1 VALUES, WISDOM & KNOWLEDGE – THE ULTIMATE AIM OF EDUCATION

INTRODUCTION

What is the ultimate aim of 'Education' or studying any subject? It is generally thought that education means acquiring a Certificate or Degree after passing an examination. You think that even if you forget everything after the exam, but you have got the certificate or degree, you are educated. This is a wrong notion. After earning a certificate or a degree, you are only a qualified person, not an educated person.

Some others think that education means acquiring knowledge, which is generally equated to getting information about a subject, which is needed to pass an exam with good marks. This is also a wrong notion. 'Knowledge' is not just 'Information'. It is much more than that. Information may be limited to our immediate purpose, which is in our context passing an exam and so limited to the syllabus or even limited to the important or expected questions in the exam.

Knowledge, in fact, is not, and cannot be the end of all education. Knowledge without understanding, without application in real life situations, is useless. Ultimately, the aim of education is to acquire wisdom. Wisdom is also closely related to what is called 'World View', which means a holistic understanding of our world, our universe, and our environment. World View comes by correlating the knowledge from all subjects.

Do you know that there is a close relationship between values, wisdom, and knowledge? Wisdom includes values and knowledge. Wisdom cannot be visualized without values. One cannot be called wise if he/she does not adhere to human values. And of course, knowledge that does not lead to wisdom is valueless.

Values can be defined as a set of norms of behavior that guide the people to do things in such a way that there will be joy, satisfaction, peace of mind, and harmony among individuals and in society.

Derived from a Latin word 'valere', values can be conceptualized as preferences, enduring beliefs, or standards of behavior which guide behaviour and attitude of an individual towards what is right or acceptable.

1.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Elucidate the ultimate aim of education

- Appreciate and explain the relationship between Values, Wisdom and Knowledge
- List and appreciate Universal and Eternal Values
- Explain the Hindu concept of '*Vasudhaiva Kutumbakam'* as a basic Hindu value
- Explain 'True Secularism'
- Discuss in detail *Satyam*, *Shivam* and *Sundaram*
- List Universal 'Vices' that need to be avoided as sins
- List Universal Virtues enumerated in the '*Gita*' as '*Daivi Sampath*' or Divine Virtues
- Discuss Linguistic Connotations and sources of Knowledge and wisdom in Ancient Bharat
- Explain the terms: *Gyan, Pragya, Darshan, Vidya* and *Kala*
- Discuss the Meaning of Knowledge and Disciplines of Knowledge

1.2 UNIVERSAL AND ETERNAL VALUES

There are three eternal universal human values: ***Satyam, Shivam Sundaram*** **(or Truth, Beauty and Goodness/Godliness)**. All human beings are in search of these three values, though what they mean can vary from place to place as well as time to time. The main branches of Philosophy are based on these three values. Satyam, Shivam, Sundaram has its roots in Indian philosophy and also Western philosophy where it is known as Truth, Beauty and Goodness/Godliness. The main branches of Philosophy are:

(i) Metaphysics/Ontology (Study of Reality)
(ii) Epistemology (Theory of Knowledge/Methods of Knowledge)
(iii) Logic (The most important method of Knowledge)
(iv) Ethics/Axiology (Study of Good and Bad, Right and Wrong)
(v) Aesthetics (Study of Beauty)

Evidently, the first three, i.e., Metaphysics/Ontology, Epistemology and Logic search for Satyam or Truth; the fourth, i.e., Ethics explores Shivam or Goodness; and the fifth, i.e. Aesthetics studies the concept of Sundaram or Beauty. These three values – Satyam, Shivam and Sundaram are very closely linked to our lives.

All truth—material, philosophic, or spiritual—is both beautiful and good. All real beauty—material, art or spiritual symmetry—is both true and good. All genuine goodness—personal morality, social equity & justice, or divine spirituality—is equally true and beautiful. Health, sanity, and happiness are integrations of truth, beauty, and goodness as they are blended in human experience. Such levels of efficient living come about through the unification of energy systems, idea systems, spiritual systems and value systems.

Satyam, Shivam, Sundaram also teach us to strengthen loving attitude towards everyone.

1.2.1 *Vasudhaiva Kutumbakam*: Key to Secularism

Another related wonderful concept given by Indian philosophy is '***Vasudhaiva Kutumbakam*'**, meaning that the whole world, all human beings are one family.

'Vasudhaiva' means the Mother Earth or the World, implying all human beings, possibly all living beings on Earth. '*Kutumbakam*' means family. Since all human beings are members of one family, we should have a loving attitude towards everyone, irrespective of religious, geographical, social or economic background. **Under this philosophy, all religions are considered to be different paths leading to a common end or goal.** There is one Supreme Power that is called '*Brahm*'. The Supreme Power is also called as God, *Ishwar, Allah*, etc. in various religions. Thus, Hindu religion, which is also called *Sanatan Dharma* (and includes Jainism, Buddhism and Sikhism as a part of the same ethos) is secular by virtue of its philosophy and its very nature. Even if there is a Hindu Country (or *Rashtra*), it will be secular naturally and all citizens will be able to live in harmony and peace. The Hindus never harm anyone of any other religion, unless someone tries to harm them. True Secularism means that:

- There is no discrimination in the name of religion;
- All religions are equal and so there is a common law or civil code for everyone (there is no scope for law based on religion);
- There is religious freedom and everyone is allowed to practice his/her religion;
- No one should interfere with the religion of others and so no one should try to convert others forcibly or by false propaganda
- There is no scope for partisan fundamentalist education, propagating fundamentalism or hatred towards other religions

Now, let us discuss the three Universal Eternal Values in detail, one by one.

1.2.2 Satyam/Truth

All of us are in search of truth – at every level. We are all seeking knowledge, which is closely linked to truth. Truth works at least at three levels – facts, reality and ultimate truth.

Facts can be comprehended through our five senses – seeing, hearing, smelling, touching and tasting. All sciences (physical & natural and social) try to establish facts. For instance, Physics studies the physical world; Chemistry studies facts of chemical reactions; and Biology studies the world of flora and fauna, i.e. living world.

Metaphysics goes beyond the physical world and attempts to study (and find) reality, which is beyond the five senses. Epistemology gives us the methods of finding knowledge, i.e. reality. Logic is the most important of these methods. In Indian Thought, there is the concept of '*Para Vidya*' and '*Apara Vidya'*. '*Para*' literally means beyond, and so *Para Vidya* refers to knowledge of the beyond or Metaphysics, whereas *Apara Vidya* is knowledge of the Empirical World, which can be acquired through our 5 senses or physical perception.

Even in everyday life, we like truth to prevail. Those who tell lies are not appreciated or liked in society. Can you identify any religion or faith which says that speaking truth is wrong?

We are also looking for truth about questions like:

- Who am I?
- What is the purpose of life?
- What is death? Is there life after death?
- What is God? Does He/She/It really exist?
- Is there a soul? Is it eternal?

All religions try to answer these questions. These are elements of what we may call the ultimate truth.

CHECK YOUR PROGRESS 1.1

(i) What is the ultimate aim of 'Education'?

(ii) What is the meaning of the word 'Values'?

(iii) What is the relationship between Values, Wisdom and Knowledge.

(iv) Which are the 3 Universal and Eternal Values?

(v) Name the 5 Branches of Philosophy? Also, mention the Universal and Eternal Value that it corresponds to.

(vi) What do you understand by the term **'*Vasudhaiva Kutumbakam*'?**

(vii) What are the different names given to the Supreme Power in different religions?

(viii) Explain how Hinduism, Hindus and Hindu Rashtra are naturally secular.

(ix) What is true secularism?

(x) Distinguish between '*Para Vidya*' and '*Apara Vidya'*.

(xi) *Satyam, Shivam, Sundaram* has its roots in …………………..

(xii) ………………..is the branch of philosophy that deals with methods of knowledge.

(xiii) Axiology is the branch of philosophy that deals with ………………

1.2.3 Shivam/Goodness/Godliness

Just as we are in search of truth, we are also in search of Goodness/Godliness. Right from childhood, one wants to be a good child; we want to be called good persons all our lives. Even a criminal would try to justify his/her actions and try to prove that he/she is good, not bad.

Ethics provides the moral code, or philosophy, that guides a person's choices and behaviors throughout their life. The idea of a moral philosophy extends beyond the individual to include what is right (and what is wrong) for the community and society at large. Ethics is concerned with rights, responsibilities, use of ethically appropriate language, what it means to live an ethical life and how people make moral decisions.

Morality can be subjective; people may have strong and stubborn beliefs about what's right and wrong that can be in direct contrast to the moral beliefs of others. Yet even though morals can vary from person to person, religion to religion, and culture to culture, there are some universal moral values that stem from basic human emotions. For instance, **non-violence and not harming human beings, irrespective of their religious background, is and should be considered as a universal virtue. If someone kills or harms other human beings, even those who follow another religion, he/she cannot be called virtuous. Any claims that religion teaches killing other human beings are false claims. True religion cannot teach killing other humans, even those humans who follow other religions.**

Those who are considered morally good are said to be virtuous, holding themselves to high ethical standards, while those viewed as morally bad are thought to be wicked, sinful, orcriminal.

1.2.3.1 Vices

There are some vices considered to be deadly vices by most religions. These are:

- *Kaam* (Lust))
- *Krodh* (Anger/Wrath)
- *Lobh* (Greed)
- *Ahankar* (Ego/Vanity)
- *Irshya* (Jealousy)

Hinduism also includes *Moh* (Attachment to worldly objects and pleasures); and Christianity also includes Gluttony (habitual greed or excess in eating) and Sloth (reluctance to work or laziness).

According to Gandhiji, the following are signs of vice or immorality:

- Wealth without Work
- Pleasure without Conscience
- Science without Humanity

- Knowledge without Character
- Politics without Principle
- Commerce without Morality
- Worship without (Self) Sacrifice

1.2.3.2 Virtues

The ***Gita*** enumerates many virtues as *Daivi-Sampat* or divine qualities:

- Fearlessness
- Purity of heart
- Steadfastness and wisdom
- *Vivek* (ability to discriminate between right and wrong)
- *Nishkam Karma* (desireless action or doing one's duty without caring for the result)
- Charity
- Self-restraint
- Sacrifice
- Study of the scriptures
- Austerity or simplicity
- Straightforwardness
- Harmlessness (tendency of not harming anyone)
- Truth
- Absence of anger
- Renunciation
- Peacefulness
- Absence of crookedness
- Compassion to all living beings
- Non-covetousness (not having, or showing, a desire to possess something belonging to someone else)
- Mildness (soft-heartedness and sensitivity towards others)
- Modesty or humility
- Absence of fickleness (changeability, especially with regard to one's loyalties or affections)
- Vigour
- Forgiveness
- Purity
- Absence of jealousy, vanity and arrogance.

