

03) Using given English letters, mention the path of the auditory impulse that start from ear to the brain.



Technical Terms

Long sight	-	දුර දෘෂ්ටිකත්වය	-	சேய்மைப் பார்வை
Short sight	-	අවිදුර දෘෂ්ටිකත්වය	-	அண்மைப் பார்வை
Binocular vision	-	ද්විනේත්‍රික දෘෂ්ටිය	-	இருவிழிப்பார்வை
Stereoscopic vision	-	ත්‍රිමාණ දෘෂ්ටිය	-	முப்பரிமானப் பார்வை
Retina	-	දෘෂ්ටිවිතානය	-	விழித்திரை
Optic nerve	-	දෘෂ්ටික ස්නායුව	-	பார்வை நரம்பு
Cornea	-	ස්වච්චය	-	விழிவெண்படலம்
Iris	-	තාරාමණ්ඩලය	-	கதிராளி
Pupil	-	කණිනිකාව	-	கண்மணி
Fovea	-	කහ ලපය	-	மஞ்சளிடம்
Blind spot	-	අන්ධ බින්දුව	-	குருட்டிடம்
Convex lens	-	උත්තල කාචය	-	குவிவு வில்லை
Concave lens	-	අවතල කාචය	-	குழிவு வில்லை
Cataract	-	ඇසේ සුද	-	கட்காசம்
Glaucoma	-	ග්ලූකෝමාව	-	குளுக்கோமா
Tympanic membrane	-	කර්ණපටහ පටලය	-	செவிப்பறை மென்சவ்வு
Cochlea	-	කර්ණ සංඛය	-	நத்தைச்சுருள்
Ossicles	-	කර්ණ අස්ථිකා	-	செவிச் சிற்றென்புகள்
Eustachian tube	-	යුස්ටේකීය නාළය	-	ஊத்தேக்கியாவின் குழாய்
Auditory nerve	-	ශ්‍රවණ ස්නායුව	-	செவிநரம்பு
Semi-circular canals	-	අර්ධ චක්‍රාකාර නාළ	-	அரை வட்டக்கால்வாய்

3 Nature and Properties of Matter

Recall what you have learnt about the properties of matter in grade 8. You may call back to your mind how matter was classified as pure substances and non-pure substances (mixtures). Based on that knowledge engage in the activity 3.1.

Activity 3.1

Classify and tabulate the substances given below as pure substances and mixtures.

air, drinking water, aluminium, silver, copper, salt solution, distilled water, carbon, sulphur, zinc, copper sulphate, sodium chloride

Matter that contain only one constituent with specific properties are called **pure substances**. Accordingly, aluminium, silver, copper, distilled water, carbon, sulphur, zinc, copper sulphate and sodium chloride belong to the class of pure substances.

Matter that contain two or more constituents are known as **mixtures**. Hence, air, drinking water and salt solution can be named as mixtures.

In grade 8 you have learnt that pure substances can be further classified as **elements** and **compounds**. To strengthen that knowledge further, involve in the activity 3.2.

Activity 3.2

Classify and tabulate the following pure substances as elements and compounds.

sulphur, glucose, chlorine, sodium chloride, silver, copper, copper sulphate, zinc

The pure substances with specific properties which, cannot be further divided by either physical or chemical methods into substances with different properties, are called **elements**. Accordingly iron, sulphur, chlorine, silver, zinc and copper belong to elements. There are about 120 elements have been discovered upto now.

Figure 3.1- Some common elements

The **compounds** are pure substances with specific properties, formed by the chemical combination of two or more elements in a fixed ratio. Thus, sodium chloride, copper sulphate and glucose belong to the class of compounds. In nature, there are very large number of compounds, which occur from the combination of various elements in various forms.

Figure 3.2 - Some common compounds

3.1 Elements

3.1.1 Symbols for elements

We know that, in various instances we use various symbols to facilitate communication. Symbols are also used to indicate elements. All countries in the world use these internationally accepted symbols to indicate elements.

Very often, English name of the element is used as the base for these symbols. In such case the first letter of the name of the element is used as the symbol. When a single letter is used as the symbol, compulsorily it should be a capital letter. Table 3.1 presents some examples.

Table 3.1

Element	Symbol
Carbon	C
Oxygen	O
Sulphur	S

When the names of several elements commence in the same letter, the next letter or another letter in the name is added to the symbol. In that, the second letter is a simple letter. Table 3.2 gives some examples.

Table 3.2

Element	Symbol
Chlorine	Cl
Calcium	Ca
Magnesium	Mg
Aluminium	Al

In some elements, the symbol originates in its Latin name. Table 3.3 lists some examples for such symbols.

Table 3.3

English name	Latin Name	Symbol
Sodium	Natrium	Na
Copper	Cuprum	Cu
Lead	Plumbum	Pb
Gold	Aurum	Au
Mercury	Hydrargyrum	Hg
Iron	Ferrum	Fe
Silver	Argentum	Ag

Table 3.4 illustrates names of several elements and their symbols.

Table 3.4

Element	Symbol
Hydrogen	H
Carbon	C
Oxygen	O
Nitrogen	N
Sulphur	S
Chlorine	Cl
Aluminium	Al

Element	Symbol
Magnesium	Mg
Zinc	Zn
Silicon	Si
Phosphorous	P
Argon	Ar
Calcium	Ca
Iodine	I

3.1.2 Building units of elements

You have learnt that, matter is composed of particles. These particles cannot be observed by the naked eye or even by the powerful microscopes. These very small particles are called **atoms**.

John Dalton (1766 - 1844) was the first scientist to use the term atom for the smallest, indivisible particle from which the matter is made. The English name 'atom' for this particle has originated from the Greek word 'atomos' meaning, "**cannot be divided further."**

Figure 3.3 - John Dalton

An element is composed of the atoms of the same type. The atoms which, form different elements are different to each other. For example, the element iron is formed from iron atoms. Aluminium is formed from aluminium atoms. The structures of aluminium atoms and iron atoms differ from each other.

The units formed by the combination of one or more atoms of the same type or one or more atoms of different types are called **molecules**.

Under normal conditions, the element oxygen exists as oxygen molecules composed of two oxygen atoms. The smallest form in which oxygen can exist independently is a molecule. Some examples for the elements which can exist as molecules are given in table 3.5.

Table 3.5

Element	Symbol of the molecule
Oxygen (O)	O_2
Nitrogen (N)	N_2
Chlorine (Cl)	Cl_2
Hydrogen (H)	H_2
Fluorine (F)	F_2

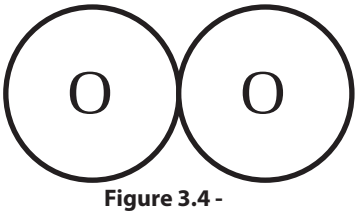


Figure 3.4 - A representation of an Oxygen molecule

Figure 3.5 - A representation of a Hydrogen molecule

Since the above molecules are formed by the atoms of the same elements they are known as **homo-atomic molecules**.

Therefore, elements are composed either, from atoms of the same kind or from molecules formed by combining those same kind of atoms. Thus, they cannot be further divided into simple substances chemically.

3.1.3 Atomic structure

We know that the building units of matter are atoms. What is wonderful is the fact that, a greater part of the atom is an empty space. Almost the entire mass of the atom is concentrated at a central core. This central core is positively charged and is called the **nucleus**. It was first discovered by **Ernest Rutherford** (1871-1937), a New Zealander that, the atom consists of a large empty space and a positively charged central nucleus.

Figure 3.6 - Ernest Rutherford

In the past, the atom was considered a very small particle which cannot be divided further. But, according to findings of the experiments conducted later, the atom was found to be a collection of subatomic particles. These subatomic particles are known as electrons, protons and neutrons.

Protons and neutrons are found in the nucleus situated at the centre of the atom. Electrons which are very much lighter than the protons and neutrons, exist moving around the nucleus. Relative to the entire volume of the atom, the volume of the nucleus is extremely small.

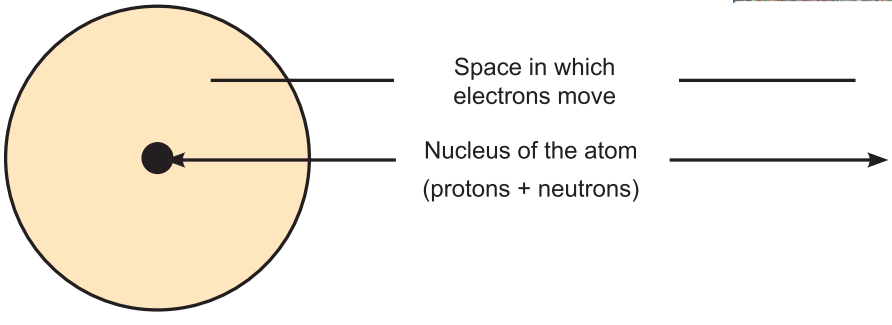


Figure 3.7 - Illustration of an atom

Table 3.6 presents location and some properties of the subatomic particles.

Table 3.6 - Relative masses and relative charges of subatomic particles

	Protons	Neutrons	Electrons
Location	in the nucleus	in the nucleus	around the nucleus
Mass (relative to proton)	1	1	$\frac{1}{1840}$
Charge (relative to electron)	+1	0	-1

Atomic number (Z)

The number of protons present in the nucleus of a given atom of an element is called the atomic number. It is generally designated by the symbol Z. The atomic number or the number of protons in the nucleus is a unique property of the element. As an atom is electrically neutral, number of protons and number of electrons are equal. The atomic numbers of some elements are given in table 3.7.

Table 3.7 – Atomic number of atoms of some elements

Element	Number of Protons	Number of Electrons	Atomic Number
Carbon (C)	6	6	6
Nitrogen (N)	7	7	7
Oxygen (O)	8	8	8
Fluorine (F)	9	9	9
Neon (Ne)	10	10	10
Sodium (Na)	11	11	11

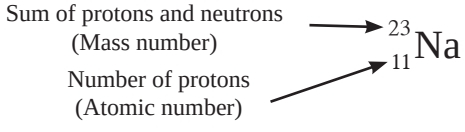
Mass number (A)

The sum of the protons and neutrons present in the nucleus of a given atom of an element, is called the mass number of the atom of that element. The mass number is represented by the symbol A.

Table 3.8 - Mass number of atoms of some elements

Element	Number of protons (p)	Number of Neutrons (n)	Mass number (p + n)
N	7	7	14
O	8	8	16
F	9	10	19
Na	11	12	23
Cl	17	18	35

There is a standard method of representing atomic number and mass number of an atom. This standard method is, writing atomic number at the left hand side bottom end and mass number at the left hand side top end of the symbol of the atom. The information related to an atom of element sodium (Na) is given below.



3.2 Compounds

Compounds are formed by the chemical combination of two or more elements in a certain ratio. Some of those compounds exist in nature as molecules. Since those molecules contain atoms that are different from one another, they are called **hetero-atomic molecules**.

e.g. A Hydrogen chloride molecule is formed by the combination of one hydrogen atom and one chlorine atom.

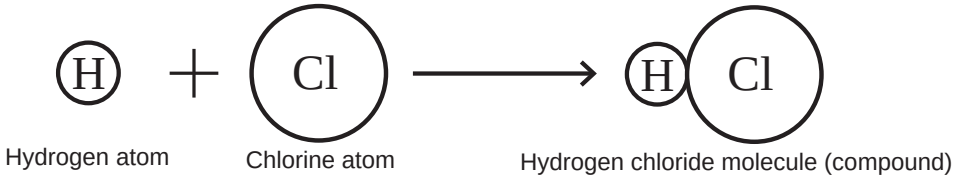


Figure 3.8 - Illustration of the formation of a hydrogen chloride molecule

Thus, a main difference between elements and compounds is that an element is composed of the atoms of the same kind while a compound is formed from atoms belonging to two or more kinds of elements.

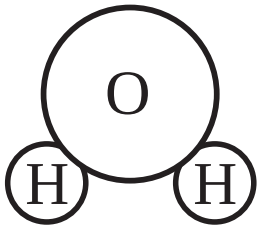


Figure 3.9 - Water molecule

e.g. A water molecule is formed by the combination of an oxygen atom and two hydrogen atoms. This is illustrated by figure 3.9.

Assignment 3.1

Using various materials create models for several homo-atomic and hetero-atomic molecules. Display the models you made in the classroom.

A carbon dioxide molecule is formed by the combination of a carbon atom and two oxygen atoms. This is shown by figure 3.10.

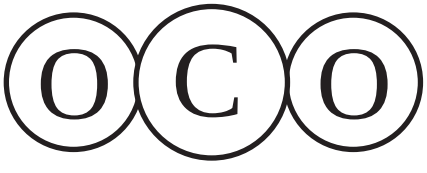


Figure 3.10 - Carbon dioxide molecule

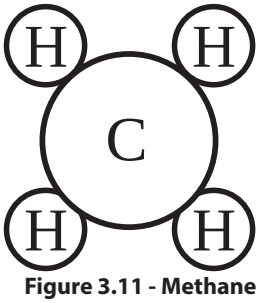


Figure 3.11 - Methane molecule

A methane molecule is formed by the combination of a carbon atom with four hydrogen atoms. This is illustrated by figure 3.11.

An ammonia molecule is formed by the combination of a nitrogen atom with three hydrogen atoms. This is illustrated by figure 3.12.

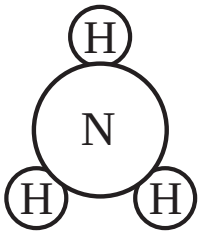


Figure 3.12 - Ammonia molecule

There are specific chemical symbols for compounds also. These symbols are known as **chemical formula** of compounds. You will study them in higher grades.

Table 3.9

Compound	Chemical formula of the compound (Building unit of the compound)	Elements contained
Water	H_2O	H and O
Glucose	$C_6H_{12}O_6$	C, H and O
Methane	CH_4	C and H
Carbon dioxide	CO_2	C and O
Sodium chloride (Common salt)	NaCl	Na and Cl
Copper sulphate	$CuSO_4$	Cu, S and O
Calcium carbonate	$CaCO_3$	Ca, C and O

The elements contained in the smallest unit that form a compound, cannot show the properties of that compound.

The different compounds formed by even the same set of elements have different chemical properties.

e.g. 1: Same compounds formed by the set of elements C, H are given below.

- Methane (a component of biogas) - CH_4
- Hexane (a solvent) - C_6H_{14}
- Benzene (a solvent) - C_6H_6
- Acetylene (a gas burnt to generate heat essential for welding metals) - C_2H_2
- Ethene (a gaseous raw material needed to make polythene) - C_2H_4

e.g. 2 : Given below are some compounds formed by the set of elements C, H, O

- Glucose (a simple sugar) - $C_6H_{12}O_6$
- Acetic acid (contained in vinegar) - CH_3COOH
- Ethanol (contained in alcoholic beverages) - C_2H_5OH
- Dimethyl ether (an anaesthetic) - CH_3OCH_3
- Sucrose (contained in sugar cane) - $C_{12}H_{22}O_{11}$

3.3 Mixtures

Next, let us study about the non-pure substances (mixtures).

Pay your attention to sea water. Various salts and various gases are dissolved in it. That means, it contains several constituents. Therefore, sea water is a mixture. In natural environment mostly we come across mixtures and not pure substances. Air, soil, river water and rocks around us are all mixtures. Yoghurt, ice cream and fruit salad we eat are also mixtures. The drinks such as tea, coffee and soft drinks too are mixtures.