These virtues are manifestations of the four fundamental virtues: Non-violence, Truth, Purity, and Self-control. In fact, all the religions in the world speak of virtues. Right actions bring us happiness, peace and well-being. So, it is not surprising that all the major religions talk of virtues. For instance, in Christianity, there are seven virtues: Faith, Hope, Charity, Fortitude, Justice, Prudence, and Temperance. Every religion speaks of virtues, because every religion is a living entity and believes in the happiness and well being of all.

1.2.4 Sundaram/Beauty

Sundaram/Beauty is the third universal and eternal value. Similar to truth and goodness, we are in search of beauty, too, in our lives. What is beauty? The concept of beauty may change from person to person. In that sense, this is the most subjective among these three values, because where one looks for beauty may also change. Thus, some people look for beauty in nature (flora, fauna); some look for it in Arts (Painting, Sculpture, etc.); some search for beauty in literature (poetry, prose, drama); some look for beauty in people; some may find beauty in philosophical or spiritual or religious pursuits; and so on and so forth. Some look for beauty outside and others within. Some like people who are physically beautiful; others may like people who have inner beauty, those who are virtuous or accomplished people. In fact, you will be surprised to know how many different things people can find beauty in – things, people, places, ideas.

The famous Romanticist poet John Keats wrote, "*Beauty is truth, truth beauty. That is all ye know on earth, and all ye need to know*". In another poem, he wrote, "*A thing of beauty is a joy forever*".

Beauty is an emotional element, a pleasure of ours, which nevertheless we regard as a quality of things. The idea of beauty is found in almost every culture and at almost every time in human history, with many similarities. Beauty was, and still is, a term of great esteem linking human beings and nature with artistic practices and works since the early civilizations. From the early cultures, beauty, goodness and truth are customarily related. Beauty carries a double meaning. It is inclusive and exclusive. In the inclusive sense, beauty pertains to anything worthy of approbation, to human virtues and characters, to nobility and goodness, to hidden things and truth, to the natural and divine worlds. In the exclusive, restricted sense, it pertains to how things appear, their manifestations, and to the joys human beings experience when presented with beautiful things, human bodies, artefacts, natural creatures and things. The nature of beauty and its role in philosophy and aesthetics was explained right from the early periods.

CHECK YOUR PROGRESS 1.2

(i) What do you understand by the term '*Shivam*'?

(ii) List the Universal Vices.

(iii) List the signs of vice or immorality as given by *Gandhiji*.

(iv) List the Universal Virtues enumerated in the '*Gita*' as '*Daivi-Sampat*' or Divine Qualities of a person.

(v) Name the 4 fundamental virtues.

(vi) What do you understand by the term '*Sundaram*'?

1.3 LINGUISTIC CONNOTATIONS AND SOURCES OF KNOWLEDGE AND WISDOM IN ANCIENT BHARAT

From ancient times, India has given a great importance to acquisition of knowledge and it has a vast fund of this knowledge in the form of intellectual texts - the world's largest collection of manuscripts, scriptures and thinkers and schools in so many domains of knowledge. *Shree Krishna* in *Bhagwad Gita* tells Arjun that knowledge is the greatest purifier and liberator of the self.

Various terms are closely related to pursuit of knowledge like *Gyan, Pragya, Shiksha, Vidya*, *Kala* and *Darshan*. The root of the great reverence for all knowledge that is *Gyan*, wisdom that is *Pragya*, discipline that is *Vidya*, education that is *Shiksha*, craft that is *Kala* and philosophy that is *Darshan* is attached to the *Guru* in the Indian tradition as he/she is considered as the ultimate authority and source of all knowledge.

- ***Gyan* or *Jnana* (Knowledge):** In Vedic India, education was regarded as the means of self realization and salvation that is *moksha*, which was considered as the highest end of life. Learning was done to acquire *atmagyan* (knowledge about Self) or *brahmagyan* (knowledge about the Supreme).
- ***Pragya* or *Prajna* (Wisdom):** To acquire knowledge merely with the help of sense organs is called *Ajñāna* (ignorance) and to get knowledge by name and form is *Sajna* or *Sjnana*. Acquisition of special knowledge through analysis or contemplation which always remain constant is *Pragya*. Wisdom that is *Pragya* is built on our previous knowledge to give us new understanding by incorporating various value judgments and experiences and it develops our ability to predict and make inferences.
- ***Darshan*:** *Darshan* is the system or the point of view which leads to knowledge. Indian philosophers, *rishis* and *saints* use the term *Darshan* for philosophy. They expressed in *Darshan* experiences that they experienced themselves. Perception of truth is known as *Darshan*. In the words of *Dr. Radhakrishnan*, *Darshan* is the logical expression of the nature of reality.
- ***Vidya***: When knowledge is gained in a particular domain and it is organised and systematized for reflection and pedagogy, it is known as *Vidya* which is based on discipline. 18 *Vidyas* have been enumerated, which include:
    - 4 *Vedas*: *Rigveda, Yajurveda, Samaveda, Atharva Veda*
    - 6 *Vedangas*: *Chhandassu, Kalpam, Nirukttham, Sikshaa, Vyakarana, Jyotisham*
    - *Ashtadasa* (18) *Puranas*: (History)
    - *Mimamsa* (Study of Actions) and *Vedanta* (Study of Knowledge)
    - 4 Subsidiary *Vedas* - *Ayurveda* (Medicine), *Dhanurved* (Weaponry) *Gandharvaveda* (Music), *ArdhaShastram* (Economy and Polity)
    - *Shilpa* (Architecture)
    - *Nayaya* and *Dharamshastras* (Law and Justice)
    - 6 Auxiliary Sciences - Phonetics, Grammar, Metre, Astronomy, Ritual and Philology.

- ***Kala***: In the Indian context, Knowledge in different domains has been categorised into many disciplines that is *Vidya* and Arts that is *Kala*. Indian tradition talks of 18 major *Vidyas* that is theoretical disciplines (enumerated above) and 64 *Kalas* which are applied or vocational disciplines, that is Art and Craft. Applied Sciences, that is *Kala*, have a direct bearing on day-to-day life of the people and some of them are still a part of contemporary Indian life. The traditional list of *Kala* includes Poetry, Calligraphy, Dancing, Cooking, Carpentry, Agriculture, Animal Husbandry, Fishing, etc. Even for the crafts there are basic texts, for example the popular text *Pingla*.

CHECK YOUR PROGRESS 1.3

(i) Define *Gyan*.

(ii) Define *Pragya*.

(iii) Define *Darshan*.

(iv) Define *Vidya*.

(v) Define *Kala*.

(vi) To acquire knowledge with the help of sense organs is called ………….

(vii) Indian *Rishis* and *Saints* use the term *Darshan* for ………………….

(viii) Indian tradition talks of …..major *vidyas* and …….. *Kalas*.

(ix) ………………….. is the popular text of craft.

1.4 MEANING OF KNOWLEDGE AND DISCIPLINES OF KNOWLEDGE

1.4.1 Meaning of Knowledge

Knowledge and its transmission is one of the key elements of education, apart from, and only second to, values and wisdom. What aspects of the vast fund of human knowledge are to be selected for transaction and which methods are to be used for this transmission? These questions are very important. According to *Nyaya*, one of the nine Schools of Thought in Indian Philosophy, "Valid methods of knowledge include perception, inference, comparison and memory." Now, let us explore and discuss the meaning of knowledge in detail.

The word 'Knowledge' is derived from the verb 'to know'. It includes all which a person knows and believes to be true. According to the most widely accepted definition, knowledge is justified true belief. It is a kind of belief that is supported by the facts and truths. For example, the sun rises in the east is the knowledge or true belief which is supported by the fact, which is arrived at through daily observation by millions of people. To have a deeper understanding about knowledge let us analyze the following definitions:

- **Oxford Dictionary:** Knowledge means facts, information and skills acquired through experience or education. It is the theoretical or practical understanding of a subject.
- ***Bertrand Russel:*** "Knowledge is that which enlightens the human mind."
- ***William James:*** "Knowledge is another name for practical achievement and success."
- ***Joad:*** "Knowledge is an addition to our existing information and state of experiences."
- ***Socrates:*** "Knowledge is the highest virtue."
- ***Radhakrishnan:*** "Self-knowledge is inseparable from self-existence and it is the only true direct knowledge. It is obtained through all the three experiences i.e., cognition, conation and emotion."
- ***John Wieley:*** "Knowledge is a body of information, technique and experience that coalesces around a particular subject."
- ***Nancy M. Dixon:*** "Knowledge is defined as the meaningful links people make in their minds between information and its application in action in a specific setting."

In the light of above definitions, we can say that, knowledge is the familiarity, awareness or understanding of someone or something such as facts, information, description or skills, which is acquired through experience or education by perceiving, discovering or learning.

Knowledge can be conceived as experience organized through language into patterns of thought or structures of concepts thus creating meaning which in turn helps us to understand the world we live in. It can also be conceived of as patterns of activity, or physical dexterity with thought, contributing to acting in the world, and the creating and making of things. Human beings over time have evolved many bodies of knowledge which include a repertoire of ways of thinking, of feeling and of doing things or constructing more knowledge.

Knowledge includes the beliefs about matters of facts, about things, objects, events or about relationships between facts and about principles, laws, theories related to nature and society. It includes the fact or condition of knowing which is gained through experience or education. Knowledge is the sum of human understanding of the world, be it physical, biological, social, mental or spiritual. In simple, but generalized way, knowledge is sum of human understanding of material and mental reality – given and constructed.

1.4.2 Nature of Knowledge

- **Knowledge is both Process and Product:** As a process, it refers to the method of coming to know the phenomenon. Knowledge as a product, is the result of knowing the process. Knowing happens through perception, reason and emotion.
- **Purpose of Knowledge:** The purpose of knowledge is different in different contexts.

- **Knowledge is Dynamic in Nature:** Knowledge keeps changing with the passage of time.
- **Knowledge is of Different Types:** Sources of knowledge are knower's senses and mind. Different sources of knowing construct different forms of understanding and different types of knowledge.
- Knowledge is subjective as well as objective in nature.
- Knowledge is a means to reach the truth.
- **Social Nature of Knowledge:** Knowledge is socially shared understanding as it is developed through collective efforts of people of society. It is acquired by individuals from their own experiences, as well as they build-up this knowledge by associating with other human beings. Therefore, the knowledge is acquired and built-up only in society and it is deep rooted in the social activities of humans.
- **Knowledge is Cumulative:** Knowledge is cumulative as it is preserved and transmitted from one generation to other. New innovations and facts are added with time. Knowledge grows through a process of not only adding to but also perfecting and rectifying the already existing body of knowledge.

1.4.3 Disciplines of Knowledge

Discipline means deep and detailed content knowledge of a particular academic area. Discipline can be defined as a term of learning that is structured in terms of a single type of knowledge. It has a set of concepts that are unique and distinct. Disciplines can be categorized into:

I. **Basic Disciplines** - Basic Disciplines have their own concepts which are unique and distinctive to that discipline only. Principal Basic Disciplines are Humanities, Social Sciences Mathematics (also called Formal Science), Natural and Physical Sciences, Applied Sciences.

II. **Applied Disciplines** - When knowledge of a basic discipline is used in other disciplines, they are called applied disciplines. For example, knowledge of science and technology is used in Engineering, so it is an applied discipline. Some other examples are: Agriculture; Architecture and Design; Business Studies & Accountancy; Education; etc.

Humanities: History, Languages and Literature, Law, Philosophy, Theology, Visual Arts, Performing Arts

Social Science: Anthropology, Archaeology, Economics, Geography, Political science, Psychology, Sociology, Social work

Natural Science: Biology, Chemistry, Physics, Earth Science, Space Science,

Formal Science: Computer Science, Mathematics

Applied Science: Agriculture; Architecture and Design; Business Studies & Accountancy; Education; Engineering and Technology; Environmental Studies and Forestry, Home Science& Human Ecology; Journalism, Media studies and Communication; Library and Information Science; Medicine and Health; Military Science; Public Administration&Public Policy; Social Work, Tourism; Transportation, etc.

1.4.3.1 Interdisciplinary Approach

Interdisciplinary Approach utilizes one discipline or several disciplines as a centre for organizing curriculum. For example, if we consider Economics, then knowledge of Mathematics and other branches of Social Science help to understand the key concepts of this discipline. This is an Interdisciplinary approach where one discipline is the principal organiser, related disciplines are serving as the support system aiding the principal organiser. Interdisciplinary approach is a mode of acquiring integrated knowledge from two or more disciplines, in order to have a better understanding and to solve a problem which would not have been possible through a single discipline.

1.4.3.2 Multidisciplinary Approach

In Multidisciplinary Approach, concepts are selected from various disciplines to create a new field of study. The new field results from intermingling the abstract concepts and is independent of the separate discipline from which it is formed. For example, in the area of Environmental Education, the knowledge of Biology, Geography, Physics, Chemistry and Education are used. There are other areas that are multidisciplinary like Home Economics, Sociology, Biology.

CHECK YOUR PROGRESS 1.4

(i) Define Knowledge.

(ii) Knowledge is the highest ……………

(iii) What are 'Basic Disciplines'?

(iv) What are 'Applied Disciplines'?

(v) What is 'Interdisciplinary Approach?

(vi) What is 'Multidisciplinary Approach?

(vii) When knowledge of basic discipline is used in other disiplines, they are called…………………

(viii) ……………………… is an example of multidisciplinarity.

RECAPITULATION POINTS

- Knowledge, in fact, is not, and cannot be the end all of education. Knowledge without understanding, without application in real life situations, is useless. Ultimately, the aim of education is to acquire wisdom. Wisdom is also closely related to what is called 'World View', which means a holistic understanding of our world, our universe, our environment. World View comes by correlating the knowledge from all subjects.

- There is a close relationship between values, wisdom and knowledge. Wisdom includes values and knowledge. Wisdom cannot be visualised without values. One cannot be called wise if he/she does not adhere to human values. Knowledge that does not lead to wisdom is valueless.

- There are three eternal universal human values: ***Satyam, Shivam Sundaram*** **(or Truth, Beauty and Goodness/Godliness)**. All human beings are in search of these three values, though what they mean can vary from place to place as well as time to time.

- The main branches of Philosophy are: Metaphysics / Ontology (Study of Reality); Epistemology (Theory of Knowledge/Methods of Knowledge); Logic (The most important method of Knowledge); Ethics (Study of Good and Bad, Right and Wrong); and Aesthetics (Study of Beauty)

- Metaphysics/Ontology, Epistemology and Logic search for *Satyam* or Truth; Ethics explores *Shivam* or Goodness; and Aesthetics studies the concept of *Sundaram* or Beauty.

- These three values – *Satyam, Shivam* and *Sundaram* are very closely linked to our lives.

- Another related wonderful concept given by Indian philosophy is **'*Vasudhaiva Kutumbakam*'**, meaning that the whole world, all human beings are one family. '*Vasudhaiva*' means the Mother Earth or the World, implying all human beings, possibly all living beings on Earth. '*Kutumbakam*' means family. Since all human beings are members of one family, we should have a loving attitude towards everyone, irrespective of religious, geographical, social or economic background.

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- Hinduism also includes *Moh* (Attachment to worldly objects and pleasures); and Christianity also includes Gluttony (habitual greed or excess in eating) and Sloth (reluctance to work or laziness).

- According to Gandhiji, signs of vice or immorality: Wealth without Work; Pleasure without Conscience; Science without Humanity; Knowledge without Character; Politics without Principle; Commerce without Morality; and Worship without Sacrifice.

- The ***Gita*** enumerates many virtues as *Daivi-Sampat* or divine qualities: Fearlessness; Purity of heart; Steadfastness and wisdom; *Vivek* (ability to discriminate between right and wrong); *Nishkam Karma* (desireless action or doing one's duty without caring for the result); Charity; Self-restraint; Sacrifice; Study of the scriptures; Austerity or simplicity; Straightforwardness; Harmlessness (tendency of not harming anyone); Truth; Absence of anger; Renunciation; Peacefulness; Absence of crookedness; Compassion to all living beings; Non-covetousness (not having, or showing, a desire to possess something belonging to someone else); Mildness (soft heartedness and sensitivity towards others); Modesty or humility; Absence of fickleness (changeability, especially with regard to one's loyalties or affections); Vigour; Forgiveness; Purity; Absence of jealousy, vanity and arrogance.

- Four fundamental virtues are: Non-violence, Truth, Purity, and Self-control.

- Right actions bring us happiness, peace and well-being. So, it is not surprising that all the major religions talk of virtues. For instance, in Christianity, there are seven virtues: Faith, Hope, Charity, Fortitude, Justice, Prudence, and Temperance. Every religion speaks of virtues, because every religion is a living entity and believes in the happiness and well being of all.

- Beauty is an emotional element, a pleasure of ours, which nevertheless we regard as a quality of things. The idea of beauty is found in almost every culture and at almost every time in human history, with many similarities. Beauty was, and still is, a term of great esteem linking human beings and nature with artistic practices and works since the early civilizations.

- From the early cultures, beauty, goodness and truth are customarily related.

- Beauty carries a double meaning. It is inclusive and exclusive. In the inclusive sense, beauty pertains to anything worthy of approbation, to human virtues and characters, to nobility and goodness, to hidden things and truth, to the natural and divine worlds. In the exclusive, restricted sense, it pertains to how things appear, their manifestations, and to the joys human beings experience when presented with beautiful things, human bodies, artefacts, natural creatures and things. The nature of beauty and its role in philosophy and aesthetics was explained right from the early periods.

- From ancient times, India has given a great importance to acquisition of knowledge and it has a vast fund of this knowledge in the form of intellectual texts - the world's largest collection of manuscripts, scriptures and thinkers and schools in so many domains of knowledge.

- *Shree Krishna* in *Bhagwad Gita* tells Arjun that knowledge is the greatest purifier and liberator of the self.

- Various terms are closely related to pursuit of knowledge like *Gyan, Pragya, Shiksha, Vidya, Kala* and *Darshan.*

- The root of the great reverence for all knowledge that is *Gyan*, wisdom that is *Pragya*, discipline that is *Vidya*, education that is *Shiksha*, craft that is *Kala* and philosophy that is *Darshan* is attached to the *Guru* in the Indian tradition as he/she is considered as the ultimate authority and source of all knowledge.

- In the Indian context, Knowledge in different domains has been categorised into many disciplines that is *Vidya* and Arts that is *Kala*. Indian tradition talks of 18 major *Vidyas* that is theoretical disciplines and 64 *Kalas* which are applied or vocational disciplines, that is Art and Craft.

- Knowledge and its transmission is one of the key elements of education, apart from and only second to values and wisdom. What aspects of the vast fund of human knowledge are to be selected for transaction and which methods are to be used for this transmission? These questions are very important. According to *Nyaya*, one of the nine Schools of Thought in Indian Philosophy, "Valid methods of knowledge include perception, inference, comparison and memory."

- Knowledge can be conceived as experience organized through language into patterns of thought or structures of concepts thus creating meaning which in turn helps us to understand the world we live in. It can also be conceived of as patterns of activity, or physical dexterity with thought, contributing to acting in the world, and the creating and making of things. Human beings over time have evolved many bodies of knowledge which include a repertoire of ways of thinking, of feeling and of doing things or constructing more knowledge.

- Basic Disciplines have their own concepts which are unique and distinctive to that discipline only. Principal Basic Disciplines are Humanities, Social Sciences Mathematics (also called Formal Science), Natural and Physical Sciences, Applied Sciences.

- When knowledge of a basic discipline is used in other disciplines, they are called applied disciplines. For example, knowledge of science and technology is used in Engineering, so it is an applied discipline. Some other examples are: Agriculture; Architecture and Design; Business Studies & Accountancy; Education; etc.

- Interdisciplinary Approach utilizes one dicipline or several disciplines as a centre for organizing curriculum.

- In Multidisciplinary Approach, concepts are selected from various disciplines to create a new field of study. The new field results from intermingling the abstract concepts and is independent of the separate discipline from which it is formed.

TERMINAL EXERCISE

(a) Write a detailed note on 'Ultimate aim of Education.

(b) Explain how Values are related to Wisdom, Knowledge and Education.

(c) Write an essay on '*Satyam*'.

(d) Write an essay on '*Shivam*'.

(e) Write an essay on '*Sundaram*'.