Fruit salad Coffee Ice cream

Figure 3.13 - Some mixtures

Mixtures are formed when two or more pure substances get mixed. The pure substances in a mixture are called as constituents.

Let us identify constituents in some mixtures. Let us study table 3.10.

Table 3.10 - Mixtures and their constituents

Mixture	Constituents
Air	nitrogen, oxygen, argon, carbon dioxide, water vapour
Sea water	water, salts, dissolved oxygen, dissolved carbon dioxide
Cake mixture	sugar, flour, water, colouring, butter, eggs
Crude oil	diesel, petrol, kerosene, tar

The specific feature of a mixture is that, its constituents can be separated by physical methods. When rice is mixed with sand they can be separated by sifting using the sifting bowl. So, sifting is a physical method of separating constituents in a mixture. Let us involve in activity 3.3 to study about the physical methods of separating constituents in a mixture.

Activity 3.3

- You are provided with the following mixtures. Suggest suitable methods for separating the constituents in those mixtures.
    1. A mixture of sugar and sand
    2. A mixture of salt and water
    3. A mixture of iron powder and sulphur powder
    4. A mixture of rice and sand
    5. A mixture of chaff and stone
- Describe how the constituents of the mixtures are separated.

Given below are some physical methods of separating constituents in a mixture and some instances in which they are used. They will be studied in detail in grade 11.

Panning	- Separating sand from rice, Separating gems from ores
Winnowing	- Separating chaff from rice
Floating on water	- Separating sterile seeds from seed paddy
Sifting	- Separating gravel from sand
Evaporation	- Obtaining salt from sea water
Fractional distillation	- Separating various fuels from crude oil
Steam distillation	- Separating cinnamon oil from cinnamon leaves
Crystallization	- Separating sugar from cane sugar syrup
Uses of magnets	- Separating some minerals from mineral sands

Figure 3.14 - Gem mining

Figure 3.15 - Winnowing paddy

Assignment 3.2

Prepare a chart to show the physical methods used to separate constituents of a mixture and the instance in which those methods are used.

According to that, mixtures can be described as follows.

A matter which consists of two or more constituents which can be separated by physical methods are called mixtures.

According to the nature, mixtures can be divided into two categories.

1. Homogeneous mixtures 2. Heterogeneous mixtures

Homogeneous mixtures

Let us involve in activity 3.4 to study about homogeneous mixtures.

Activity 3.4

1. Weigh about 2 g of salt, add it to a beaker containing 500 ml of water, mix well with a glass rod and allow to stand for a few minutes.
2. Observe carefully.

You will be able to see that properties like colour and transparency are alike throughout the mixture. The mixtures with a uniform composition right throughout the mixture are called **homogeneous mixtures**.

e.g. Salt solution, sugar solution, sea water

Heterogeneous mixtures

Dissolve a little clay in water, allows to stand from some time and observe. If you observe carefully you may be able to see that the colour and transparency of the mixture is different from place to place.

The mixtures in which the composition is not uniform throughout the mixture are known as **heterogeneous mixtures**.

e.g. Muddy water, mortar mixture, ice cream, fruit salad

Assignment 3.3

- Prepare mixtures by mixing each of the following with small amount of water and observe these mixtures.

  salt, soap, copper sulphate, limestone, washing blue, chilli powder
- Record the observations
- Classify the mixtures you have prepared as homogeneous and heterogeneous.

Summary

- Matter can be classified as pure substances and non-pure substances (mixtures).
- Pure substances can be further classified as elements and compounds.
- The pure substances which bear specific properties and cannot be further divided into substances with different properties by physical or chemical methods are called elements.
- The pure substances which have specific properties and are formed by the chemical combination of two or more elements in a definite ratio are termed as compounds.
- Atoms and molecules are the building units of elements.
- Homo-atomic molecules are formed by the combination of two or more atoms of the same kind whereas hetero-atomic molecules are formed by the combination of two or more atoms of different kinds.
- The atom consists of subatomic particles.
- Electrons, protons and neutrons are the subatomic particles in an atom.
- An atom comprises a large empty space and a positively charged nucleus at the centre of it.
- Protons and neutrons are contained in the nucleus. Electrons move around the nucleus.
- The number of protons in the nucleus of an atom is called the atomic number of that element. It is a unique property for that element.
- The sum of the protons and neutrons in the nucleus of an atom is called the mass number.
- Mixtures are matter consisting of two or more pure constituents that can be separated by physical methods.
- Mixtures can be classified as homogeneous mixtures and heterogeneous mixtures.

Exercise

01) Select the correct or most suitable answer.

1. The number of protons, neutrons and electrons in the $^{35}_{17}Cl$ atom respectively are,
   1. 17, 18, 18 2. 17, 18, 17 3. 17, 17, 18 4. 17, 17, 17

2. Of the following statements given about the atom, select the **false** statement.
   1. Atoms are the building units of matter.
   2. A large portion of an atom is empty space.
   3. There is a positively charged nucleus at the center of an atom.
   4. An atom cannot be further divided.

3. A unique property for a certain atom is,

1. its atomic number
2. the number of neutrons in the nucleus
3. its mass number
4. the sum of the number of neutrons and protons

4. Which of the following contains matter belonging to the same set?

1. sodium, carbon, oxygen
2. oxygen, water, air,
3. water, carbon, sodium
4. air, carbon, oxygen

5. Of the following statements given about the element nitrogen, select the **false** statement.

1. Nitrogen is a pure substance.
2. Nitrogen molecules are the building units of nitrogen.
3. Nitrogen molecule is formed by the combination of a large number of nitrogen atoms.
4. Nitrogen is a constituent of air.

6. Of the following substances given, the pure substance is,

1. air
2. salt solution
3. vinegar
4. copper sulphate

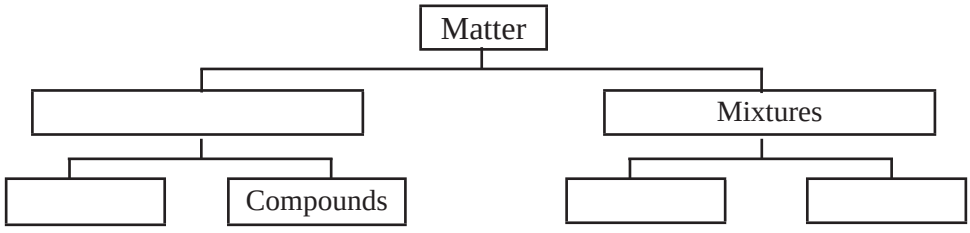
02) Fill in the blanks considering proton and neutron amounts of particular elements.

Element	Number of protons	Number of neutrons	Atomic number	Mass number
Sodium	11	.....	.....	23
Calcium	.....	20	20	.....
Iron	.....	.....	26	56
Sulphur	.....	16	16	.....
Bromine	35	.....	.....	80

03) Indicate whether the mixtures given below are homogeneous or heterogeneous.

1. Tea
2. Sea sand
3. Rice mixed with chaff
4. Vinegar
5. Copper sulphate solution

04) Copy the following figure on classification of matter in your book and fill in the blanks.



05) Give short answers.

1. Name three pure elements and three pure compounds.
2. Write the formulae of three compounds which you know and name the elements in them.
3. Write the chemical symbols and names of five elements symbolized by a single letter.
4. Write the chemical symbols and names of five elements symbolized by two letters.

Technical Terms

Atom	-	පරමාණුව	-	அணு
Molecule	-	අණුව	-	மூலக்கூறு
Matter	-	පදාර්ථය	-	மேட்டர
Elements	-	මූලද්‍රව්‍ය	-	மூலகங்கள்
Nucleus	-	න්‍යෂ්ටිය	-	கரு
Proton	-	ප්‍රෝටෝන	-	புரோத்தன்
Electron	-	ඉලෙක්ට්‍රෝන	-	இலத்திரன்
Neutron	-	නියුට්‍රෝන	-	நியுத்திரன்
Homogeneous mixture	-	සමජාතීය මිශ්‍රණය	-	ஏகவினக் கலவை
Heterogeneous mixture	-	විෂමජාතීය මිශ්‍රණය	-	பல்லினக் கலவை
Compounds	-	සංයෝග	-	சேர்வைகள்
Atomic number	-	පරමාණුක ක්‍රමාංකය	-	அணுவெண்
Mass number	-	ස්කන්ධ ක්‍රමාංකය	-	திணிவெண்
Homo-atomic molecules	-	සමපරමාණුක අණු	-	ஏகவின அணுமூலக்கூறுகள்
Hetero-atomic molecules	-	විෂමපරමාණුක අණු	-	பல்லின அணுமூலக்கூறுகள்

4 Basic Concepts Associated with Force

4.1 Force

Let us consider situations like lifting an object, pushing a table, opening or closing a door or hitting a ball (figure 4.1).

Figure 4.1

In such instances what we do is, pulling or pushing the object. Such a pulling or pushing is called a force, simply a **force means a pull or a push**.

When we push a book on the table, it moves. A ball moves faster if we kick it. But, you can not push and move a wall. A single person cannot push and move a bus or a lorry. Thus, it is clear that, sometimes we can move an object by applying a force and sometimes a force cannot result any motion.

When you catch a ball that comes towards you, a force is applied to stop it. When you hit a ball with a bat, you apply a force to change the direction and the speed of the ball.

You can press a ball by keeping it on the ground and tread on it. Here, you change the shape of the ball by applying a force.

Accordingly, by applying a force;

- object at rest can be moved.
- object in motion can be stopped.
- the speed of motion can be changed.
- the direction of motion can be changed.
- the shape of object can be changed.

4.2 Magnitude of force

A ball can be moved slowly by hitting slightly. If you hit it harder it moves fast. When hitting slowly, it applies a small force. Hitting fast, applies a large force. Thus, it is clear that the force has a magnitude.

There are several equipment that can be used to measure the magnitude of a force. Spring balance is a simple equipment used for this purpose. What is inside of a spring balance is a spring, that changes its length according to the force applied. It is calibrated according to the stretched length of the spring.

There are several units to measure the magnitude of a force. According to the international system (SI) of units, magnitude of force is measured in Newtons (N). There are spring balances in school laboratories, which are calibrated in Newtons. But, spring balances which are used for commercial purposes are usually calibrated in grams (g) or kilograms (kg).

Do the activity 4.1 to understand how a spring balance can be used to measure a force.

Activity 4.1

You will need :- A Newton spring balance, a piece of stone, a wooden block, a helical spring, a piece of thread, a metal hook, a G-Clamp

Method :-

- Tie the stone by a piece of thread.
- Hang the stone on the spring balance as shown in figure 4.2, and take the reading.
- This reading gives the magnitude of the gravitational force exerted by the Earth on the piece of stone. This is known as the weight of the stone.

Figure 4.2

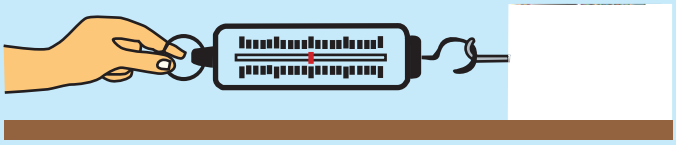


Figure 4.3

- Fix the metal hook to the wooden block.
- Connect the spring balance to the hook as shown in figure 4.3. Pull the spring balance, while keeping it horizontally, till the block just starts to move. Take the reading of the spring balance. It is the magnitude of the force exerted by your hand on the wooden block.

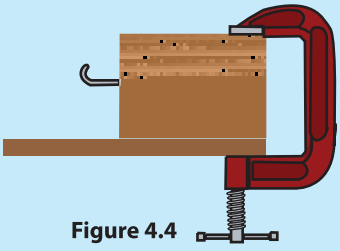


Figure 4.4

- Fix firmly, the wooden block with metal hook, to the table-top using the G-clamp (figure 4.4).
- Connect the helical spring as shown in figure 4.5.
- Join the other end of the helical spring to the spring balance as shown in figure 4.5. Pull the spring balance till the length of the helical spring is increased by 10 cm. Then, take the reading of the balance.

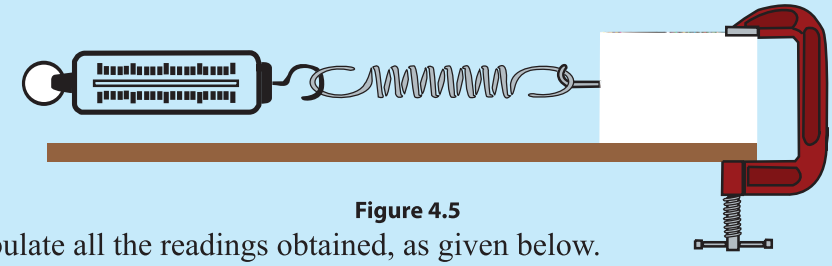


Figure 4.5

- Tabulate all the readings obtained, as given below.

Table 4.1

Instance	Quantity	Magnitude of force (N)
1	Weight of the piece of stone	
2	Force applied to pull the wooden block	
3	Force applied on helical spring	

According to the activity 4.1, it is clear that the force has a magnitude.

4.3 Direction of force and point of application

When a ball is being hit, the direction of the hit decides the direction of its motion. When a drawer is being opened, it should be pulled towards us. When it is to be closed, it should be pushed to the opposite direction. Thus, it is clear that not only the magnitude, but also the direction of application of force is important.

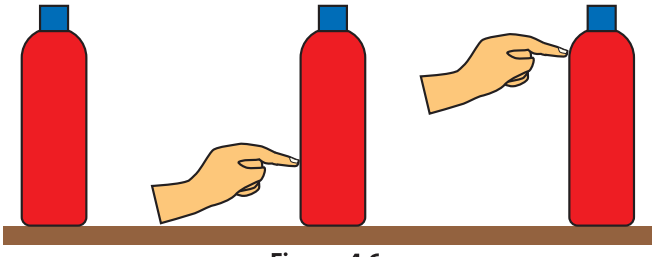


Figure 4.6

Apart from this, the result of a force changes according to the point on which it is applied. For an example consider a bottle placed on a table. If it is pushed with the finger, kept closed to the bottom, it will move away along the table top. But if it is pushed at the top, it may topple. **The point of an object, on which the force is exerted is known as the point of application of force**.

Let us do activity 4.2 and activity 4.3 to furthermore study about the direction of force.

Activity 4.2

You will need :- A wooden block, few tintex nails, some thread

Method :-

- Fix a nail at the mid point on one side of the wooden block. Tie a piece of thread to the nail (figure 4.7), so that the thread is leaning on the block.

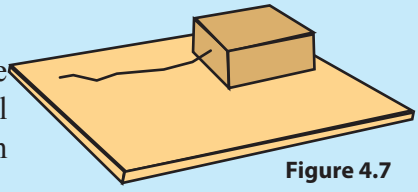


Figure 4.7

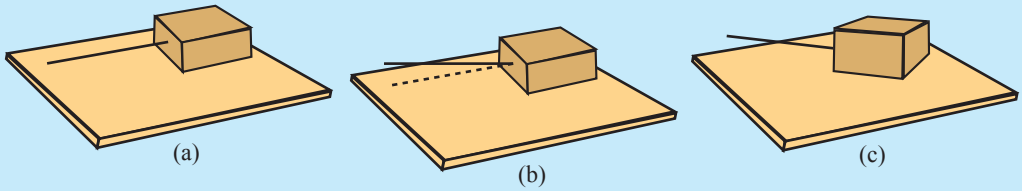


Figure 4.7 - The wooden block on the table viewed from the top

- Place the wooden block on the table as in figure 4.7 (a), and pull it by the thread, keeping the thread horizontally. Observe the direction of motion of the wooden block.
- Then, change the direction of the thread to a side, while keeping it horizontally as in figure 4.7 (b) and draw. Observe the direction of motion of the wooden block.