(f) Write an essay on '*VasudhaivaKutumbakam*'.

(g) Write an essay on 'True Secularism'.

(h) Write an essay on the Indian concept of Knowledge, explaining related terms like *Gyan, Pragya, Shiksha, Vidya, Kala* and *Darshan*.

(i) Write an essay on 'Meaning of Knowledge'.

(j) Write an essay on 'Nature of Knowledge'.

(k) Write an essay on 'Disciplines of Knowledge'.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 1.1

(i) To acquire wisdom

(ii) Page 1, 1: Paragraph 5

(iii) Page 1, 1:Paragraph 4

(iv) *Satyam, Shivam, Sundaram* (Truth, Beauty and Goodness/Godliness)

(v) Page 2 - Metaphysics / Ontology…..Aesthetic (Study of Beauty)

(vi) The whole world, all human beings are one family

(vii) *Brahman, Ishwar*, God, *Bhagwan, Allah, Khuda*

(viii) Page 3, Paragraph 1

(ix) Page 3, Paragraph 1

(x) Page 3, 3.1: Paragraph 4

(xi) Indian philosophy and Western Philosophy

(xii) Epistemology

(xiii) Study of values

CHECK YOUR PROGRESS 1.2

(i) Goodness/Godliness

(ii) Page 5, 3.2.1: Paragraph 1

(iii) Page 5, 3.2.1: Paragraph 3

(iv) Page 5, 3.2.2: Paragraph 1

(v) Non-Violence, Truth, Purity & Self-Control

(vi) Page 6, 3.3: Paragraph 1

CHECK YOUR PROGRESS 1.3

(i) Page 7, 4: Paragraph 3

(ii) Page 7, 4: Paragraph 4

(iii) Page 7, 4: Paragraph 5

(iv) Page 8, 4: Paragraph 1

(v) Page 8, 4: Paragraph 2

(vi) *Pragya*

(vii) Point of view which leads to knowledge

(viii) 18, 64

(ix) *Pingla*

CHECK YOUR PROGRESS 1.4

(i) Page 8, 5.1: Paragraph 1

(ii) virtue

(iii) Page 10, 5.3 I

(iv) Page 10, 5.3 I

(v) Page 11, 5.3.1, Paragraph 1

(vi) Page 22, 5.3.2, Paragraph 1

(vii) Applied Discipline

(viii) Environmental Education/Home Economics/Sociology/Biology

SUPPLEMENTARY STUDY MATERIAL

- *Bhagavad Gita* as It is - Pocket Size by *Bhaktivedanta Swami Prabhupada* (Author)
- https://www.youtube.com/playlist?list=PLETbXIpqYH_qEOkBsrztDD4arUW1cGrm6
- http://www.bhagavatgita.ru/files/Bhagavad-gita_As_It_Is.pdf
- https://vedpuran.files.wordpress.com/2012/03/unencrypted-geeta.pdf

2 KNOWLEDGE AND WISDOM IN SCIENCE

INTRODUCTION

Carl Sagan, one of the famous American scientist writer, said "Science is a way of thinking more than it is a body of knowledge"

Knowledge and Wisdom is a vast realm of thought. It is not pertaining to one subject but covers an immense dimension in life and all its processes but here, we will focus on scientific inquiry which leads to the scientific method and ultimately scientific temperament in every activity, whether be it in the laboratory or in our own lives.

2.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Develop scientific Inquiry
- Gain knowledge about Scientific Methods
- Enhance Scientific Temperament
- Understand the correlation of science with other subjects
- Apply the knowledge gained in day-to-day life
- Guidance of scientific principles

2.2 SCIENTIFIC INQUIRY

Scientific inquiry refers to the research and study that scientists carry out. They perform all the research and gather evidence to prove/disprove the theory in question. The results derived from their research are made public so that others can study about that subject and know the things around the world.

There are two primary functions of this inquiry. First, it explains how to conduct a scientific inquiry. The second function is to explain why it is essential to carry out the inquiry on the basis of scientific methods.

This includes observing, analyzing data, interpreting, inferring, questioning, classifying, measuring, and predicting. There is a specific order in which scientists use these steps to make an inquiry which are broadly known as the scientific methods.

There are three types by which inquiry can be done and can develop explanations for the things you want to research. They are comparative investigation, descriptive investigation, and experimental investigation. This helps in their scientific pursuits.

To put in a more specific way, let us ask the following questions:

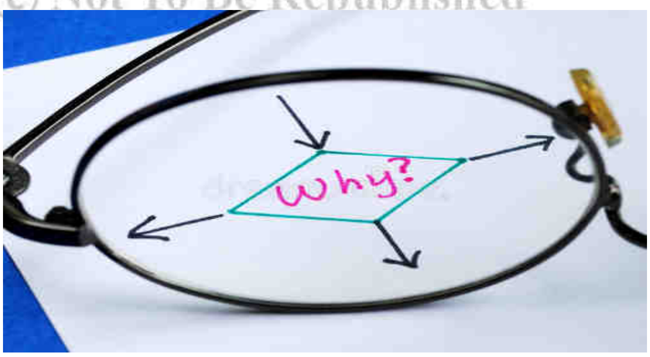
2.2.1What is scientific inquiry?

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work.

2.2.2What are the aspects of the scientific inquiry?

Scientific inquiry extends beyond development of process skills such as observing, inferring, classifying, predicting, measuring, questioning, interpreting and analyzing data, which must occur in that order for proper scientific inquiry to happen.

2.2.3 Steps of science inquiry



The steps in the Science enquiry are

- Ask Questions.

- Hypothesize and predict.
- Test hypothesis.
- Analyze results.
- Draw conclusions.
- Communicate results.
- Carry out further scientific inquiry.

This further leads to adopt scientific methods for the inquiry to process and come to it's logical consequences in order to gain scientific knowledge and truth. So, the next question would be what are the scientific methods?

2.3 SCIENTIFIC METHODS

The scientific method was not invented by any one person, but is the outcome of centuries of debate about how best to find out how the natural world works. The ancient Greek philosopher Aristotle was among the first known people to promote that observation and reasoning must be applied to figure out how nature works. The Arab Muslim mathematician and scientist Hasan Ibn al-Haytham (known in the western world as Alhazen) is often cited as the first person to write about the importance of experimentation. Since then, a large number of scientists have written about how science should ideally be conducted and contributed to our modern understanding of the scientific method. Those scientists include Roger Bacon, Thomas Aquinas, Galileo Galilei, Francis Bacon, Isaac Newton, John Hume, and John Stuart

Mill. Scientists today continue to evolve and refine the scientific method as they explore new techniques and new areas of science.

The scientific method is a process for experimentation that is used to explore observations and answer questions. Does this mean all scientists follow exactly this process? No.

Some areas of science can be more easily tested than others. For example, scientists studying how stars change as they age or how dinosaurs digested their food cannot fast-forward a star's life by a million years or run medical exams on feeding dinosaurs to test their hypotheses. When direct experimentation is not possible, scientists modify the scientific method.

In fact, there are probably as many versions of the scientific method as there are many scientists also! But even when modified, the goal remains the same: to discover cause and effect relationships by asking questions, carefully gathering and examining the evidence, and seeing if all the available information can be combined in to a logical answer.

2.3.1 STEPS OF THE SCIENTIFIC METHOD

1. Ask a Question

The scientific method starts when you ask a question about something that you observe: How, What, When, Who, Which, Why, or Where?

2. Do Background Research

Rather than starting from scratch in putting together a plan for answering your question, you want to be a savvy scientist using library and Internet research to help you find the best way to do things and ensure that you don't repeat mistakes from the past.

3. Construct a Hypothesis

A hypothesis is an educated guess about how things work. It is an attempt to answer your question with an explanation that can be tested. A good hypothesis allows you to then make a prediction:
"If _____*[I do this]* _____, then _____*[this]*_____ will happen."

State both your hypothesis and the resulting prediction you will be testing. Predictions must be easy to measure.

4. Test Your Hypothesis by Doing an Experiment

Your experiment tests whether your prediction is accurate and thus your hypothesis is supported or not. It is important for your experiment to be a fair test. You conduct a fair test by making sure that you change only one factor at a time while keeping all other conditions the same.

You should also repeat your experiments several times to make sure that the first results weren't just an accident.

5. Analyze Your Data and Draw a Conclusion

Once your experiment is complete, you collect your measurements and analyze them to see if they support your hypothesis or not.

Scientists often find that their predictions were not accurate and their hypothesis was not supported, and in such cases they will communicate the results of their experiment and then go back and construct a new hypothesis and prediction based on the information they learned during their experiment.

6. Communicate Your Results

To complete your science fair project, you will communicate your results to others in a final report and/or a display board. Professional scientists do almost exactly the same thing by publishing their final report in a scientific journal or by presenting their results on a poster or during a talk at a scientific meeting. In a science fair, judges are interested in your findings regardless of whether or not they support your original hypothesis.

In brief, ask these questions

What are the six steps of the scientific method?

The six steps of the scientific method include: 1) asking a question about something you observe, 2) doing background research to learn what is already known about the topic, 3) constructing a hypothesis, 4) experimenting to test the hypothesis, 5) analyzing the data from the experiment and drawing conclusions, and 6) communicating the results to others.

Do scientists actually use the scientific method?

Scientists do use the scientific method, but not always exactly as laid out in the organized steps taught in the classroom. Just like a chef might make a few changes to a recipe because of the ingredients at hand, a scientist may modify the scientific method by skipping steps, jumping back and forth between steps, or repeating a subset of the steps because he or she is dealing with imperfect real-world conditions. But scientists always strive to keep to the core principles of the scientific method by using observations, experiments, and data to support or reject explanations of how a phenomenon works. While experimenting is considered the best way to test explanations, there are areas of science, like astronomy, where this is not always possible.

CHECK YOUR PROGRESS 2.1

Q1 State true (T) or false (F)

a) Scientific inquiry is illogical. ______
b) All scientists follow the same scientific method. __________
c) Inquiry begins by asking questions. _________________
d) Aristotle made the first scientific method. ____________
e) Hypothesis does not do predictions______________

Q2) Answer the following Questions

a) What is scientific inquiry? Tell very briefly
b) Briefly describe the steps of scientific method

2.4 SCIENTIFIC TEMPER

It is very essential to develop scientific temper from an early age onwards owing to the fact that, scientific temper will ensure you to apply logic in a much better way and remain relevant in the world. More so in the case of students who have to shape their careers successfully amidst tight competition.

This is also mentioned that every citizen should develop, mostly students a trait of scientific temperament as per Indian Constitution article 51A.

Scientific temper allows individuals and in this case students to understand the concepts of what they are learning and logically apply those concepts in a real-world scenario. And in the current Indian higher education realm where the industry academia gap is widening, students who can apply their theoretical knowledge into practical applications in the industry have better chances of getting employed. Educators also have a huge role when it comes to developing the students scientific temper and some techniques that they can follow in order to help the students with developing their scientific temper are given as follows.

1. Encourage Students Scientific Curiosity: The first and foremost aspect that is crucial when it comes to developing a student's scientific temper is to feed his/her natural curiosity and encourage them to ask more questions. This will not only help to develop their scientific temper, but it will also help to cultivate their interest regarding the things that they are learning about.

2. Improve Critical Thinking Capabilities: Developing the students critical thinking capabilities will allow them to be more interested in their learning curve and with greater curiosity, students will be inclined to learn more things. This continuous learning process will not only help them to learn more but it will also help them to develop their scientific temper. So, by being self-motivated to learn on a constant basis, students will also be better equipped to meet the requirements of the modern-day industry.

3. Supporting the Students with their Experiments: In line with feeding the students scientific curiosity, what educators can do to help the students develop their scientific temper is to help them with their experiments and encourage them to do more. Regardless of the size of the experiment, educators should be able to support the students with their experiments and this will also help the students to feel more motivated to do more and improve.

4. Offer Opportunities to Practice: This is crucial to ensure that the students have opportunities to practice what they have learned in an organized manner. This exposure will be crucial when it comes to ensuring that the scientific temper of the students is being developed. The hands-on experience that they receive while practicing what they have learned will also help the students acquire valuable practical experience.

5. Make Learning Fun: One of the most effective methods to not only develop a student's scientific temper but also to make him/her engaged in the learning process is to make learning fun. By introducing various games, try to bring that fun element into education which will help the students to not lose interest in learning and at the same time, stay motivated and excited to learn more.

These above-mentioned tips will ensure that educators are able to develop their students scientific temper in an efficient and effective manner which is crucial in order to equip them with the needed skills required to face the challenges that they might face in the future.

2.5 CORELATION OF SCIENCE WITH OTHER SUBJECTS

Science is a vast subject, because of which the task of correlating it with other subjects of curriculum would be an easy task. Deliberate effort should be done by the science teacher to bring about co-relation in between the science and other subjects of the curriculum, which are being imparted to the students. Through this, students will find the opportunity to relate the knowledge which they have already gained, with the knowledge which they are gaining. It will help in their overall development.

(a) CIVICS

The main objective of imparting information of both the subjects is to create good and useful citizens for the nation, thus it is possible to correlate both of these subjects with each other. Through science, students become able to understand the utility of scientific inventions in their life, by which they become more responsible.

They begin to realise a sense of responsibility, which help them in playing important role in development of the nation. Through information of scientific facts, students get to know about various kinds of diseases and the role which they can play in creating a healthy and clean atmosphere around them. Through this kind of information, they become more responsible citizens and play an important role in creating an ideal civic life in the society and nation as a whole.

(b) LANGUAGE

Although science is a practical subject, but it is very important for it's learners to be able to express their views and ideas in clear and attractive form. For this purpose, it is necessary that they should have thorough knowledge of language which they use. Student who does not have good control over the language cannot express his views and various scientific laws and principles in front of others.

To co-relate science with language subjects, students can be asked to write essays on some scientific topic. If student make any kind of grammatical mistake, then the teacher can ask him to make correction in his language. Likewise, language teacher can give the task of writing about some scientific happening in the assignment designed for them. In this manner, he can correlate science with the language.

(c) HISTORY

Mentioning about the various scientific discoveries taken place in the earlier periods, teacher can relate with the major events of the world history. Students should be told about that what was the situation of science at the time of reigns of various famous kings or rulers. Teacher should narrate to the incidences which inspired various scientists to found out the medical remedies of various diseases.

Not only this, the function of co-relating science with history can be done by mentioning the kind of living standard people used to experience at different parts of the human history. It is an important step, then one can learn; how science was developed in different periods of civilization.

(d) MATHEMATICS

The significance of mathematics in the science can be proved by the views of the experts that mathematics has given sound footing to the scientific laws and principles. Before beginning any topic in the science, it is essential for the teacher to make sure that mathematical basis of all the students is strong and vast.

Probably, mathematics is considered to be sole language of science because of which real understanding of science is considered to be impossible without adequate knowledge of mathematics.

For this reason, it can be said that without making use of examples from mathematics, it is not possible for science teacher to explain various scientific principles and concepts properly to the students.

(e) GEOGRAPHY

Geography is the subject in which various concepts relating to earth on which we live are dealt with. Everything existing on earth, on different planets of the universe are also main subjects of geography. Which kind of crop should be sown in which kind of soils, how many kinds of rocks are found on the earth are some of the main topics which are covered by Geography. One will be surprise by this fact as these topics are also covered by the subject of Science.

In science, various concepts relating to the atmosphere and earth in which living and non-living beings exist help in understanding, the subjects better. There are various topics which are of common interest for geographers and scientists. Thus, it can be said that both of these subjects are complementary to each other.

(f) ARTS

Science is a practical subject, as a result of which, science teacher is required to draw various kinds of diagrams, models and charts, which cannot be performed unless he does not have sound artistic skills. Not only this, it is equally important for an artist to have thorough knowledge of scientific principles, as without it, he will find it difficult to keep the colour contrast of his images in attractive and controlled position.

An artist should know the principles of light and shade, objects and background for drawing or keeping the colour contrast in attractive condition. Thus, it can be said that some common features are found in the subjects of science and art, because of which they can be co-related with each other effectively.

Thus, it can be said that if science teacher will relate science with other subjects of the curriculum, then he will get more justifiable and satisfactory results.

CHECK YOUR PROGRESS 2.2

Q1 Match the following

1. Scientific temper	A good citizen
2. Art	B Constitution article 51 A
3. Civics	C mathematics
4. Language	D scientific diagram
5. Scientific logic	E good communication

Q2. Answer the following questions.

a) What is said in our constitution article 51A?

b) Does mathematics help Science? Describe briefly

2.6 APPLICATIONS OF INQUIRY AROUND US

Science is valued by society because the application of scientific knowledge helps to satisfy many basic human needs and improve living standards all through the inquiry process of the human mind. Finding a cure for cancer and a clean form of energy are just two topical examples. Similarly, science is often justified to the public as main driving force behind economic growth and fulfillment.

Scientists often justify their work using these and similar arguments—currently linked to personal health and longer life expectancies, technological advancement, economic profits, and/or sustainability—in order to secure funding and gain social acceptance. They point out that most of the tools, technologies and medicines we use today are products or by-products of research, from pens to rockets and from aspirin to organ transplantation. This progressive application of scientific knowledge is the most widely accepted tool of inquiry.

To improve the cultural level of human societies is a long-term venture in which science will need to play a critical role. We first need to accept that scientific reasoning is intimately linked to human nature.

Moreover, science has demonstrated that it is a supreme mechanism to explain the world, to solve problems and to fulfill human needs.

Scientists—especially those working in public institutions—should make a greater effort to communicate to society what science is and what is not; how is it done; what are its main results; and what are they useful for.

Scientists should still use the other arguments—technological progress, improved health and well-being and economic gains—to justify their work, but better education would provide the additional support needed to convince citizens about the usefulness of science beyond its economic value.

Science is not only necessary for humanity to thrive socially, environmentally and economically in both the short and the long term, but it is also the best tool available to satisfy the fundamental human thirst for knowledge, as well as to maintain and enhance the human cultural heritage, which derives it's source of all applications through inquiry of knowledge.

Science has developed, invented and discovered different mediums of swift communication that are very useful for us in our everyday life. Time and distance have been conquered.

Science has invented different types of machines that are very useful for us in our daily life. Machine lifts weight from us, plough our fields, cook our food and also serve it for us. Computers have made each and everything easy like calculations and other stuff beyond our imagination.

Electricity is the greatest invention of man. It serves us in hundreds and thousands of ways. It runs our trains, mills and factories. It cools and keeps our houses warm. It washes and irons our clothes. It gives us cool air and entertains us through Cinema, TV and radio, besides lighting our houses. Modern life is impossible without electricity.

The greatest blessings of science are its inventions in the field of medicine and surgery. Human pain and treatment of different types of diseases that don't have any treatment available in the early times that have now become very easy and and the human life survival rate is increased.

X-Ray and body scanning machines are the window through which we can get a peep into the inside of our body. There are machines and different types of scanners and detectors which can sense and tell us about the diseases that are inside the human body.

Science has given comfort to human life very much. Many inventions of science are for our enjoyment and entertainment. Cinema is very cheap means of entertainment that provides enjoyment both for rich and poor. Through radio we can enjoy music, dialogues, dramas, short stories. Through the television we can see dramas, dances, etc; being staged at the television station.

With the discovery of atomic energy man has found an inexhaustible source of energy. It can meet the demands of energy of the world for a long time.

Computer is one of the greatest inventions of modern Science. In every field of life man has been using computer.

Science has created wonders in the field of communication. Telephone, telex, fax, internet, networking, cell phones, laptops, GPS systems, E-mail, VSATs, wireless, telegrams are great wonders. They have brought the world closer to us. We can send news from one corner of the world to other within a single moment.

Science is very much helpful in our daily life. The world would have been stopped without inventions of the Science based upon scientific inquiry and gaining scientific knowledge in our lives.

2.7 GUIDANCE OF SCIENTIFIC PRINCIPLES

Scientific knowledge is empirically based.

Observation is an important way to learn about the world. Through observation one can learn to compare, contrast, and note similarities and differences.

Accurate observations and evidence are necessary to draw realistic and plausible conclusions.

The analysis of evidence and data is essential in order to make sense in the scientific terminology.

Scientific knowledge is tentative.

The analysis of data from a systematic investigation may provide the researcher with a basis to reach a reasonable conclusion.

The scientific establishment sometimes rejects new ideas, and new discoveries

Constant revaluation in the light of new data is essential to keeping scientific knowledge going.

Scientific knowledge is the product of observation and inference.

An inference is a conclusion based on evidence about events that have already occurred. Accurate observations and evidence are necessary to draw realistic and plausible conclusions. To communicate an observation accurately, one must provide a clear description of exactly what is observed and nothing more.