You can observe that the wooden block moves in the direction of pull as in the figure 4.7 (a) of the above activity. When the direction of pulling is changed as in figure 4.7 (b), the direction of motion of the wooden block changes as shown in figure 4.7 (c).

Thus, it can be concluded as follows.

- The force acts to the direction of pulling, along the thread.
- The object moves along the direction of force exerted.

Activity 4.3

You will need:- A wooden block, a circular wooden disc, few tintex nails, some thread

Method :-

- Fix tintex nails to the points A, B and C on the upper surface of the wooden block as shown in figure 4.8.
- Fix a nail to the center of the wooden disc as shown in figure 4.9.

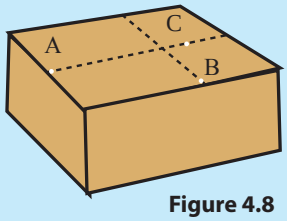


Figure 4.8

- Now tie a piece of thread to the nail A of the wooden block and pull the thread, keeping it horizontally. Observe the direction of motion of the wooden block .

- In the same way, tie pieces of thread to points B and C of the block and pull separately. Observe the direction of motion of the wooden block.
- Then, tie a piece of thread to the nail fixed at the centre of the disc. Pull the thread to the directions 1, 2 and 3 keeping it horizontally as shown in the figure. Observe the motion of the disc.

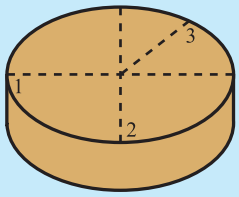


Figure 4.9

In the above activity, it is observed that, the objects move to the direction of force, irrespective of the shape and the change of direction. Moreover, the thread is directed to the direction of force applied through the point of tying it to the object.

Here, the point that the thread is tied is point on which the force is acting on the object. That point is known as the **point of application of the force**.

The quantities that have a magnitude as well as a direction are known as **vector quantities**. In the above activities, it is confirmed that the force has a **magnitude** and a **direction.** Therefore, **force is a vector quantity**.

4.4 Graphical representation of force

The magnitude, direction and the point of application of a force can be graphically represented by a segment of straight line. Here;

- The **magnitude** is represented by the **length**,
- The **direction** is represented by the **arrow head**,
- The **point of application** is represented by the **dot** at the starting point of the segment of straight line.

For example let us consider a force of 10 N acting on the wooden block X, and a force of 5 N acting on the wooden block Y.

The magnitude of the force of 10 N acting on the object X is denoted by the length of the horizontal line, the direction by the arrow head and the point of application by point P in figure 4.10.

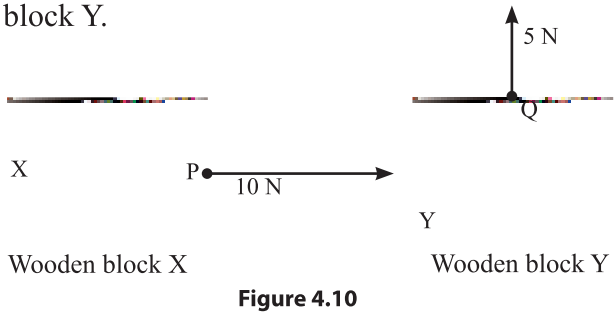


Figure 4.10

The magnitude of the force of 5 N acting on the object Y is denoted by the length of the vertical line, the direction by the arrow head and the point of application by point Q, in figure 4.11.

Moreover the length of the straight line drawn to denote the force of 10 N on X should be twice as long as the one drawn to denote the force of 5 N on Y.

In our day-to-day life, we apply forces on various objects. When we write with a pen, we have to apply forces to move the pen on the sheet of paper. When walking, forces are applied on the floor by our feet. When playing cricket, forces are applied on the ball by hitting the bat. To move the bat, the player has to apply force on the bat.

Figure 4.11

We have to make an effort to do these types of work. Most of the time, we apply forces in the easiest way to reduce effort. For example, let us consider the figure 4.11 (a). A person drawing a loaded cart is shown there. He applies a horizontal force, because the cart should be moved horizontally. But, the person has to bend and pull with a difficulty to maintain the horizontal force. This difficulty can easily be overcome by drawing the cart to a direction shown in figure 4.11 (b). Although the force is not applied horizontally, the cart moves to the direction we want. What we do here is changing the direction of force to make the work easy.

Figure 4.12

A person pushing a loaded cart is shown in the figure 4.12 (a). The person has to bend and push it with difficulty. To ease the work, a wooden or metal handle can be fitted to the cart and the point where the force is applied (point of application) can be changed (figure 4.12 (b)).

In our day-to-day life, we select the way of applying forces in such a way, that the work is handled easier. What is applied here is not merely the scientific knowledge, but our practical experiences also contribute a lot. But, if there is some knowledge about forces, our tasks can be fulfilled easier.

Summary

- Force is a pull or a push.
- When a force is applied,
  - an object at rest can be moved.
  - an object in motion can be stopped.
  - the speed of motion can be changed.
  - the direction of motion can be changed.
  - the shape of an object can be changed.
- Standard unit of measuring force is Newton (N).
- Newton spring balance is used to measure the magnitude of a force.
- Force has a direction and a magnitude. Therefore, force is a vector quantity.
- The point on which the force is acting on the object is known as the point of application of the force.
- Day-to-day life activities can be done easily by changing the direction and the point of application of a force.

Exercise

01) Select the correct or most suitable answer.

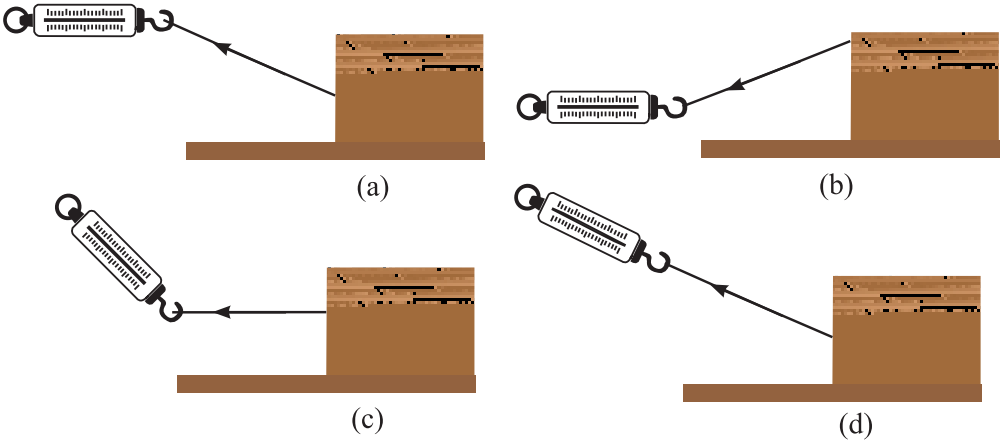
1. The weight of an object is a force. What is the unit of measurement of weight?
   1. kg 2. kg s 3. N 4. N s

2. Force is considered as a vector quantity, because it has,
   1. a magnitude.
   2. a point of application.
   3. a direction.
   4. a magnitude and a direction.

3. A force can be graphically represented by a straight line. Consider the following statements in this regard.
   a. The magnitude of force is denoted by the length of the straight line.
   b. The direction of force is denoted by the arrow head on the line.
   c. The point of application of the force is indicated by the mid point of the straight line.

   The true statements are;
   1. a and b only
   2. a and c only
   3. b and c only
   4. a, b, and c all

4. Figures given below show, how a Newton spring balance is used to measure the magnitude of a force applied on an object.



Which figure above, shows the correct way of using the spring balance?

1. a 2. b 3. c 4. d

5. Consider the statements given below, about a force.
Because of a force applied on an object,

a. object at rest can be moved.
b. object in motion can be stopped.
c. the direction of motion can be changed.

What are true from the statements above?

1. a and b only
2. a and c only
3. b and c only
4. a, b and c all

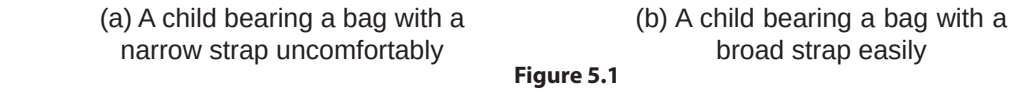
Technical Terms

Force	- බලය	- விசை
Vector	- දෛශිකය	- காவிக் கணியம்
Point of application of force	- බලයේ උපයෝගී ලක්ෂ්‍යය	- விசையின் பிரயோகப் புள்ளி
Magnitude of force	- බලයේ විශාලත්වය	- விசையின் பருமன்
Direction of force	- බලයේ දිශාව	- விசையின் திசை
Graphical representation	- රූපික නිරූපණය	- வரிப்பட வகைகுறிப்பு
Spring balance	- දුනු තරාදිය	- விற்றராசு
Newton	- නිව්ටනය	- நியுற்றன்

5 Pressure Exerted by Solid

5.1 Pressure

You may have experienced that, when the strap of your school bag is narrow, it is uncomfortable to the shoulder. When it is broad it is not that uncomfortable.



(a) A child bearing a bag with a narrow strap uncomfortably

(b) A child bearing a bag with a broad strap easily

Figure 5.1

There are two school bags of equal weight. The shoulder strap of one of them is narrow and that of the other one is broad. Though, the strap is narrow or broad, the force exerted by the weight of school bag is the same. But, when the strap of it is narrow, the contact area is less, and when it is broad that area is more.

Thus it is clear that, though the force is the same, the pressure against the shoulder differs with the area of contact of the strap.

Consider two bags having the straps of the same breadth and different weights of books. The bag with more weight gives more press against the shoulder.

(a) A child bearing a light-weight bag easily

(b) A child bearing a heavy bag uneasily

Figure 5.2

The force exerted by the weight of the school bag, is distributed through out the area of contact. It is the distributed force, that is felt by the shoulder.

When the strap of the bag is broad, the force is distributed over a large area. Hence, the pressure felt by the shoulder is less. In these instances, it is useful to know the force exerted over a unit area.

The force exerted over a unit area is known as the pressure.

5.2 Factors affecting the pressure

Let us do activity 5.1 to study the factors affecting the pressure.

Activity 5.1

You will need :- several cakes of soap, thin metal wire, several bags of sand with the weight of 10 N each, a piece of plank which is longer than the length of the cake of soap and similar in breadth of the same, a stop watch

Method :-

- Place the cake of soap on the plank which is kept on two tables as shown in the figure 5.3.
- Hang one sand bag on the wire which is sent round the cake of soap. Observe what happens.

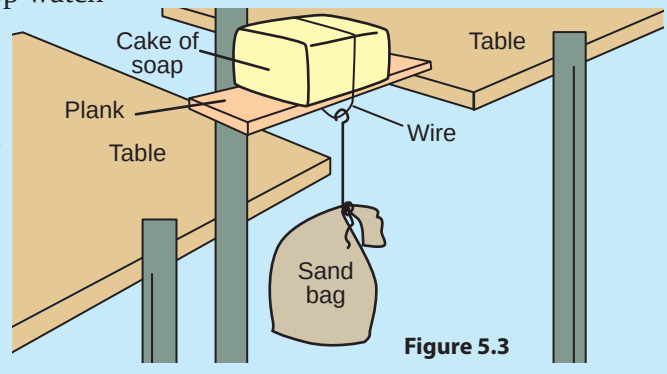


Figure 5.3

- Increase the number of sand bags one by one using a new cake of soap in each instance. Measure the time taken to pass the metal wire through each cake of soap.
- Tabulate your readings as shown below.

Table 5.1

Instance	No. of sand bags hung	Weight of sand bags (N)	Time taken to cut through the cake of soap (s)
01	01	10	-
02	02	20	
03			
04			

In the activity 5.1, sometimes one sand bag will not be enough for the wire to cut through the cake of soap. If it is so, the reason is that the force exerted by the weight of one sand bag is not enough to cut the cake of soap. When the number of sand bags are being increased, time taken for the wire to cut through the cake of soap becomes less.

Two facts are revealed by this activity. They are;

- Force affects the pressure exerted on a solid object.
- Pressure increases with the increase of force.

These facts are confirmed by the activity 5.2.

Activity 5.2

You will need :-

a piece of plank with the size of 15 cm × 10 cm × 1 cm,
a piece of plank with the size of 20 cm × 15 cm × 1 cm,
a wooden block with the size of 15 cm × 10 cm × 5 cm,
a piece of sponge with the size of 15 cm × 10 cm × 5 cm,
four 1” nails, a ruler of 15cm or a scale, weight of 2 kg,
weight of 5 kg, a hammer, a Newton spring balance

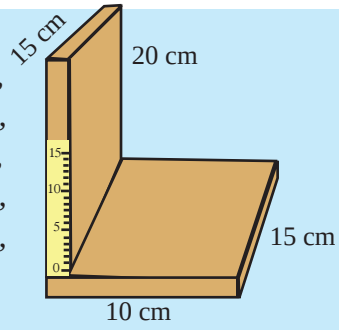


Figure 5.4 a

Method :-

- Fix the planks of the sizes 20 cm × 15 cm × 1 cm and 15 cm × 10 cm × 1 cm as shown in the figure 5.4 a, with nails. Paste the scale of 15 cm along the 20 cm long vertical side of the plank.
- Place the piece of sponge on the horizontal plank as shown in the figure 5.4 b.
- Note down the reading of the scale, which is relevant to the upper horizontal edge of the piece of sponge.

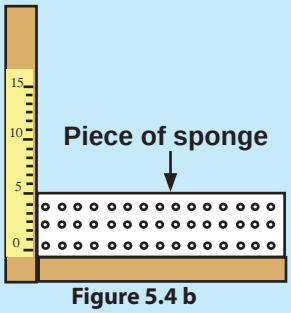


Figure 5.4 b

- Weigh the wooden block of 15 cm × 10 cm × 5 cm using the Newton spring balance.
- Now, place this wooden block on the piece of sponge, as shown in figure 5.4 c. Note down the new reading of scale at the upper edge of the piece of sponge.

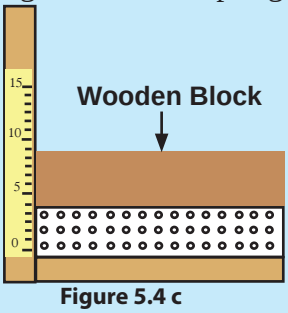


Figure 5.4 c

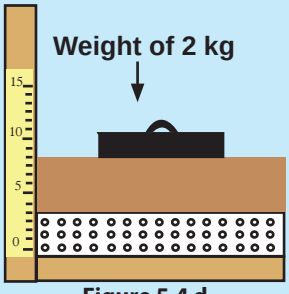


Figure 5.4 d

- Then place the weight of 2 kg on the wooden block as shown in figure 5.4 d and take the reading of the upper edge of the piece of sponge as before.
- Next, remove the weight of 2 kg and place the weight of 5 kg on the wooden block and take the reading.
- Tabulate the readings, you obtained as below in the table 5.2.

Table 5.2

Instance	Force exerted on the piece of sponge (N)	Reading at the upper edge of the piece of sponge (cm)	Reduction of the height of sponge (cm)
Sponge only			
Wooden block on the sponge			
Wooden block and weight of 2 kg on the sponge			
Wooden block and weight of 5 kg on the sponge			

In every instance of the above activity, the area of the wooden block, in contact with the piece of sponge is the same. The force exerted on the piece of sponge is increased gradually. Accordingly, the contraction of the sponge is also increased. Thus, it is clear that the pressure on the piece of sponge is increased gradually. Therefore, it can be concluded that the pressure increases with the increase of force.

Activity 5.3

You will need :- a cake of soap, a piece of thin wire with the diameter of 0.2 mm, a piece of thick wire with the diameter of 1.5 mm, a sand bag of the weight of 20N, a piece of plank which is similar in breadth to the cake of soap

Method :-

- Place the piece of plank between two table-tops and keep the cake of soap on the plank as shown in the figure 5.5.
- Send the thick wire round the cake of soap and hang the sand bag of 20 N weight. Observe what happens.

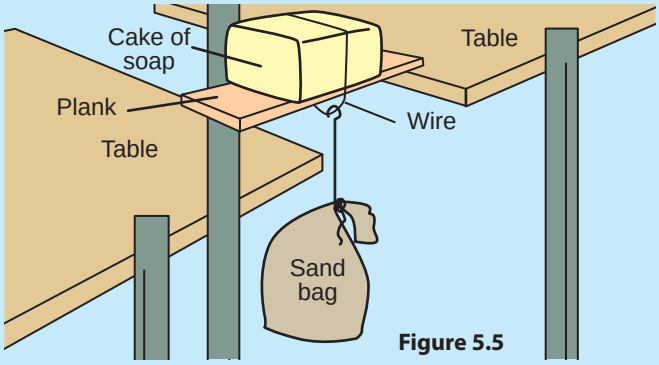


Figure 5.5

- Remove the thick wire and repeat the above step using the thin wire. Observe what happens again.
- What can be concluded according to the observations you made?

In the activity 5.3 above, same weight is used in both instances; with the thick wire as well as with the thin wire. Hence, the force exerted on the cake of soap is same in both instances. But, the cake of soap is cut through easily when the thin wire is used. The reason for this is that, the force acted on unit area of the cake of soap is greater when the thin wire is used. That means, the pressure is greater when thin wire is used, than when the thick wire is used. Cutting through the cake of soap is easier when more pressure is exerted.

The manner the pressure changes according to the area on which force is acted, can be understood further by doing the activity 5.4.

Activity 5.4

You will need :-

a piece of plank with the size of 15 cm × 10 cm × 1 cm,
a piece of plank with the size of 20 cm × 15 cm × 1 cm,
a wooden block (A) with the size of 15 cm × 10 cm × 5 cm,
a piece of sponge (B) with the size of 15 cm × 10 cm × 5 cm,
a piece of sponge (C) with the size of 15 cm × 5 cm × 5 cm,
a piece of sponge (D) with the size of 10 cm × 5 cm × 5 cm,
four 1” nails, a scale of 15 cm, a hammer, a Newton spring balance

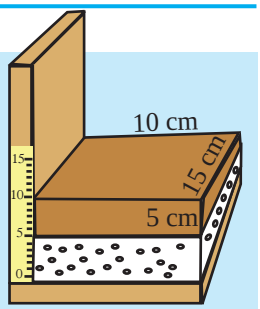


Figure 5.6 a

Method :-

- Weigh the wooden block using the spring balance.
- Paste the scale of 15 cm on to the L shaped frame made as in the activity 5.2.
- Now place the sponge B on the plank. Note down the reading of the scale relevant to the upper horizontal edge of the sponge.
- Then place the 15 cm × 10 cm surface of the wooden block on the sponge as shown in figure 5.6 a.

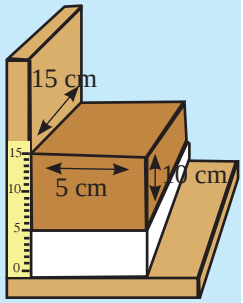


Figure 5.6 b

- Note down the new reading of the scale relevant to the upper horizontal edge of the sponge.
- Now remove the sponge B and place the sponge C on the plank as shown in figure 5.6 b (place the 15 cm × 5 cm surface horizontally). Note down the reading of the scale relevant to the upper horizontal edge of the sponge.
- Then place the 15 cm × 5 cm surface of the wooden block on the sponge. Note down the reading of the scale relevant to the upper horizontal edge of the sponge.

- Now remove the sponge C and place the sponge D on the plank (place the 10 cm × 5 cm surface horizontally). Note down the reading relevant to the upper horizontal edge.
- Then place the 10 cm × 5 cm surface of the wooden block on the 10 cm × 5 cm surface of the sponge. Now take the reading of the upper edge of the sponge.
- Tabulate your readings as below.

Table 5.3

Instance	Force exerted on the surface (N)	Contact surface area (cm^2)	Height of the sponge (cm)	Reduction of the height of sponge (cm)
Sponge B only				
When wooden block contacts its 15 cm × 10 cm surface				
Sponge C only				
When wooden block contacts its 15 cm × 5 cm surface				
Sponge D only				
When wooden block contacts its 10 cm × 5 cm surface				

- What is the conclusion that can be made according to the observations?

During this activity, same wooden block is kept on all sponges. Therefore, the force exerted on all different sponges is the same. But, the contact area of the wooden block on each piece of sponge is changed.

When the contact area is large, the contraction of the sponge is less and when that area is less, the contraction of sponge is higher.

Therefore, it is clear that the pressure is less, when the contact area is high and vice-versa.

Accordingly, it can be concluded as follows.

- The pressure exerted by a solid object on a solid surface depends on the surface area on which the force is acting.
- Higher the surface area on which the force is acting, pressure become low.
- Lower the surface area on which the force is acting, pressure become high.

According to the above activities it is confirmed that the pressure exerted by a solid object on a solid surface depends on two factors. They are;

1. Perpendicular force acting on the surface
2. Surface area on which the force is acting

Pressure is defined as the perpendicular force acting normally on an unit area. Pressure exerted by a solid object on a solid surface can be calculated according to the following formula.

$$\text{Pressure } (P) = \frac{\text{Perpendicular force } (F)}{\text{Surface area on which the force is acting } (A)}$$

5.3 Units of pressure

Units of pressure can be deduced by using the above relationship of pressure. The standard unit of measuring force is N (Newton) and the standard unit of measuring surface area is m^2 (square metre).

$$\text{Pressure} = \frac{\text{Perpendicular force}}{\text{Surface area on which the force is acting}}$$

$$\text{Pressure} = \frac{N}{m^2}$$

$$= N\ m^{-2} \text{ (Newton per square meter)}$$

The standard unit of measuring pressure is N m^{-2}. It is also known as Pascal (Pa). In honour of the French mathematician Blaise Pascal, unit of pressure was named after him.

$$1 \text{ N m}^{-2} = 1 \text{ Pa}$$

Let us pay our attention to the solved problems on pressure.

Solved example 1: What is the pressure exerted on a surface of 2 m^2, when a normal force of 300 N is acting on it?

$$\text{Pressure} = \frac{\text{Perpendicular force}}{\text{Surface area on which the force is acting}}$$

$$= \frac{300 \text{ N}}{2 \text{ m}^2}$$

$$= 150 \text{ N m}^{-2} \text{ or } 150 \text{ Pa}$$

Solved example 2: Weight of a cubic box is 400 N. It is kept on a horizontal plane surface. Pressure exerted by the box on the surface is 200 Pa. What is the contact area of the surface of the box?

$$\text{Pressure} = \frac{\text{Perpendicular force}}{\text{Surface area}}$$

$$\text{Surface area} = \frac{\text{Perpendicular force}}{\text{Pressure}}$$

$$\text{Surface area} = \frac{400 \text{ N}}{200 \text{ N m}^{-2}}$$

$$\text{Surface area} = 2 \text{ m}^2$$

5.4 Changing the factors affecting pressure as needed

When cutting something it is easier if the knife is well sharpened. When sharpening, the knife-edge becomes very thin. It can exert a high pressure on the object. So, the object can be cut thinner and easier (figure 5.7).

Figure 5.7

The bottom of the skates used by skiers is made sharp like a knife-edge (figure 5.8). Because of this, a high pressure is exerted on ice, when the skier is skating. That high pressure makes the ice liquify and form a slippery surface.

Figure 5.8

Roads can be easily damaged because of the high pressure exerted by heavily loaded trucks and container carriers. To avoid this, such vehicles are made with a large number of wheels (figure 5.9). Then, the contact area with the road is increased and the pressure is decreased. Hence, the damages to the roads are minimized.

Figure 5.9

Assignment 5.1

In our day-to-day activities, we have to increase or decrease pressure. One way of doing this is the change of surface area. List such instances and explain them scientifically.

Summary

- Pressure is defined as the perpendicular force acting on an unit area.
- The pressure exerted by a solid object on a solid surface depends on two factors. They are,
    - Perpendicular force acting on the surface
    - Surface area on which the force is acting
- $$\text{Pressure } (P) = \frac{\text{Perpendicular force } (F)}{\text{Surface area } (A)}$$
- The unit of measuring pressure is N m^{-2} / N/m^2 or Pascal (Pa).
- Pressure can be increased or decreased by manipulating the factors which affect on pressure.

Exercise

01) Select the correct or most suitable answer.

1. What is the unit of measuring pressure?

   1. N m^2 2. N m 3. N m^{-1} 4. N m^{-2}

2. What is the unit of measuring pressure, that indicates a specific name?

   1.Newton 2. Joule 3. Pascal 4. Watt

3. Consider the following statements of pressure.

   a. Pressure is equal to the ratio, $\frac{\text{Perpendicular force}}{\text{Surface area}}$

   b. Pressure increases when perpendicular force is increased.

   c. Pressure increases when surface area is increased.

   Which of the above statements are true?

   1. a and b only 2. a and c only
   3. b and c only 4. a, b and c all

4. A perpendicular force of 60 N was applied on an area of 3 m^2. What is the pressure exerted on the surface?

   1. $\frac{1}{60\ N \times 3\ m^2}$ 2. $\frac{3\ m^2}{60\ N}$ 3. $\frac{60\ N}{3\ m^2}$ 4. 60 N × 3 m^2

5. The pressure was 50 Pa, when a perpendicular force was applied on a surface area of 2.5 m^2. The force applied was;

   1. $\frac{1}{25}$ N 2. $\frac{1}{20}$ N 3. 20 N 4. 125 N

06. In which of these instances, the devices are applied to decrease pressure?

1 2

3 4

02) Answer the following questions.

1. (a) What are the units of pressure?

   (b) Mention the factors affecting pressure.

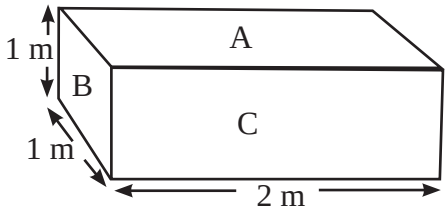
   (c) Write down a relationship for pressure in terms of those factors.

2. (a) Write two examples where the factor, area is practically used to increase pressure.

   (b) Mention two examples where the factor, area is practically used to decrease pressure.

   (c) State two examples where the factor, perpendicular force is practically used to increase pressure.

03) The length, breadth and height of the cuboid shown in the figure are 2 m, 1 m and 1 m respectively. Its weight is 400 N.



(a) The cuboid is kept on a horizontal surface as shown in the figure. How much is the pressure acting on the surface?

(b) While the cuboid is in the position as in part (a), an object weighing 150 N is kept on it. Then, what is the pressure acting on the horizontal surface?

(c) The object weighing 150 N is removed and the cuboid is kept to contact its surface B with the horizontal surface. Then, what is the pressure exerted on the horizontal surface?

04) (a) The figure shows a machine used in the construction of roads. Clarify how the factors affecting pressure are changed, to change the pressure exerted by this machine on the road.

(b) Living being show various natural adaptations to increase pressure. Give 2 examples for such instances.

(c) Living being show various natural adaptations to decrease pressure. Give 2 examples for such instances.

Technical Terms

Pressure	-	පීඩනය	-	அமுக்கம்
Perpendicular force	-	අභිලම්බ බලය	-	செங்குத்து விசை
Surface area	-	පෘෂ්ඨ වර්ගඵලය	-	மேற்பரப்பின் பரப்பளவு
Pascal	-	පැස්කල්	-	பஸ்கால்

6 The Human Circulatory System

The circulatory system transports blood throughout the human body. It is a closed system. Heart is the organ that pumps blood into the blood vessels of the circulatory system. Let us observe the structure of the heart and learn about its functions.

Activity 6.1

You will need: - a model or a diagram of the heart

Method :-

- Observe the model or the diagram of the heart.
- Identify the parts of the heart.
- Use a labelled diagram of a longitudinal section of the heart to identify and study the parts.

Figure 6.1

6.1 Structure of the human heart

Figure 6.2 shows the longitudinal section of human heart.

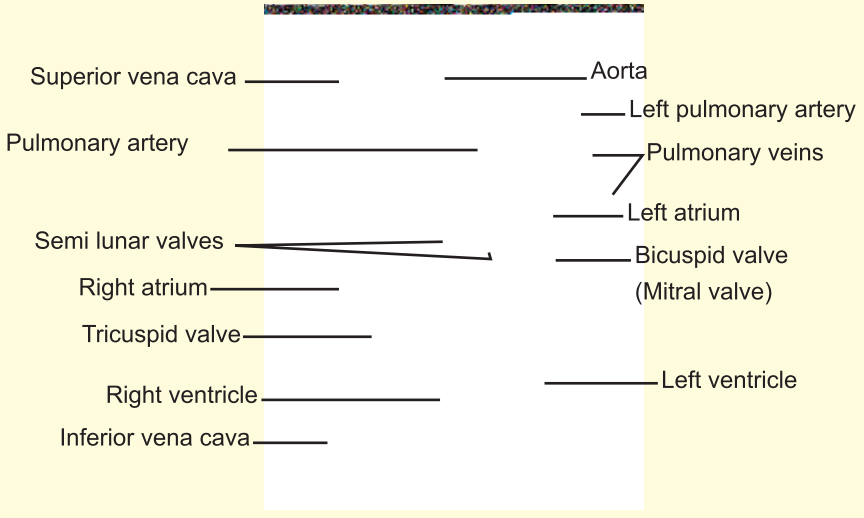


Figure 6.2 - Longitudinal section of the human heart

- The heart has four chambers. The upper chambers are called atria and the lower chambers are called ventricles.
  - ⋆ Left atrium
  - ⋆ Right atrium
  - ⋆ Left ventricle
  - ⋆ Right ventricle
- There are two valves between the atria and ventricles.
  - ⋆ Bicuspid valve is in between the left atrium and left ventricle.
  - ⋆ Tricuspid valve is in between the right atrium and right ventricle.
- There are two main arteries connected to the ventricles.
  - ⋆ Aorta starts from the left ventricle.
  - ⋆ Pulmonary artery starts from the right ventricle.
- There are semi lunar valves at the starting points of the main arteries.
  - ⋆ Aortic semi lunar valve is at the starting point of the aorta.
  - ⋆ Pulmonary semi lunar valve is at the starting point of the pulmonary artery.
- Main veins are connected to the atria.
  - ⋆ The superior vena cava and inferior vena cava open to the right atrium.
  - ⋆ Left and right pulmonary veins open to the left artrium.

Assignment 6.1

- Construct a model of the heart to show the structure of the heart.

6.2 Arteries, veins and capillaries

The blood vessels that take blood away from the heart are known as arteries while, the vessels that take the blood towards the heart are known as veins. Main arteries starting from the heart divide into branches.