Scientific conclusions are based both on verifiable observations (science is empirical) and on inferences.

Scientific knowledge is the product of creative thinking

Scientists rely on creativity and imagination during all stages of their investigations.

Science is a human endeavor relying on human qualities, such as reasoning, insight, energy, skill, and creativity as well as intellectual honesty and openness to new ideas.

Scientific laws and theories are different kinds of scientific knowledge.

Scientific laws are generalizations of observational data that describe patterns and relationships. Laws may change as new data become available.

Scientific theories are systematic sets of concepts that offer explanations for observed patterns in nature. Theories provide frameworks for relating data and guiding future research. Theories may change as new data become available

Scientists use many methods to develop scientific knowledge.

Experimental studies sometimes follow a sequence of steps known as the Scientific Method: stating the problem, forming a hypothesis, testing the hypothesis, recording and analyzing data, stating a conclusion. However, there is no single scientific method. Science requires different abilities and procedures depending on such factors as the field of study and type of investigation.

Different kinds of problems and questions require differing approaches and research. Scientific methodology almost always begins with a question, is based on observation and evidence, and requires logic and reasoning. Not all systematic investigations are experimental.

Scientific knowledge is subjective and culturally influenced.

Investigation not only involves the careful application of systematic (scientific) methodology, but also includes the review and analysis of prior research related to the topic. Numerous sources of information are available from print and electronic sources, and the researcher needs to judge the authority and credibility of the sources.

It is typical for scientists to disagree with one another about the interpretation of evidence or a theory being considered. This is partly a result of the unique background (social, educational, etc.) that individual scientists bring to their research.

CHECK YOUR PROGRESS 2.3

Q 1. Is electricity, the best invention of man?

Q 2. Science has improved our health. Justify the statement.

Q3. Computer is greatest invention of modern times. Give reasons

Q4. Science is empirical. Do you agree with the statement? If yes, why?

Q5. How does culture influence science?

RECAPITULATION POINTS

- Scientific inquiry primarily focuses on asking questions and make observations to develop critical and logical thinking.
- Scientific Method consists of several steps – ask a question, do background research, construct a hypothesis, experiment, analyze data to come to logical conclusions and communicate results.
- Scientific temperament arouses curiosity, helps in focused analysis, to build critical thinking, offers opportunities and overall makes a good learning process.
- Science is co-related with many subjects – art, mathematics, history, civics, language & so forth.
- Everyday life is influenced by science by it's uses and applications.
- Guidance to scientific principles

TERMINAL EXERCISE

Answer the following questions in brief.

1. Discuss scientific inquiry giving details.
2. Elaborate scientific method
3. How can students acquire scientific temper?
4. Co-relate science with three subjects
5. How science influences our everyday life? Give examples.
6. How are scientific principles guided?
7. Do scientists use the same scientific method? Give reasons.
8. Science opens up with a widening hands to all other subjects

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 2.1

1. True (T) or False (F)

a) F
b) F
c) T
d) T
e) F

2. (a) Scientific Inquiry is a way of thinking, analyzing, observing things to find out the truth.

(b) Brief steps of scientific method are – ask questions, do background research, predict hypothesis, experiment, analyze data and communicate results.

CHECK YOUR PROGRESS 2.2

1. Match the following

i. B
ii. D
iii. A
iv. E
v. C

2. (a) It mentions about the need to develop scientific inquiry in our citizens as per Constitution article 51A

   (b) Most scientific explanation is done with the help of mathematics. Without mathematics, scientific theories and laws cannot be understood. This is the crucial relationship between science and mathematics.

CHECK YOUR PROGRESS 2.3

1) Yes. Previously, it was considered that electricity is the best invention of man. It is widely used everywhere – home, offices, factories and so on.
2) Science has improved the health conditions for each and every human being. It has increased life expectancy i.e.; man's has a longer life due to scientific inventions to fight diseases.
3) Computer is greatest invention of modern times. In every field, it is used – medicine, banking, communications, office work, education and almost anywhere. True, you cannot think of living without a computer in today's world.
4) Science is always empirical. It is based upon observation and experimentation. This is how scientists work.
5) It is true that culture influences science because scientists come from different cultural backgrounds. Their customs, beliefs, traditions from different races, nations become a part of where they are working and more so in scientific work. So, in this way culture influences science

3 ORIGIN AND EVOLUTION OF SCIENCE IN ANCIENT INDIA

INTRODUCTION

Let us begin with a quote of one of the biggest scientist of the world "We owe a lot to the ancient Indians, teaching us how to count. Without which most modern scientific discoveries would have been impossible." – Albert Einstein

Indians have played an important role in the field of science and technology. The Indus Valley Civilization, Vedic age and later periods saw great achievements by Indians in the field of science and technology. In modern times many Indian scientists and mathematicians have done phenomenal work and some of them even received awards like Nobel Prize for their contributions to science and technology.

3.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Gain knowledge about the glorious achievements of Science in Ancient India
- Know the contribution of Scientists in Medieval India
- Appreciate the development of Science in Modern India
- Instill the feeling of pride in Achievements of Indians at National and International level (Nobel Laureates)

3.2 SCIENCE IN ANCIENT INDIA

One of the oldest civilizations in the world, the Indian civilization has a strong tradition of science and technology. Ancient India was a land of sages and seers as well as a land of scholars and scientists. Research has shown that from making the best steel in the world to teaching the world to count, India was actively contributing to the field of science and technology centuries long before modern laboratories were set up. Many theories and techniques discovered by the ancient Indians have created and strengthened the fundamentals of modern science and technology.

3.2.1 MATHEMATICS

a) CONCEPT OF ZERO

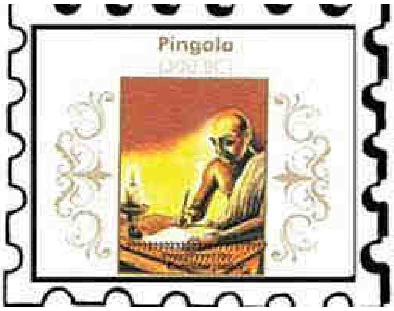
The mathematical digit 'zero', one of the most important inventions of all time. Mathematician Aryabhata was the first person to create a symbol for zero. it was through his efforts that mathematical operations like addition and subtraction started using the digit, zero. The concept of zero and its integration into the place-value system also enabled one to write numbers, no matter how large, by using only ten symbols.

b) HELIOCENTRIC THEORY

Mathematicians of ancient India often applied their mathematical knowledge to make accurate astronomical predictions. The most significant among them was Aryabhatta whose book, *Aryabhatiya,* represented the pinnacle of astronomical knowledge at the time. He correctly propounded that the Earth is round, rotates on its own axis and revolves around the Sun i.e the heliocentric theory. He also made predictions about the solar and lunar eclipses, duration of the day as well as the distance between the Earth and the Moon.

c) BINARY NUMBERS

Binary numbers is the basic language in which computer programs are written. Binary basically refers to a set of two numbers, 1 and 0, the combinations of which are called bits and bytes. The binary number system was first described by the Vedic scholar Pingala, in his book *Chandahśāstra*, which is the earliest known Sanskrit treatise on prosody (the study of poetic metres and verse).

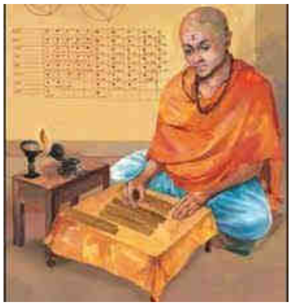


d) DECIMAL SYSTEM

India gave the ingenious method of expressing all numbers by means of ten symbols – the decimal system. In this system, each symbol received a value of position as well as an absolute value. Due to the simplicity of the decimal notation, which facilitated calculation, this system made the uses of arithmetic in practical inventions much faster and easier?

3.2.2. ASTRONOMY

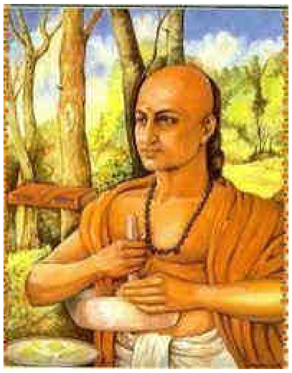
Indian astronomy is thought to have originated from the Vedas. The use of astrology in Vedang literature was based on the principles of astronomy. Indian scientist Aryabhatta told the circular shape of the Earth and the principle of circling on its axis. After that, the famous German astronomer Copernicus give this theory. Brahmagupta confirmed the Earth's gravitational theory even before Sir Isaac Newton



3.2.3 MEDICAL SCIENCE

a) AYURVEDA

Long before the birth of Hippocrates, Charaka authored a foundational text, *Charakasamhita,* on the ancient science of Ayurveda. Referred to as the Father of Indian Medicine, Charaka was was the first physician to present the concept of digestion, metabolism and immunity in his book.



b) SURGERY

Written by Sushruta in 6th Century BC, *Sushruta Samhita* is considered to be one of the most comprehensive textbooks on ancient surgery. The text mentions various illnesses, plants, preparations and cures along with complex techniques of plastic surgery. The *Sushruta Samhita* 's most well-known contribution to plastic surgery is the reconstruction of the nose, known also as rhinoplasty.

The first cataract surgery is said to have been performed by the ancient Indian physician Sushruta,

3.2.4 ENGINEERING AND ARCHITECTURE

From the Indus Valley Civilization, India was a pioneer in the field of architecture. The urban system of the Indus is an inspiration for the present cities. Buildings, pillars, cave construction, chaitya construction during the Mahajanapada period and Maurya period are examples of advanced architecture of India.