- The pulmonary artery which starts from the heart transport blood to lungs. Aorta supply blood to the other organs. Within an organ an artery further divides into arterioles and then into capillaries.
- The capillaries join together to form venules and venules join together to form veins.
- Pulmonary veins starting from the lungs take the blood to left atrium.
- Veins from the organs above the heart join the superior vena cava and veins from the organs below the heart join the inferior vena cava. Both the superior and inferior vena cava open into the right atrium.

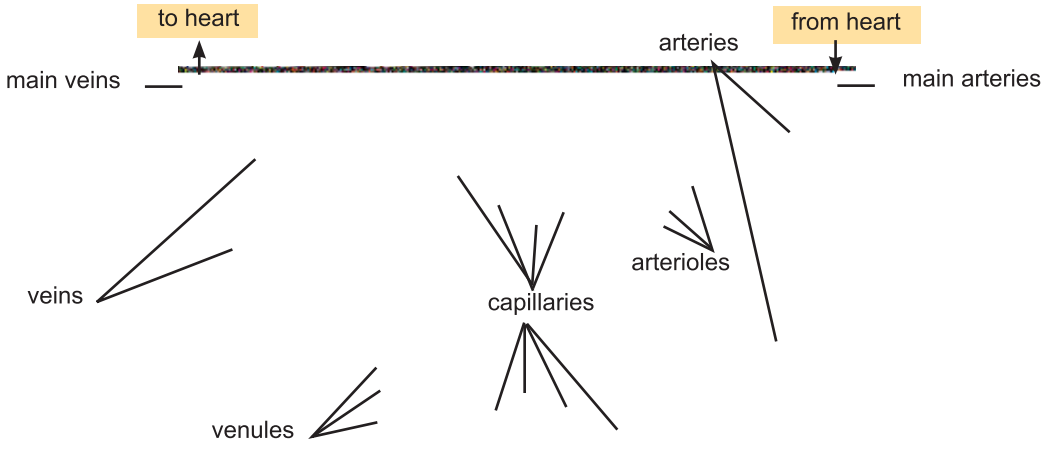


Figure 6.3 - Blood circulation in arteries, veins and capillaries

The artery walls are thick and elastic. So, it can withstand the high pressure of the blood being pumped directly from the heart.

Veins collect blood from the capillaries in the body organs and transport to the heart. The pressure of blood, that flows inside the veins is relatively low. Hence, the walls of veins are thin and less elastic. The valves in the veins open towards the heart to prevent the back flow (figure 6.4 b).

Walls of the capillaries consists of a single cell layer. As they spread among the cells the nutrients and gases in blood diffuse into the cells and the waste matter in the cells diffuse into the blood capillaries (figure 6.4).

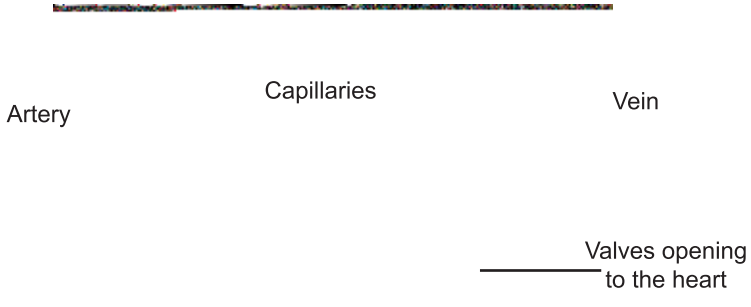


Figure 6.4 - Structure of arteries, veins and capillaries

Activity 6.2

Compare the structural and functional characteristics of arteries, veins and capillaries of the blood circulatory system.

6.3 Components of blood and their functions

Although you see blood as a red fluid, only 55% of its value is in liquid form. This liquid part is called as the plasma. The other 45% of its volume consists of corpuscles which is in solid form.

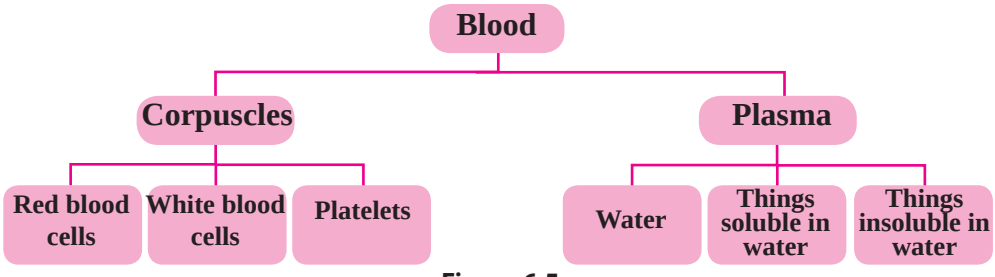


Figure 6.5

A microscopic observation of a blood sample shows three types of corpuscles.

- Red blood cells/ erythrocytes
- White blood cells/ leukocytes
- Platelets

Erythrocytes and leukocytes are cells while the platelets are cell fragments.

Functions of blood

Red blood cells/ erythrocytes

Red blood cells contain a red pigment which is called haemoglobin. Haemoglobin carries oxygen from lungs to the body cells and also gives blood its red colour.

White blood cells/ leukocytes

White blood cells defend the body by destroying pathogens and producing antibodies. White blood cells are categorized into neutrophils, eosinophils, basophils, lymphocytes and monocytes.

Platelets

Platelets help in the clotting process of blood at a bleeding site. Some virus infections cause a rapid decline in a platelet percentage. e.g. Dengue, Leptospirosis

Plasma

The main function of the plasma is transporting substances dissolved in it.

Some examples are given below;

- It transports the digestive products, minerals and vitamins to the cells.
- It transports the excretory products during biochemical reactions within the cells to the excretory organs.
- Plasma transports hormones, proteins, enzymes and gases to the relevant parts of the body.

6.4 Blood transfusion

The transfer of blood from one individual to another is known as **blood transfusion**. The person who donates blood is called the **donor** and the person who receives is called the **recipient**. However, blood transfusion is not possible between **any** two individuals.

For a transfusion to take place, compatibility of the blood group and the Rhesus factor between the donor and the recipient is compulsory.

Compatibility of the blood group

There are four blood groups as A, B, AB and O depending on the protein components present in blood cells.

Figure 6.6

Compatibility of blood groups in transfusion is represented in the table 6.1. (√ represent positive compatibility of blood group while × represent lack of compatibility of blood group)

Table 6.1- Compatibility of blood group

		Recipient			
	Blood type	**A**	**B**	**AB**	**O**
Donor	**A**	√	×	√	×
	B	×	√	√	×
	AB	×	×	√	×
	O	√	√	√	√

According to the table, blood group AB can receive blood from all other blood groups. Therefore, blood group AB is called the **universal recipient**.

Blood group O can donate to all the other blood groups. Therefore, blood group O is called the **universal donor**.

Information in the table 6.1 can be illustrated as in figure 6.7.

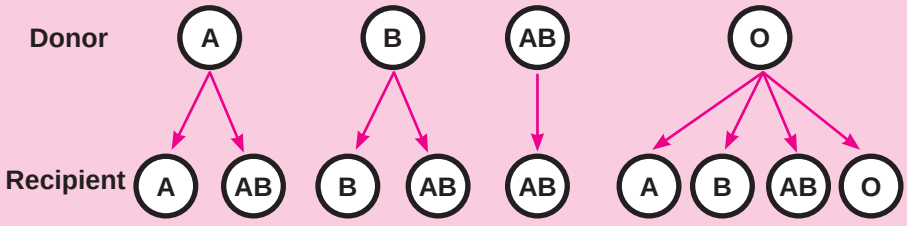


Figure 6.7 - Compatibility of blood group

For a blood transfusion, not only the blood group, but also the Rhesus factor (Rh factor) must be compatible.

Compatibility of Rhesus factor

If the Rhesus factor is present in one's blood it is considered as Rh^+ and if Rhesus factor is absent, it is considered as Rh^-. The recipients who are Rh^+ can receive both Rh^+ and Rh^- blood. However, the Rh^- recipients can receive Rh^- blood only. The table 6.2 shows the compatibility of blood with Rhesus factor.

(√ represent positive compatibility of blood with Rhesus factor while × represent negative compatibility of blood with Rhesus factor

Table 6.2 - Compatibility of Rhesus factor

Donor	Recipient		
		Rh^+	Rh^-
	Rh^+	√	×
	Rh^-	√	√

The figure 6.8 represents the same facts in table 6.2.

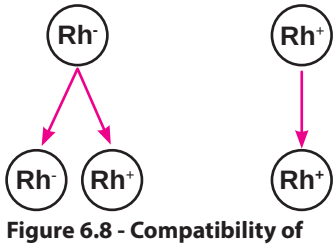


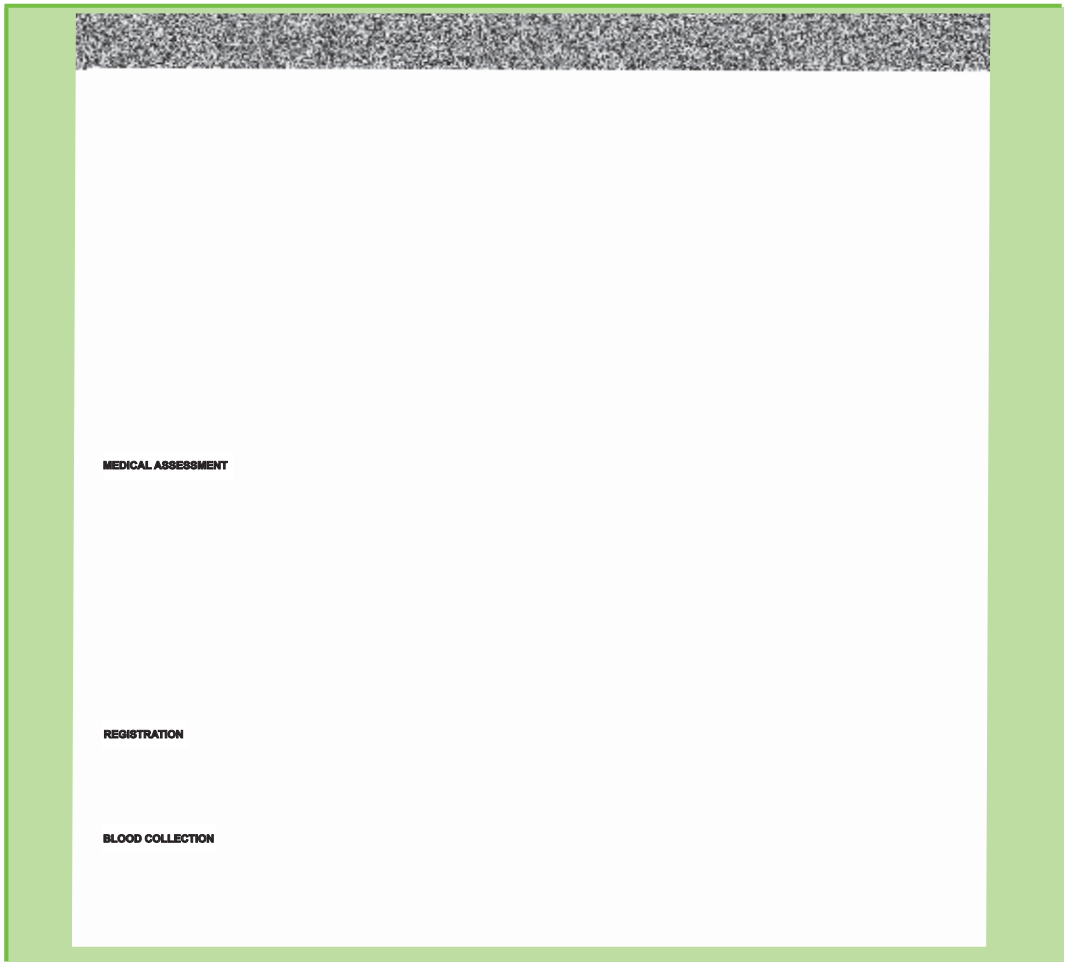
Figure 6.8 - Compatibility of Rhesus factor

Hence both the blood group and the Rhesus factor have to be matched to donate blood. Both the blood group and Rhesus factor are considered when expressing the blood group of an individual.

e.g. $A^+, A^-, B^+, B^-, AB^+, AB^-, O^+, O^-$

The National Blood Transfer Service (NBTS) has a list of other qualifications a donor must fulfill. A donor has to complete the Blood Donor Declaration correctly and hand it over to the NBTS before donating blood. Blood donor declaration and donation record is given in the extra knowledge frame.

For extra knowledge



Blood agglutination

Clumping of the transfused blood particles in the body of the recipient is called **agglutination**.

This happens when the blood groups of donor and recipient are incompatible.

Blood clotting/ coagulation is an important process that prevents excessive bleeding when there is an injury or internal bleeding. This coagulation mechanism differs from the coagulation mechanism of agglutination.

When there is an injury or bleeding, the platelets at the damaged blood vessels breakdown and the resulting chemical process forms a blood clot to stop bleeding.

Maintaining a proper functioning of the blood circulatory system is vital for a healthy life of a person.

Some favourable habits to maintain healthy blood circulation system

- Maintain mentally less stressful lifestyle
- Engage in physical exercises daily
- Maintain the correct Body Mass Index (BMI) value according to height and weight, with a healthy diet.
- Reduce salt consumption
- Control conditions like high blood pressure and diabetes
- Add more vegetables and fruits to meals
- Reduce consumption of fatty foods
- Refrain from smoking and liquor
- Have more concern if there is a family history of heart attacks, high blood pressure and diabetes

Assignment 6.3

- Collect newspaper cuttings about the good health habits that should be followed to maintain a healthy blood circulatory system.
- Share that knowledge with your classmates.

Summary

- The human heart has four chambers.
- The upper chambers are the right atrium and left atrium and the lower chambers are the right ventricle and left ventricle.
- Aorta is connected to the left ventricle while pulmonary artery is connected to the right ventricle.
- Left and right pulmonary veins are connected to the left atrium while superior vena cava and inferior vena cava are connected to the right atrium.
- Semi lunar valves are at the beginning of main arteries.
- Bicuspid valve is between the left ventricle and left atrium.
- Tricuspid valve is between the right atrium and right ventricle.
- The blood vessels that take the blood away from the heart are arteries and the vessels that take the blood towards the heart are veins.
- An artery ends up with a capillary and a vein starts with a capillary.
- The main functions of blood are transportation and protection.

- Depending on the protein components in blood cells, there are four blood groups as A, B, AB and O.
- Compatibility of the blood group and the Rhesus factor between the donor and the recipient is important for blood transfusion.
- AB is the universal recipient and O is the universal donor.
- Clumping of the transfused blood particles in the body of the recipient is known as blood agglutination.
- The mechanism of blood coagulation during an injury differs from the mechanism of blood coagulation in the process of agglutination.
- There is a list of qualifications a blood donor must fulfill.
- It is vital to maintain a proper functioning blood circulatory system as to lead a healthy life.

Exercise

01) Select the correct or most suitable answer.

1. Aorta starts from,
   1. left ventricle
   2. right ventricle
   3. left atrium
   4. right atrium

2. What are the blood types that can be transfused to a person with the blood group B
   1. A and B
   2. A and O
   3. O and B
   4. A and AB

3. The universal donor and the universal recipient are,
   1. A and O
   2. A and B
   3. O and AB
   4. AB and O

4. Following are some ideas given by a student about blood transfusion.
   a. Compatibility of blood group is compulsory.
   b. Rh^- blood can be transfused to a person with Rh^+.
   c. Only Rh^- blood can be transfused to a person with Rh^-.
   The correct statements are,
   1. a and b only
   2. b and c only
   3. a and c only
   4. a, b and c all

5. During an internal bleeding the blood cells that help for blood coagulation are,
   1. Red blood cells
   2. White blood cells
   3. Platelets
   4. Plasma

6. Followings are some ideas given by a student about the functions of blood.

a. Carries oxygen to the body cells
b. Kill pathogenic micro-organisms
c. Agglutination occurs when transferring blood

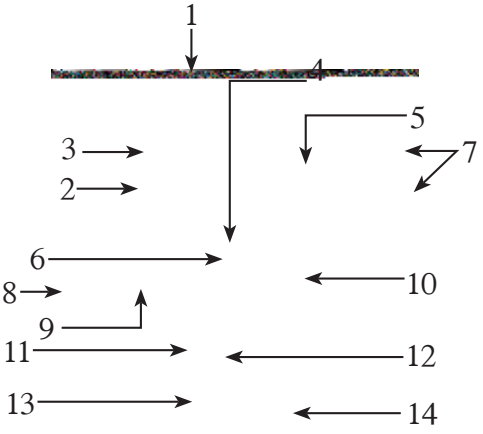
1. a and b only
2. b and c only
3. a and c only
4. a, b and c all

02) Give short answers.

1. Use only the numbers in the figure when you answer the given questions related to the human heart.

   a. What are the two veins that open to the right atrium?
   b. Write the numbers of bicuspid valve and tricuspid valve.
   c. Write down the names of the four chambers and the relevant numbers

2. Write five good habits that help in maintaining a healthy circulatory system.



Technical Terms

Blood circulatory system	-	රුධිර සංසරණ පද්ධතිය	-	குருதிச் சுற்றோட்டத் தொகுதி
Blood groups	-	රුධිර ගණ	-	குருதி வகைகள்
Blood transfusion	-	රුධිර පාරවිලයනය	-	குருதிக் குறுக்குப் பாய்ச்சல்
Universal donor	-	සාර්ව දායකයා	-	சர்வ வழங்கி
Universal recipient	-	සාර්ව ප්‍රතිග්‍රාහකයා	-	சர்வ வாங்கி
Rhesus factor	-	රීසස් සාධකය	-	ரீஸஸ் காரணி
Agglutination	-	ශ්ලේෂණය	-	ஒருங்கொட்டல்

7 Plant Growth Substances

7.1 Introduction to plant growth substances

You know that air, water, light and minerals are essential for plant growth. It has been discovered that some chemical substances also affect towards the plant growth.

Have you ever thought how does a stem of a plant grows upwards and its roots grow downwards after the seed germination? Observe the figures 7.1 a and 7.1 b .

Figure 7.1 a

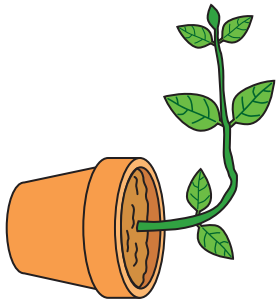


Figure 7.1 b

Have you ever thought how does a stem of a plant grows upwards and its roots grow downwards even the plant pot falls down? Let us do the activity 7.1 to study about it.

Activity 7.1

You will need :- Two similar potted plants

Method:-

- Cut and remove the apex of one plant. Then, measure the heights of both plants.
- Supply same environmental conditions for both plants and measure their heights daily for a week.

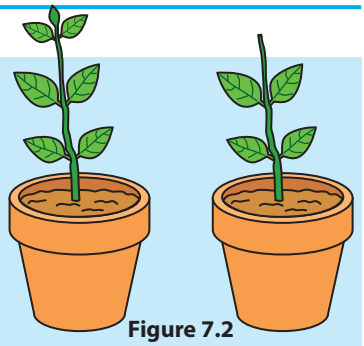


Figure 7.2

You will observe that the plant with the apex grows and its height increases while the height of the plant without the apex does not change. So, we can guess that there is an effect of the apex on plants to increase their height. Let us do the activity 7.2 to find out more about it.

Activity 7.2

You will need :- Two similar potted plants, a box covered with a black paper

Method:-

- Cut and remove the apex of one plant.
- Place the two plants inside the box in a way that both plants get light only from one direction.

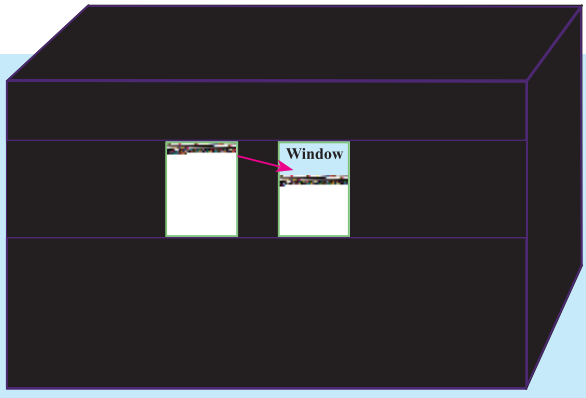


Figure 7.3

You will observe that the plant with the apex grows to the direction of the light and the plant without the apex does not turn towards light. Therefore, we can come to a conclusion that there is an effect of the apex on the growth of a plant. The reason is the chemical compounds synthesize in plant apex.

The **chemical compounds which regulate the growth of a plant are known as plant growth substances**. Some growth substances **promote** the growth of a plant while some **inhibit** the growth of a plant.

Some plant growth substances that promote the growth of plants are given below.

- Auxins
- Gibberellins
- Cytokinins

Auxins

Auxin is a growth promoting hormone in plants which produce in the tips of the shoots and roots. Auxins stimulate cell elongation in stem and root (figure 7.4). Stem apex turn towards light due to dissimilar cell elongation of stem.

When light falls, auxins diffuse downwards

Collection of auxins in areas where intensity of light is low

Growth of the tip towards light due to the cell elongation of that area with more auxin concentration

Figure 7.4

Auxins, produced in the apex diffuse downwards. It speeds up the growth of new cells and the shoot of the plant grows upwards. IAA (Indole Acetic Acid) is a natural growth substance found in plants.

Auxin concentrate more in the side of plant where intensity of light fall is low and auxin concentrate less in the other side of the plant. Auxin move to the darker side of the plant, causing the cells there to grow longer than corresponding cells on the other side of the plant. This causes a curving of the plant stem tip towards the light. This is known as positive phototropic movement. Auxin also inhibit the growth of lateral buds (figure 7.5).

Pruning of plant apex is practised in horticuture to maintain bushy plants.

Figure 7.5 - Growth of lateral buds in Pomegranate plant

Gibberellins

Gibberellin promotes mainly the elongation of the stem and growth of the fruits.

Cytokinins

Cytokinin accelerates the cell division. So, the growth of flowers, leaves, fruits and roots get accelerated. They stimulate seed germination and delay plant ageing.

Figure 7.6 - Growth of Cabbage plant due to gibberellin

Figure 7.7 - Increasing the rate of rooting in plants using Cytokinin

For extra knowledge

Abscisic acid is a plant growth substance. It is a chemical substance that cause closing of stomata when the plant experiences shortage of water. Thus, it decreases transpiration.

Ethene is a simple organic compound which produces in low amounts in plants. It is necessary for ripening of fruits. In ripening, starch stored in plants converted to sugar. If a plant is damaged, ethene released to the wound area and a new tissue forms to recover the wound.

What is the reason for falling leaves and fruits when matured?

When you observe a stalk of a naturally fallen leaf and a stalk of a broken leaf, it would be clear to you that, the naturally fallen leaf stalk has a clear **abscission layer**. The reason for making an abscission layer is, the reduction results in the amount of growth substances in fruits and leaves with their maturity. As a result, fruit fall and leaf fall take place in plants.

7.2 Uses of artificial growth substances

Artificial growth substances are widely used in horticulture and growing ornamental plants. Some of these are given in the table 7.1.

Table 7.1

Artificial growth substances	Uses
2,4 DPA (2,4 Dichloro Phenoxyacetic Acid)	As a broad leaf weedicide for paddy fields
2,4,5 TPA (2,4,5 Trichloro Phenoxyacetic Acid)	
(IAA) Indole Acetic Acid	To induce root formation of stem cuttings, To grow fruits quickly
(IBA) Indole Butyric Acid	
(NAA) Naphthalene Acetic Acid	To prevent pre-mature fruit drop, To induce flowering in pine apple in off-seasons
Cytocell	To get mango fruits in the off-season

Assignment 7.1

- Collect information about the instances that artificial growth substances are used.
- If possible arrange a visit to a plant nursery where artificial growth substances are used.
- Collect information about the use of artificial growth substances and prepare a report.

Assignment 7.2

Prepare a collection of flower plants by the root induction of their stem cuttings using artificial growth substances. Plant them to beautify your school environment.

Summary

- The organic substances that influence some physiological processes during the growth of a plant are known as growth substances.
- Some growth substances promote the growth while some inhibit the growth of plants.
- Auxin, Gibberellin and Cytokinin are some examples for growth promoting substances.
- Artificial growth substances and inhibitors are used for agricultural purposes.

Exercise

01) Select the correct or most suitable answer.

1. The figure shows the growth of a plant close to a window. What can be there in the side to which its apex has grown?
   1. light 2. water
   3. soil 4. air

2. An artificial growth substance that is used to encourage root formation of a stem cutting is,
   1. Indole Acetic Acid
   2. 2, 4 Dichloro Phenoxyacetic Acid
   3. Naphthalene Acetic Acid
   4. 2, 4, 5 Trichloro Phenoxyacetic Acid

3. Select the **incorrect** statement regarding growth substances.
   1. organic substances which control physiological activities in plants
   2. growth substances can be artificially synthesized for use
   3. some are used for inducing fruit formation
   4. stimulate the growth only

4. Three artificially synthesized growth substances are given below.

a. Indole Acetic Acid
b. Indole Butyric Acid
c. Napthalene Acetic Acid

Which of these are useful in initiating roots ?

1. a and b only 2. a and c only
3. b and c only 4. a, b and c all

5. What is the artificial substance used to prevent pre-mature fruit drop and to induce flowering in pine apple in off seasons?

1. 2,4 DPA 2. IAA 3. IBA 4. NAA

02) Chemical substances and their effect for plant growth is mentioned in A and B colomns. Match A and B correctly.

A	B
a. Auxins	cell division
b. Cytokinins	cell elongation
b. Gibberellins	stem elongation

03) State three instances where artificial growth substances are used in agriculture. Give one example for each.

Technical Terms

Plant growth substances	-	ශාක වර්ධක ද්‍රව්‍ය	- தாவர வளர்ச்சிச்சீராக்கிப் பதார்த்தங்கள்
Growth promoters	-	වර්ධනය උත්තේජනය කරන ද්‍රව්‍ය	- வளர்ச்சி தூண்டிகள்
Growth inhibitors	-	වර්ධනය නිශේධනය කරන ද්‍රව්‍ය	- வளர்ச்சி நிரோதிகள்
Seed germination	-	බීජ ප්‍රරෝහණය	- வித்து முளைத்தல்
Plant ageing	-	ශාක වියපත් වීම	- தாவரங்கள் வயதாதல்
Phototropic movements	-	ප්‍රභාවර්තී චලන	- ஒளித்திருப்பவசைவு
Stem elongation	-	ශාක කඳන්වල දික් වීම	- தண்டு நீட்சியடைதல்
Artificial growth substances	-	කෘත්‍රිම වර්ධක ද්‍රව්‍ය	- செயற்கை வளர்ச்சிப் பதார்த்தங்கள்

8 Support and

8.1 Support and movements of animals

Living organisms change the location of their whole body or a part of its body as a response to a stimulus. This process is known as a **movement**. You know very well that movement is a feature of living organisms. Not only the animals but also the plants do movements.

Let us engage in activity 8.1 to study about the movements of animals.

Activity 8.1

You will need :- Video clips that show the movements of human and other animals or live specimens of animals such as snail, earthworm, prawn, frog, crow and fish

Method:-

- Observe the movements of the given animals (figure 8.1) by using the video clips or specimens. (Make sure not to harm the living animals)
- Identify the appendages used by these animals for movements.
- Complete the table 8.1, using your observations.

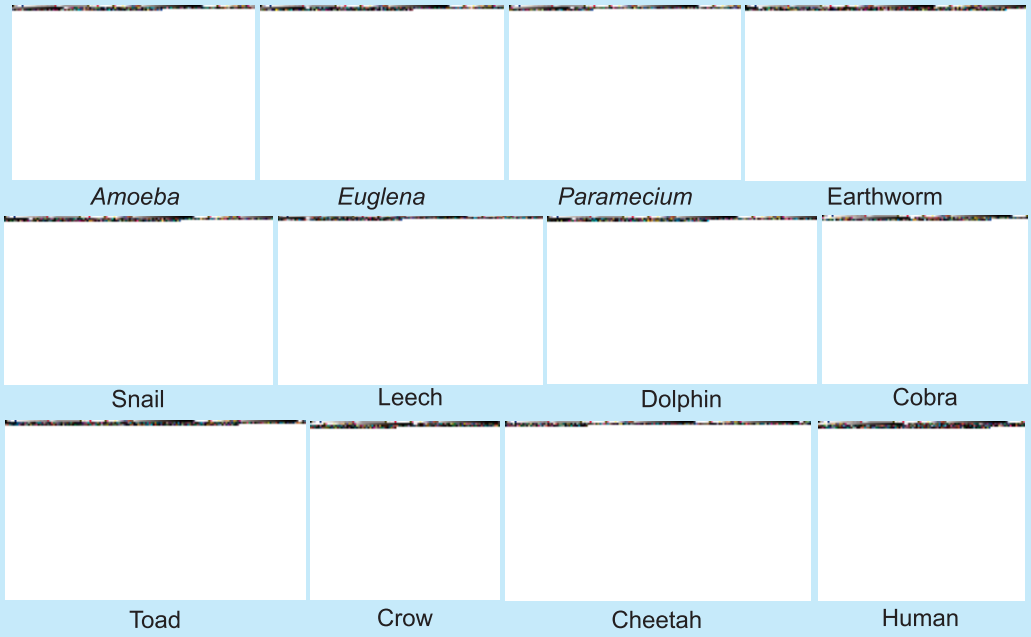


Figure 8.1 - Movements of different animals

Table 8.1 - Appendages used by animals for movements

Name of the animal	Appendages used for movements
Amoeba	False feet (pseudopodia)
Euglena	
Paramecium	
Earthworm	
Leech	
Dolphin	
Snail	
Cobra	
Toad	
Crow	
Cheetah	
Human	

Amoeba uses pseudopodia for locomotion while *Euglena* uses its flagella. *Paramecium* uses its hair like cellular organelles called cilia for locomotion.

Human beings, cheetah and toad use limbs for their locomotion. Dolphin use flippers for their locomotion. Birds such as crows use wings for their locomotion. Animals like earthworm, leech, snail and cobra do not have special appendages for their locomotion.

Animals move their body parts and most of them use muscles in those movements.

Human skeletal system Human muscular system

Figure 8.2

8.2 Bones, muscles and joints

Invertebrates use muscles while vertebrates use both muscles and bones for their movements. Bones and muscles help not only for movements but also to maintain the body shape and rigidity (support).

Let us consider about the features of a muscle to understand how a muscle function during a movement. Several features of muscles are given below.

- The cells in a muscle are arranged as fibres.
- A muscle cell has the ability to contract or shorten.
- A muscle cell has the ability to relax.
- When muscles are relaxed or contracted they have the ability to reach the original position again.