3.3 SOME ANCIENT INDIAN SCIENTISTS

a) **Baudhayana** was a mathematician who lived in ancient India around 800 BCE. His major contributions include: He gave a near accurate value of Pi(π). He gave the theorem today known as "Pythagoras theorem" before Pythagoras had developed it. Baudhayan's Sulva Sutra, which was written several years before the age of Pythagoras.

b) **Bhaskaracharya** was the leading light of 12th Century. He was born at Bijapur, Karnataka. He is famous for his book ***Siddanta Shiromani***.

c) **Mahaviracharya** wrote ***GanitSara Sangraha*** in 850 A.D., which is the first text book on arithmetic in present day form.

d) **Varahamihira** was another well known scientist of the ancient period in India. He lived in the Gupta period. Another theory, which has attracted he world of science she earthquake cloud theory given by Varahmihira in his book ***BrhatSamhita***.

e) **Kanada**, a philosopher estimated to have lived in India between the 6th century to 2nd century BCE. His name Kanada means atom eater. He was the first person to give the atomic theory. He gave the idea that Parmanu (Atom) was an indestructible particle of matter which cannot be divided further. Later on, Dalton made similar observations in Dalton's atomic theory.

f) **Charaka** is considered the "Father of Indian Medicine" who lived in around 300 BCE in India. He was among the principal contributors to the ancient system of medicine 'Ayurveda' and wrote his medical treatise the 'Charak Samhita'. He is known for his works on metabolism and the fundamentals of genetics.

g) **Sushruta** was the author of “Sushruta Samhita” an ancient Sanskrit text on medicine and surgery. He invented surgical instruments and was aware of cataract operations. He is also known as the “father of surgery” and “father of plastic surgery”.

h) **Aryabhatta** also was known as Aryabhatta 1 was the first major astronomer and mathematician who lived in between 476 to 550BCE.His major works include Aryabhatiya and Arya-Siddhanta. He calculated the orbits of planets, and scientifically explained the Solar and lunar eclipses. Calculated the distance between Earth and Moon. He proposed that Earth rotates on its axis. He calculated the circumference of the earth and proposed that the shape of Earth is not flat. Worked on the place value system and zero as a symbol and concept.

i) **Brahmagupta** was an Indian mathematician during 598 to 670 BCE and an astronomer. He was the first person to give rules to compute with zero. He was the author of the “Brāhma Sphuṭa Siddhānta”, a theoretical treatise on mathematics and astronomy, and the “Khaṇḍakhādyaka”, which was a more practical text. He worked on mathematics and astronomy and he is supposed to have invented many astronomical instruments for his observations. His work on methods for calculating the distance of the heavenly bodies is superlative.

j) **Bhaskara** 1 (600 – 680 CE). He was a mathematician who first wrote numbers in the Hindu decimal system with a circle for zero. He worked on many trigonometric formulas and gives a rational approximation of sine function.

CHECK YOUR PROGRESS 3.1

Q1) Answer the following question

a) The earth is not flat and rotates on its own axis. Which ancient Indian scientist gave this theory?
b) Pi was discovered by whom?
c) Who discovered zero?

Q2) Match the following:

	Book	Author
1	Siddanta Shiromani	A Bhaskaracharya
2	Ganit Sara Sangraha	B Brahmagupta
3	Aryabhatiya	C Baudhayana
4	Brahm Sputa Siddantika	D Mahaviracharya
5	Sulva Sutra	E Aryabhatta

3.4 SCIENCE IN MEDIEVAL INDIA

We shall now tell you about the achievements in various areas of science in medieval India.

Astronomy and Physical Sciences

Astronomy was used not only for working out the calendar, the dates of the eclipses and for the determination of time but also for casting horoscopes for astrological purposes. Astronomy was also needed for fixing the direction of Mecca, in order to properly align the mosques. We find that Firozeshah Tughlaq (1351-88) established a special observatory to study heavenly bodies.

The most important stride in the field was made at the beginning of the eighteenth century. Raja Jai Singh, under the patronage of Emperor Muhammad Shah, established observatories at a number of places, such as Delhi, Jaipur, Uijain, Benaras and Mathura. He paid special attention to the instruments of observation. A noticeable feature was the construction of large sized observational instruments for fixing time and determining latitudes called Jantar Mantar.

A familiarity with the knowledge of specific gravity and laws of motion was shown by Abu'lFazl (d. 1603). This is indicated in his book A.in-i Akbari, completed in 1595. In this he shows a clear understanding of the Archimedes principle, and the differences in the weights of bodies in air and under water

3.4.1 GEOGRAPHY

A big advance was made in the field of cartography when in 1647 SadiqIsfahani prepared an encyclopaedic work that contained a World Atlas. The maps prepared by him, particularly of India, were fairly accurate in representing India as a peninsula and adding Sri Lanka at its southern tip.

3.4.2 CHEMISTRY

The isolation of zinc was accompanied by another achievement namely the manufacture of brass, an alloy of copper and zinc. Abu'l Fazl gave three proportions of zinc and copper for obtaining brass of different varieties.

Tin-coating of copper and brass learnt from the Arab world became prevalent in medieval India, thereby enabling copper vessels to be more widely used. Soldering, particularly of gold on agates, crystals and other brittle materials, was done so efficiently, as to earn commendation from European travellers.

India seems to have discovered the freezing mixture before Europe. Saltpetre (potassium nitrate) was used for cooling water before 1580. This discovery has been attributed to Emperor Akbar.

An important application of Chemistry was in the production of paper. Kashmir, Sialkot, Zafarabad, Patna, Murshidabad, Ahmedabad, Aurangabad and Mysore became well known centres of paper production.

The Mughals knew the technique of production of gunpowder and its use in gunnery, another application of Chemistry.

3.4.3 MEDICINE

The Greek (Unani) system of medicine still widely practised in India arrived with the Muslims. One would have expected improvement by the mutual exchange between it and the already existing Indian system of Ayurveda. But the two systems remained separate. In surgery, blood clotting, and in orthopaedic, setting right dislocated bones were the known.

Medieval India witnessed considerable improvement and changes in the field of technology.

Gearing provides a device for transforming horizontal motion into vertical and vice versa and for increasing or reducing speed was extensively used.

The belt drive is a comparatively simpler device than gearing for transmission of power and for increasing or decreasing the speed of motion. Belt drive came to India in the form of the spinning wheel. Evidence of an improvement in weaving comes from a fifteenth century which describes the foot-pedals used by a weaver to control speed.

3.4.4 ARCHITECTURE

The architectural style of India underwent a drastic change after the Turkish conquest. The Sultans and their nobles insisted on having arches and domes and competent Indian masons succeeded in building them. Most famous is the Taj Mahal built by Shah Jahan, the Mughal Emperor.

CHECK YOUR PROGRESS 3.2

Q1) Match the following

Author	**Book**
1 Narayana Pandit	A Buddhivilasini
2 Gangadhara	B Mrga- paksi – sastra
3 Ganesa Daivanja	C Ganitakaumundi
4 Hamsadeva	D LilavatiVyakhya
5 Jahangir	E Tajik
6 Sukracarya	F Tuzuk -i- Jahangiri
7 Nilakantha Jyotirvida	G Sukranti

Q2) Answer the following questions

a) What were some of the paper manufacturing centres?
b) In which year Sadiq Isfahani made the world Atlas?
c) Who built the Janter Manter?

3.5 SCIENCE IN MODERN INDIA

We shall briefly discuss, the progress made by the earlier modern scientists, to some of Nobel Laureates and a few of the recent scientists.

3.5.1 Some Renowned Scientists

a) Jagdish Chandra Bose:

- Jagdish Chandra Bose was an eminent scientist. He developed the use of galena crystals for making receivers, both for short-wavelength radio waves and for white and ultraviolet light.
- In 1895, two years before Marconi’s demonstration, Bose demonstrated wireless communication using radio waves, using them to ring a bell remotely and to explode some gunpowder.
- He invented many of the microwave components such as waveguides, horn antennas, polarizers, dielectric lenses and prisms, and even semiconductor detectors of electromagnetic radiation in the last decade of the nineteenth century.
- He also proposed the existence of electromagnetic radiation from the Sun, which was confirmed in 1944. After that Bose focused his attention on response phenomena in plants.
- He presented that not only animal but vegetable tissues produce similar electric responses under different kinds of stimuli – mechanical, thermal, electrical and chemical. His instrument to measure plant movement and growth is known as Crescograph for which he became famous world over.

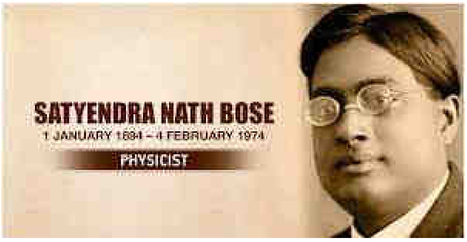
b) Srinivasa Ramanujan:

- One of India’s greatest mathematical genius, was born at Erode in Tamil Nadu on 22 December, 1887. Later on, his parents shifted to Kumbakonam, 160 kilometres from Chennai.

- Ramanujan studied at the Town Hall School in Kumbakonam, where he proved himself to be an able all-rounder. However, his love of mathematics was unusual. Numbers seemed to draw him by a strange magnetism. In school itself at the age of thirteen, he came across a book called *Synopsis of Elementary Results in Pure Mathemetic* by G.S.Carr.
  Though outdated, this book introduced him to the world of mathematics. He started working and developing his own ideas in mathematics. He used to write his ideas and results and make notes on his findings.
- Three of his research notes books are available to us. They are called Ramanujan’s Frayed Notebooks. He could not complete his college education as he kept on developing his ideas and started posing problems and solving them in the *Journal of Indian Mathematical Society.* In 1911, he published in the same journal a brilliant research paper on Bernoulli Numbers. This got him recognition and he became well known in Madras circles as a mathematical genius.

- Lack of formal education made it very difficult for him to make both ends meet. With great difficulty he could get the job of a clerk at Madras Port Trust which proved fortunate for him. Here he came in contact with many people who had training in mathematics. He found a book *'Orders of Infinity'* written by G. H. Hardy. He wrote a letter to him in which he mentioned 120 theorems and formulae. Hardy was quick to recognise his genius and he responded by arranging for him a passage to London. Despite his lack of required qualification he was allowed to enroll at Trinity College from where he got his Bachelor of Science degree in less than two years. He formed a wonderful team with Hardy and J.E. Littlewood and made amazing contributions to the field of mathematics. He published many papers in London. He was the second Indian to be elected Fellow of the Royal Society of London and the first Indian to be elected Fellow of Trinity College.
- Ramanujan had an intimate familiarity with numbers. In 1917, he fell seriously ill, but the numbers remained his friend, though his body betrayed him. Unfortunately, his health became worse and he returned to India in 1919, "With a scientific standing and reputation". He died in 1920. His mathematical genius is a proof that India indeed is the birthplace and source of great mathematical ideas.
- Srinivasa Ramanujan was a mathematician. He is extensively believed to be the greatest mathematician of the 20th Century. Srinivasa Ramanujan made a major contribution to the analytical theory of numbers and worked on elliptic functions, continued fractions, and infinite series.

c) Satyendra Nath Bose:



- Satyendra Nath Bose was an outstanding Indian physicist specialising in quantum mechanics. He is of course most remembered for his excellent role played in the class of particles 'bosons', which were named after him by Paul Dirac to commemorate his work in the field.
- Basically, he is known for his work in Quantum Physics. He is famous for "Bose-Einstein Theory" and a kind of particle in an atom has been named after his name.
- Bose adapted a lecture at the University of Dhaka on the theory of radiation and the ultraviolet catastrophe into a short article called "Planck's Law and the Hypothesis of Light Quanta" and sent it to Albert Einstein.
- Einstein agreed with him, translated Bose's paper "Planck's Law and Hypothesis of Light Quanta" into German, and had it published in ZeitschriftfürPhysik under Bose's name, in 1924.