Let us do the activity 8.2 to study how muscles help to move a bone.

Activity 8.2

You will need :- Two 5 x 30 cm sized hard cardboard pieces or wooden planks, bolt nail, hack-saw blade, cutting flyer, a broad elastic piece of 1m length

Method:-

- Prepare a model of an elbow unit by using hard cardboard pieces or wooden planks as shown in the figure 8.3.
- Contract the elastic band A without moving the wooden plank P.
- Contract B without moving P.
- Observe what happens.

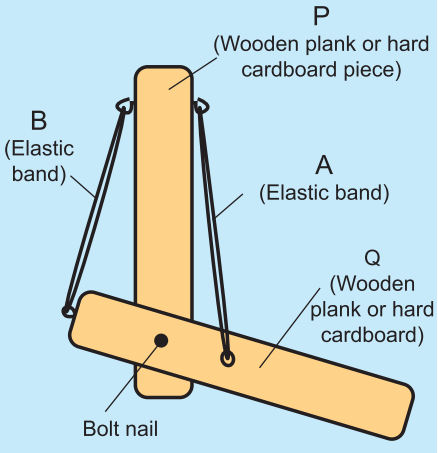


Figure 8.3

Let us use the activity 8.2 to study about how the elbow joint works.

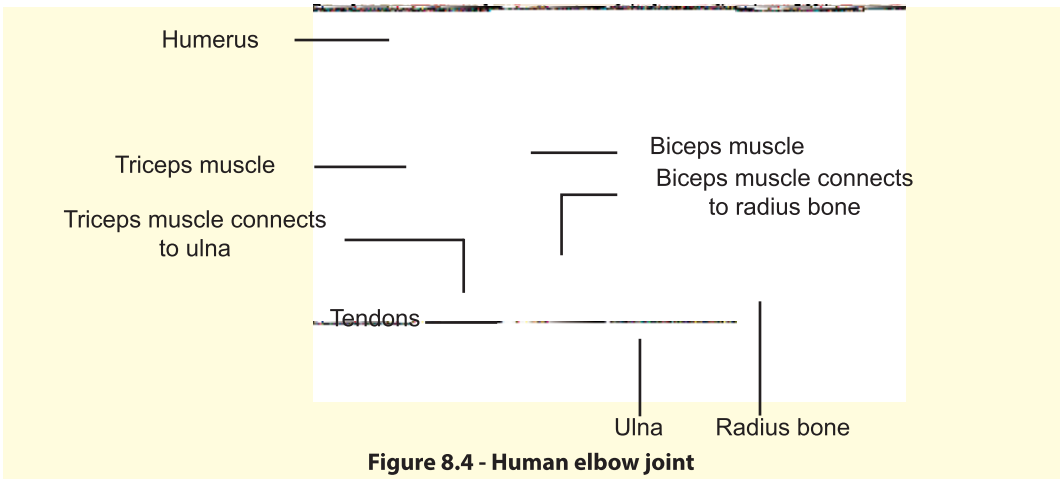


Figure 8.4 - Human elbow joint

Elastic band A represents the biceps muscle in the elbow joint. When biceps muscle is contracted the hands bends and lifts up.
Elastic band B represents the triceps muscle in the elbow joint. When triceps muscle is contracted the hand is stretched. Then, the biceps muscle comes to its original resting position.

8.3 Support and movements of plants

Support of plants

Just like in animals, tissues are present within plants for the purpose of mechanical support. Figure 8.5 shows the garden Balsam plant. You may have noticed on sunny days these plants get withered and the stem is bent down. This is due to lack of water supply to the plant.
To keep non-woody plants erect and alive it is vital to have water inside the plant, where as woody plants can be kept erect in low water percentages due to presence of various chemical substances such as cellulose, lignin deposited in the walls in heartwood of the plant. They give rigidity to the plant (figure 8.6).

Figure 8.5 - Non-woody plant (Balsam)

Figure 8.6 - Woody plant (Mango)

Movements of plants

Growth of a part in a plant as a response to a stimulus or change of the location due to a turgor change , is known as a movement of a plant. These responses can be catogorized into two main groups as,

- Tropic movements
- Nastic movements

Tropic movements

Tropic movements are growth or movements that occur due to a direct influence between the direction of stimulus and direction of response. Tropic movements occur due to the effect of growth substances. Response may be towards or away from the stimulus. Positive tropism occurs towards the stimulus. Negative tropism occurs away from the stimulus.

Some of tropic movements are described below.

- Positive geotropism - roots growing towards the ground
- Negative geotropism - stem of the plant growing away from the ground
- Positive phototropism - stem growing towards the light
- Positive hydrotropism - roots moving towards the water source
- Positive chemotropism - growth of the pollen along the tube towards the ovule
- Positive thigmotropism - coiling of tendrils in Passion fruit with the support

Let us do activity 8.3 to study about tropic movements.

Activity 8.3

You will need:- Two pots, some green gram seeds

Method :-

- Plant 5 soaked seeds in each pot.
- After seed germination, keep one healthy plant in each pot and uproot all the other plants.
- Keep one pot vertical and the other toppled down as in the figure 8.7.

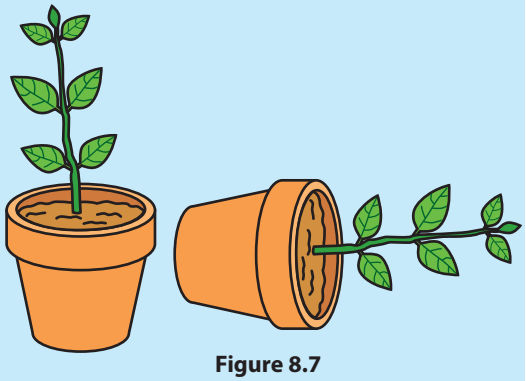


Figure 8.7

- Observe the growth pattern of root and shoot after one week.
- Identify and study tropic movements.

In both pots, roots grow towards ground. That means movement of a plant root is positive geotropic, and movement of a plant shoot is negative geotropic (figure 8.8), as it move.

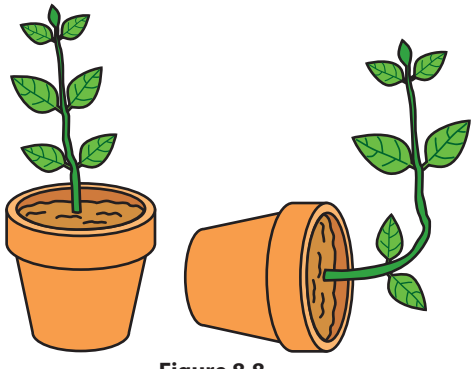


Figure 8.8

Nastic movements

In nastic movements, response of the direction does not depend on the direction of stimulus (The direction of these movements are specific). Response is always towards a specific direction; irrespective of the direction of stimulus. This reaction is not related with growth substances triggered by external stimulus. Most of them are movements due to turgor change. In legume plants, a structure called pulvinus is located as a swelling at the base of the petiole or leaflet. It contains parenchyma cells, which move according to the changes in turgor pressure.

Figure 8.9 - Shrinking of *Mimosa* leaves

Some of nastic movements are as follows.

- Nyctinastic movements - sleeping or shrinking of leaves of 'Kathurumurunga' / 'Agaththi', tamarind, *Mimosa* and 'Nelli' / 'Nellikkai' leaves when dark falls
- Haptonastic movement - sleeping or shrinking of *Mimosa* leaves, when the stimulus is touched
- Seismonastic movement - exhibiting sleeping movement during a shock
- Photonastic movement - blooming of flowers with the sunrise

Let us do the activity 8.4 to study about responses of plant parts

Activity 8.4

You will need :- *Mimosa* plants

Method :-

- Touch the leaves of a *Mimosa* plant.
- Make a vibration without touching the leaves.
- Report your observations.
- Report if there are any special features in the plants responsible for these movements.

When you touch a *Mimosa* plant the leaves show the sleep movement. It is a haptonastic movement. When you create a vibration without touching, the leaves of the *Mimosa* plant show the sleep movement. It is a seismonastic movement.

The **pulvinus** located at each leaflet and petiole base help for these movements of the plant. Pvlvini are also present in plants showing sleeping movement at dust with the decrease of sunlight.
e.g. 'Kathurumurunga', Tamarind, 'Nelli'

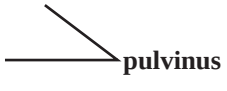


Figure 8.10 - Place where the pulvini are located

For extra knowledge

Tactic movements

In addition to tropic movements and nastic movements there is a type of movement known as tactic, which is related with the direction of stimulus. In tactic movement, the whole organism responds to the stimulus.

e.g. Small Algal Species like *Chlamydomonas*

In-situ Conservation

Although plants show movements they cannot locomote like animals. Animals can avoid external hazards by locomotion.

Plants grow in a habitat, where all necessary external factors needed to growth are present. Hence, plants can get destroyed in its habitat due to external hazards. Therefore, it is essential to conserve plants in their own habitat. Conservation of an organism, in its living environment is known as **in-situ conservation**. Strictly reserved forests which protect indigenous plants like ebony, satinwood, vitex are examples for in-situ conservation. These species of organisms can also be protected by conserving sensitive zones of environment.

Figure 8.11 - 'Vilpattu' reserve

Summary

- Animals use pseudopodia, cilia, flagella and muscles for their locomotion.
- Chordates use bones and muscles connected to the bones for movements.
- For a movement to take place, muscles must have the ability to contract, stretch and recoil to their original resting length after stretched or contracted.
- Skeletal system and the muscles give the body a shape and rigidity.
- Even though plants do not show locomotion, they show movements.
- Movements of plants are categorized as tropic movements and nastic movements.
- Conservation of an organism in its living environment, is known as in-situ conservation.

Exercise

01) Select the correct or most suitable answer.

1. The appendage used by the snail for its locomotion is,
   1. flagella 2. pseudopodia 3. cilia 4. muscular foot
2. What helps to maintain rigidity of non-woody plants ?
   1. Water 2. Air
   3. Different deposited materials 4. Plant nutrients
3. Human movements need,
   1. only the bones.
   2. only the muscles.
   3. both bones and muscles.
   4. none of above.
4. The leaves of *Mimosa* plant show sleep movement when touched. This movement is known as,
   1. haptonastic movement 2. nyctinastic movement
   3. photonastic movement 4. positive geotropic movement
5. The growth of the stem towards the light is a,
   1. positive phototropic movement 2. negative geotropic movement
   3. haptonastic movement 4. nyctinastic movement

6. A tropic movement is,
   1. a movement with a response directed towards the direction of the stimulus
   2. a movement with a response directed opposite direction of the stimulus
   3. a movement with a response independent of the direction of the stimulus
   4. a movement with a response directed towards or opposite the stimulus

7. The figure shows the demonstration of,
   1. positive geotropic movement
   2. positive phototropic movement
   3. hydrotropic movement
   4. haptonastic movement

02) Following figures show some activities and their observations used to demonstrate the plant movements. Write the name of the movement demonstrated in each activity.

a. Before After

b.

c.

d.

Technical Terms

Support	-	සන්ධාරණය	-	தாங்குதல்
Tropic movements	-	ආවර්තී චලන	-	திருப்ப அசைவு
Nastic movements	-	සන්නමන චලන	-	முன்னிலை அசைவு
Tactic movements	-	සාර්වසර චලන	-	இரசணை அசைவு
In-situ conservation	-	ස්ථානීය සංරක්ෂණය	-	உள்நிலைக் காப்பு

9 The Evolutionary Process

Diversity of living organisms in our environment is a result of the evolutionary process. When studying about the evolution it is important to consider about the origin of the universe and origin of the life.

In the past, there were many beliefs about the origin of the universe.

9.1 Origin of the Earth

It is believed that the origin of the Earth took place about 4.5 billion years ago.

Nebular theory is the first scientific explanation of the origin of the solar system. According to this theory, small particles of materials in the universe drew together by the force of gravity, clumped up, and the galaxies, the sun and other planets were formed.

Big Bang theory can be considered as the modern theory about the origin of the Earth. According to this theory, universe was an energy source with a great energy. A giant explosion took place in it and large clouds of dust particles were created. These dust particles clumped up together and the galaxies were created. It is said in the big bang theory that, our solar system was created in the galaxy known as the milky way galaxy.

Figure 9.1 - Illustration of the Big Bang

Initially the Earth had been a very hot object and its volcanic activities were high. The Earth got gradually cooled and less volatile metals with high density formed the core of the Earth. It is believed that, Earth's crust was created later, by light silicon rocks.

Various types of elements at the centre of the Earth reacted with each other and different types of gases were formed. At first the atmosphere of the Earth had gases such as Carbon dioxide (CO_2), Methane (CH_4) and Hydrogen sulphide (H_2S). The absence of Oxygen (O_2) in the early atmosphere is a significant fact.

Initially, the extreme heat of the Earth caused evaporation of water on the planet. This evaporated water got condensed and clouds were formed. Water droplets in these clouds joined together and dropped onto the Earth as rain. There had been continuous heavy rains on the Earth for many years. This rain water which was rich with minerals, collected in lower lands and oceans were formed.

Figure 9.2 - Illustrations of primitive Earth

9.2 Origin of life on the Earth

There are many beliefs and theories on origin of life on the Earth. It is believed that, about 3.5 billion years ago life originated on the Earth.

Let us consider some theories about origin of life on the Earth.

Theory of special creation

According to this theory, all living organisms on Earth were created by a super natural power. Since there is no scientific evidence to prove this theory, scientist do not pay attention to it.

Spontaneous generation theory

This theory states that life was originated from non-living things in a spontaneous manner.

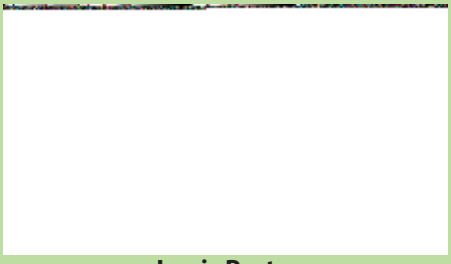
e.g.

- Rats who born from pieces of clothes
- Maggots who born from rotten meat
- Weevils who born from decayed wood

The Spontaneous generation theory has been effectively disproved by the experiments conducted by the scientist Louis Pasteur.

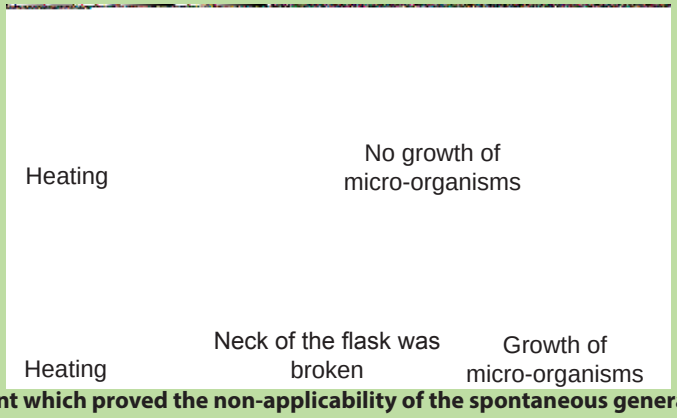
For extra knowledge

Louis Pasteur prepared an experiment to prove that spontaneous generation theory is not an acceptable theory.



Louis Pasteur

- Similar amounts of sterilized nutritional media was added to two similar swan neck flasks. No growth of living organisms was observed.
- After about one year neck of the one flask was broken and taken away.
- Microbial growth was visible in the flask without the neck and no life appeared in the other flask.
- As the conclusion, it was stated that living organisms do not generate spontaneously. This was accepted as true in 1862.



The experiment which proved the non-applicability of the spontaneous generation theory

Cosmozoic theory

This theory suggests that, the living materials might have got established on Earth from a fallen meteor with living organisms or by space crafts from other planets. This theory has not been proved scientifically.

Theory of biochemical evolution

This theory confirms that, at the beginning of the Earth, the gases in the atmosphere reacted with each other and the ingredients that make life possible were formed. It is believed that the energy required for this was supplied by electric discharges during lightning, eruption of volcanoes and by the ultra violet radiation of the sun. These materials dissolved in rain water and collected in oceans. This mixture was known as the **primordial soup**.

The first living cell or the **pre-cell** appeared as a result of a bio chemical reaction in primordial soup. The first organism was unicellular and was considered anaerobic and heterotrophic.

Scientists have experimentally shown that the first living cell was created by the primordial soup.

For extra knowledge

The two scientists Haldane and Oparin put forwarded the biochemical evolution theory about the origin of life. This theory was scientifically proved by Stanley Miller by conducting scientific investigations in laboratory.

Stanley Miller

The first form of life on the Earth is considered to be a simple unicellular bacterium. Then, the first photosynthetic organisms, unicellular algae were formed. After that, an atmosphere containing gaseous oxygen was formed.

Many changes took place for a long time period within the body of unicellular organisms and multicellular organisms were born. Gradually, tissues, organs and systems were specialized within these multicellular organisms and the world of animals and plants were created.

Cnidarians, some annelids and some arthropods are considered as the first multicellular organisms.

The fish are considered as the first type of vertebrates, and amphibians originated from fish. Amphibians can be regarded as the first vertebrates that entered into terrestrial environment. Reptiles evolved as a result of gradual evolutionary changes occurred in amphibians. The reptiles are completely adapted to the terrestrial life than amphibians. It is believed that birds and mammals evolved from reptiles during evolution.

The evolution of human took place about 12 million years ago. Modern human originated about 5 million (5 000 000) years ago.

The world of plants evolved by the gradual changes resulted in photosynthetic algae on the oceans. First, less developed plants originated which, was then followed by non-flowering plants and flowering plants at last.

Accordingly, evolution of life has occurred at different times with several changes. In order to understand that process, study the figure 9.3.

Figure 9.3

9.3 Evolution

Various changes in the natural environment can have an impact on the existence of life.

Life's existence is confirmed by changes that occur gradually in living organisms in relation to continuous changes in the environment.

Early simple living organisms on the Earth have changed over time to become complex organisms.

Gradual development occurred from simple organisms to modern complex organisms is called the evolution.

Various evidences are considered when drawing conclusions about evolution.

- Evidences from geographical animal distribution (biogeography)
- Evidences from comparative anatomy
- Evidences from fossil study (paleontology)

Fossil records show detailed evidences about the changes in living organisms.

Fossils

Preserved plant and animal parts are found during various excavations. A fossil is the preserved remains of an organism, a part of an organism or traces (foot prints, prints on shells) of a dead organism. Such types of fossils are found in rocks, ice, peat bogs, volcanic ash and in mud.

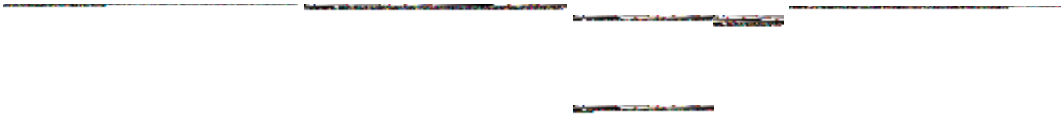


Figure 9.4 - Different types of fossils

Following are some examples for fossils.

- Harder part of an animal such as skeleton, teeth or shells
  As the part of a bone gets slowly decomposed, sludge mud seeps into the pores of the bone. Then, the bone is subjected to a high pressure and turns into a bony rock. This bony rock can be considered as a fossil.
- Some of the dead animals get deposited in the mud. Later the animal get decayed and the decayed matter is removed as gas. The resulting cavity (due to the absence of the dead animal) gets filled with materials such as Silica (sand). This fossil has the same shape of the original skeleton.
- The external skeleton of some insects are preserved in tree resins and are fossilized.
- The preserved bodies of extinct animals such as mammoth are found within ice in the countries of polar region.
- The footprints of animals such as dinosaurs, preserved due to extreme environmental conditions are also considered fossils.

Figure 9.5 - Mammoth

Figure 9.6 - Dinosaur

Let us do the activity 9.1 to create a model fossil

Activity 9.1

You will need:- Kaolin/clay, plaster of Paris, binder glue, 2 yoghurt cups, a spoon, shapes of animals (an oyster shell, fern leaf) a pair of scissors

Method:-

- Fill half of a one yoghurt cup with clay. Place the shell or the leaf on it and press. When the print of the shell or the leaf is marked on clay, remove the shell or the leaf.
- Put some plaster of paris into the other yoghurt cup. Add some water and prepare a plaster. Carefully pour the prepared plaster or binder glue on to the prints on the clay. Keep for about 2 hours to dry.
- Then, cut the yoghurt cup with the scissors and take out the clay lump out of the plaster or binder glue.
- Observe the model fossils on the surface of the clay lump and plaster made with plaster of paris.

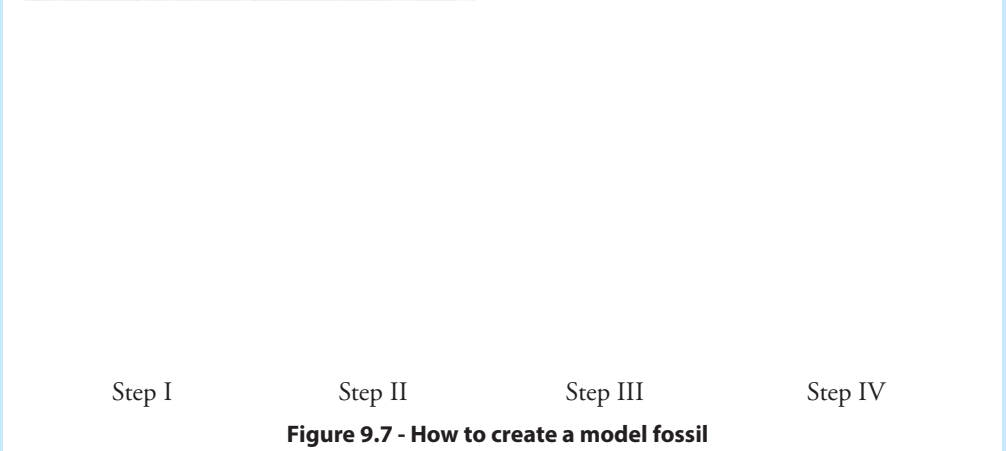


Figure 9.7 - How to create a model fossil

Assignment 9.1

Prepare an article to put up in the wall paper under the following topics.

- Origin of life
- Origin of universe
- Fossils
- Bio-diversity

Living fossils

In biological evolutionary process there must be continuous changes in the bodies of the living organisms. But, some organisms survive even today retaining their physical properties unchanged though million years have passed. These non-evolved organisms are called **living fossils**.

A fish named **Coelacanth** was discovered in the sea near South Africa in 1938, which was believed to be extinct about 70 million years ago. The physical characteristics of this fish was found to be similar to the fish lived million years ago. So, that Coelacanth fish is considered as a living fossil.

Lingula which is found around the "Thambalagamuwa" bay in Trincomalee is also called a living fossil. Not only that, the dragon fly, cockroach and lungfish are also considered as living fossils. The "Ginihota" (Tree fern) is also considered as a living plant fossil.

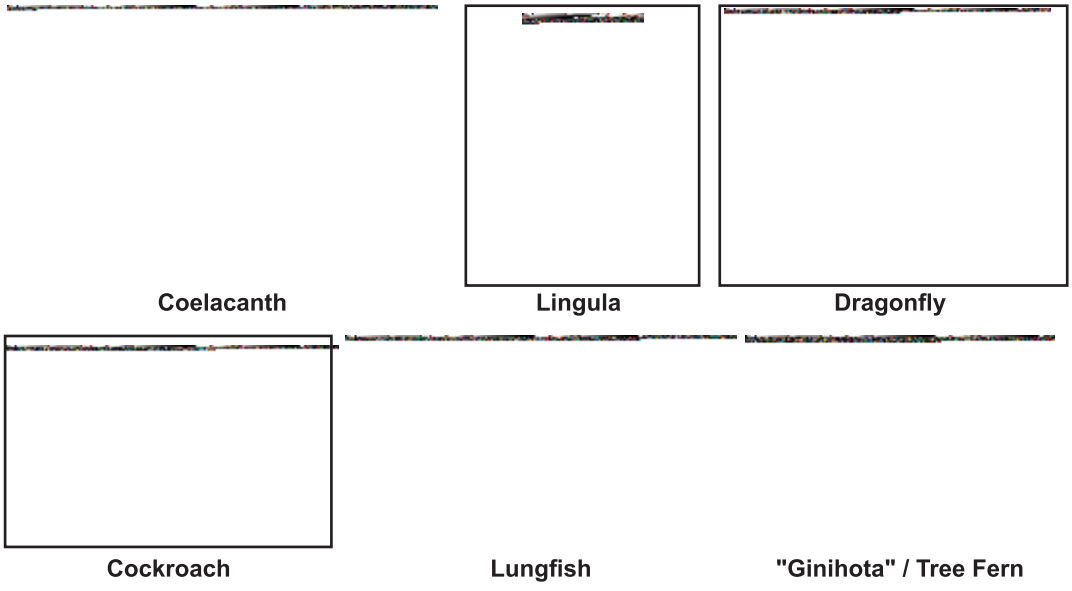


Figure 9.8 - Some living fossils

The rocks formed in different stages on the Earth were arranged in layers. These layers contain the fossils of plants and animals. The early deposited rocks are at the bottom and the older fossils can be seen there.

The rocks are deposited on top of each other. The fossils in recent era can be seen on the top layer of the rocks.

The study of fossils in the rock layers reveals about the plants and animals that lived in different periods of the Earth. It gives an idea about bio evolution.

For extra knowledge

Radioactive carbon ($^{14}_{6}C$) is an isotope of the carbon element which is used to determine the age of the fossils.

Evolution of horse

Coming to conclusions about evolution of organisms using proof from fossils leads to a number of problems, as all the stages of the evolution of an organisms is not preserved in fossil forms. Therefore, fossil evidences are like a story book with torn pages.

However, evolutionary history of horses have been completely studied and revealed clearly as there have been enough fossil records to study the complete evolutionary history of horse.

Figure 9.9 - Evolutionary process of horse

It is believed that the ancestor of modern horse had lived in North America 54 million (54×10^6) years ago. Further it has been revealed that, this animal was about 40 cm in height and was similar to a dog in the body shape. It could run. It had small legs with only three toes in the front legs. The significant feature about this animal is the fingers in front legs which, located on vertical position.

A lot of changes in this animal took place gradually during its evolutionary process. Some gradual changes took place in the methods of locomotion and feeding behaviour.

9.4 Importance of evolution in bio-diversity

There is a competition among animals for the limited resources in the environment. The creatures who succeed, will be naturally selected and be established in the environment. These selected organisms become pioneers in the environment and their population increases. These creatures have created a large bio-diversity in the natural environment. In the process of evolution, novel species can also be evolved from former species. This is known as **speciation** and this process broadens the biodiversity further.

For extra knowledge

Charles Darwin is considered as the **father of evolution**. He put forwarded the **Natural selection theory** which is a scientifically accepted theory about evolution.

Charles Darwin

Assignment 9.2

Prepare a booklet by collecting information on the evidence found in Sri Lanka, about human evolution.

Use the evidence found at "Batadombalena" in "Kuruwita", "Pahiyangala" cave in "Bulathsinhala", "Ibbankatuwa", "Rawana" falls and "Pomparippu". Include the facts about the "Balangoda Man" too.

Summary

- Origin of the Earth took place about 4.5 billion years ago and origin of life took place 3.5 billion years ago.
- "Origination of life is a result of a process of bio-chemical reactions" is the theory that is accepted today.
- Life originated from a unicellular organism that lived in the sea and developed into multicellular organisms.
- Gradual development of the simple organisms to modern complex organisms is called the evolution.
- Fossil records are the main detailed evidence of evolution.
- Animals that do not undergo evolutionary process are known as living fossils.
- Horse is an organism with complete fossil evidence about its evolution.
- Important evidences about evolution of the mankind were found in Sri Lanka.

Exercise

01) Select the correct or most suitable answer.

1. The correct sentences about the origin of the Earth is,
   a. It is considered that, origin of the Earth took place 4.5 billion years ago.
   b. The first scientific theory about the origin of the universe is Nebular theory.
   c. Big Bang theory is considered as a modern theory on origin of the Earth.

   1. a and b 2. a and c 3. b and c 4. a, b and c all

2. The false statement about the early Earth is,
   1. As there was oxygen in the atmosphere, there was life on the Earth.
   2. Gases such as carbon dioxide and methane were formed as a result of the reactions between elements.
   3. Heavy rain fell down on the Earth for many years.
   4. The rain water rich with minerals was collected to form oceans.

3. Today's accepted theory on origin of life on the Earth is the,
   1. Theory of special creation
   2. Spontaneous generation theory
   3. Cosmozoic theory
   4. Theory of bio-chemical evolution

4. The true statement on the origin of life is,
   a. First living organism on Earth was a unicellular algae.
   b. Multicellular organisms were originated from the evolution of unicellular organisms.
   c. Origin of modern human took place 4.5 billion years ago.

   1. a and b 2. a and c 3. b and c 4. a, b and c all

02) State whether the following statements are true (√) or false (x).

1. The first originated organism on primordial soup was a unicellular bacterium. ( )
2. Gradual development of modern complex organisms from simple organisms is known as evolution. ( )
3. To come to a conclusion on biological evolution, only fossil evidence is sufficient. ( )
4. Lingula is a living fossil found in Sri Lanka. ( )
5. The process of evolution too contribute towards the bio-diversity. ( )

03) Give short answers.

1. Write two examples for living fossils.
2. Simply describe the contribution of fossils to study the evolutionary process.
3. Write five places in Sri Lanka that give evidence on evolution of the mankind.
4. Write a modification on feet of horse occurred during its evolution.
5. Write three examples for organisms who became extinct from the Earth but whose fossils were found.

Technical Terms

Big Bang theory	- මහා පිපිරුම් වාදය	- பெருவெடிப்புக் கொள்கை
Bio-diversity	- ජෛව විවිධත්වය	- உயிர்ப்பல்வகைமை
Primordial soup	- ආදි සූපය	- ஆதிக்கூழ்
Bio-chemical evolution	- ජෛව රසායනික පරිණාමය	- உயிரிரசாயனக் கூர்ப்பு
Spontaneous generation theory	- ස්වයං සිද්ධ ජනනවාදය	- தன்னிச்சைப் பிறப்பாக்கக் கொள்கை
Fossil	- පොසිලය	- உயிர்ச் சுவடு
Living fossil	- ජීවමාන පොසිලය	- வாழும் உயிர்ச்சுவடு
Theory of natural selection	- ස්වාභාවික වරණ වාදය	- இயற்கைத் தேர்வுக் கொள்கை
Speciation	- විශේෂ ප්‍රාප්තිය	- இனமாதல்