- This formed the basis of the Bose-Einstein Statistics. In 1937. The Government of India awarded him India's second-highest civilian award, the Padma Vibhushan in 1954.

d) Dr Homi Jehangir Bhabha:

He is considered the originator of the Indian Nuclear Research Programme. India accomplished nuclear capability due to the extreme efforts of Homi, thereby avoiding certain conflicts simply through non-aggression treaties. This contribution of Bhabha augments the status of India on the world stage. Tata Institute of Fundamental Research (TIFR) was started in 1945, at Dr. Bhabha's ancestral home.

- He had a brilliant persona with multi-faceted qualities. He was fond of music, painting and writing. Some of his paintings are displayed in the British Art Galleries and the TIFR art collection today is rated as one of the best collections of contemporary Indian art in the country.
- India's first atomic research centre now called Bhabha Atomic Research Centre (BARC) was established at Trombay. India's First atomic reactor, Apsara was also established under his expert guidance. Bhabha became the first chairman of the Atomic Energy Commission set up in 1948.
- He is the recipient of Adam's Award, Padma Bhushan, an Honorary Fellow of the American Academy of Arts and Sciences and Foreign Associate of the National Academy of Sciences in the United States.

e) APJ Abdul Kalam:

- Dr APJ Abdul Kalam is remembered as a great scientist, an inspirational leader and an extraordinary human being. As a scientist, Kalam made an effort to develop the Polar SLV and SLV-III projects between the 1970s and 1990s. Both of which proved to be a success.

- In the 1970s, Kalam also directed two projects, namely, Project Devil and Project Valiant, which sought to develop ballistic missiles from the technology of the successful SLV programme.
- He developed five projects for defence services -Prithvi, Trishul, Akash,Nag and Agni.
- Kalam played a vital role in convincing the Union Cabinet to conceal the true nature of these classified aerospace projects. His research and educational leadership brought him

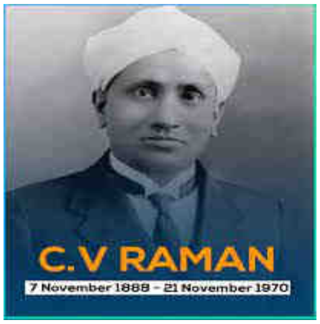
great laurels and prestige in the 1980s, which prompted the government to initiate an advanced missile program under his directorship.

- Besides a distinguished scientist and engineer, Dr APJ Abdul Kalam served as the 11th President of India from the period 2002 to 2007.
- After post-presidency, Kalam became a visiting professor at the Indian Institute of Management Shillong, the Indian Institute of Management Ahmedabad, and the Indian Institute of Management Indore; an honorary fellow of Indian Institute of Science, Bangalore.
- He taught information technology at the International Institute of Information Technology, Hyderabad, and technology at Banaras Hindu University and Anna University.
- He played an intensive political and technological role when the Pokhran-II nuclear tests were conducted. Kalam served as the Chief Project Coordinator, along with R. Chidambaram during the testing phase. Photos and snapshots of him taken by the media elevated Kalam as the country's top nuclear scientist.
- He had a brilliant and dominant personality and he was a man of vision, who always had novel ideas for the development of the country and is also popular as the Missile Man of India.

3.5.2 NOBLE LAUREATES

a) C.V. Raman

- C.V. Raman was one of the most famous scientists in India. Raman’s academic brilliance was established at a very young age. He had a pioneering work on scattering of light, C.V. Raman won the **Nobel Prize for Physics in 1930.**
- He was the first Asian and first non-White to receive any Nobel Prize in the sciences. Raman also worked on the acoustics of musical instruments. He was the first to investigate the harmonic nature of the sound of the Indian drums such as the tabla and the mridangam.
- He discovered that, when light traverses a transparent material, some of the deflected light changes in wavelength. This phenomenon is now called the Raman scattering and is the result of the **Raman Effect.**

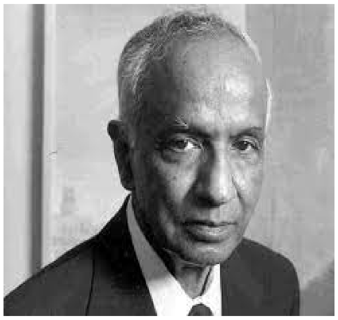


b) Har Gobind Khorana:

- Har Gobind Khorana was an American molecular biologist of Indian origin. He was awarded the Nobel Prize in the year 1968 for his work on the interpretation of the genetic code and its function in protein synthesis.
- Dr Khorana demonstrated how the genetic code determines all life processes by directing the synthesis of all cell proteins finally unravelled the secret of the DNA code of life.
- Dr Khorana received numerous awards and honours such as the Novel Prize for his achievement. Distinguished Service Award, Watumull Foundation, Honolulu, Hawaii, American academy of achievement awards, Philadelphia, Pennsylvania, Padma Vibhushan, Presidential Award, J C Bose Medal and Willard Gibbs medal of the Chicago section of American Chemical Society.
- He was also elected a member of the National Academy of Sciences, Washington, as well as a Fellow of the American Association for the Advancement of Science. In 1971, he became a foreign member of the USSR Academy of Sciences and in 1974, an Honorary Fellow of the Indian Chemical Society.

c) Subrahmanyan Chandrasekhar:

- He was one of the greatest scientists of the 20th century. He did commendable work in astrophysics, physics and applied mathematics.
- Chandrasekhar has bestowed **the** Nobel Prize in Physics in 1983 **Physics for** his mathematical theory of black holes. The Chandrasekhar limit is named after him.
- He was the nephew of CV Raman. Chandra became a United States citizen in 1953. Chandra was a popular teacher who guided over fifty students to their PhD including some who went on to win the Nobel Prize themselves.
- His research explored nearly all branches of theoretical astrophysics and he published ten books, each covering a different topic, including one on the relationship between art and science.
- His most famous work concerns the radiation of energy from stars, particularly white dwarf stars, which are the dying fragments of stars.



d) Venkataraman Ramakrishnan:

- Venkataraman, Indian born American is a senior scientist in the Structural Division at the Medical Research Council Laboratory of Molecular Biology, in Cambridge, England.
- He has worked in various fields of biology during the earlier part of his career. He is internationally recognized for the **determination of the atomic structure of the 30s ribosomal subunit.**
- Ramakrishnan received numerous awards such as he was elected a Member of the European Molecular Biology Organization (EMBO) in 2002 and a Fellow of the0 Royal Society (FRS) in 2003.
- He was chosen a Member of the U.S. National Academy of Sciences in 2004. In 2007, Ramakrishnan has bestowed the Louis-Jeantet Prize for Medicine and the Datta Lectureship and Medal of the Federation of European Biochemical Societies (FEBS).
- In 2008, he won the Heatley Medal of the British Biochemical Society. Since 2008, he is a Fellow of Trinity College, Cambridge and a Foreign Fellow of the Indian National Science Academy.
- In 2009, Ramakrishnan was honoured with the **Nobel Prize in Chemistry along with Thomas A. Steitz and Ada Yonath.** He received India's second-highest civilian honour, the Padma Vibhushan, in 2010.
- Ramakrishnan was knighted in the 2012 New Year Honours for services to Molecular Biology. In the same year, he was awarded the Sir Hans Krebs Medal by the FEBS. In 2013, he won the Spanish Jiménez-Diáz Prize.

3.5.3 NATIONAL LEVEL SCIENTISTS

a) Raja Ramanna:

- Dr Raja Ramanna was a **renowned physicist and nuclear scientist** in India. He had a multifaceted personality and played the roles of a technologist, nuclear physicist, administrator, leader, musician, Sanskrit literature scholar, and philosophy researcher.
- His interest was in Nuclear Physics and particularly attention to Atomic Research and he became the head of the Bhabha Atomic Research Centre at Trombay, Bombay.
- Dr Ramanna held several important positions in the course of his scientific career. These included the roles of Director in Babha Atomic Research Centre, Director-General in the Defence Research and Development Program, Chairman in the Atomic Energy Commission,

Vice President in Indian National Science Academy, and Director in the National Institute of Advanced Studies.

- He also played a major role in setting up the Centre for Advanced Technology at Indore and Variable Energy Cyclotron Centre at Kolkata. He was often referred to as the 'Father of India's nuclear program.
- Raja Ramanna received the Shanti SwarupBhatnagar Prize for Science and Technology in 1963, Padma Vibhushan in 1975, Padma Shri in 1968 and Padma Bhushan in 1973. He was also appointed as the Union Minister of Defence in 1990. People will remember him for his incredible contribution to nuclear physics.

b) Dr. Vikram Ambalal Sarabhai

Dr. Vikram Ambalal Sarabhai is another great genius of modem India. He was the main personality behind the launching of India's first satellite Aryabhatta. He received his primary education at a school run by his parents. He studied cosmic rays under the guidance of Dr. C.V. Raman and received his Ph.D. degree from Cambridge University. established many institutes which are of international repute. Most notable among them are Indian Institutes of Management (IIMS) which are considered world class for their management studies.

c) Narinder Singh Kapany:

He is credited for his contribution to science and acclaimed as a great scientist. **He had invented Fibre optics.**

- The process to transfer information freely and almost promptly was made possible by the original work of Narinder Kapany.
- His research and inventions have encompassed fibre-optics communications, lasers, biomedical instrumentation, solar energy and pollution monitoring.
- Fibre optics have transformed the way people communicate, offering high-speed data transfers as well as helping in medical procedures such as endoscopy and laser surgeries.
- He has a multifaceted personality.

- He also played a significant role as an entrepreneur and business executive. Dr Kapany has specialized in the processes of innovation and the management of technology and technology transfer.
- Kapany received numerous awards for his pioneering contribution in science that includes 'The Excellence 2000 Award' from the USA Pan-Asian American Chamber of Commerce in 1998 and the prestigious Pravasi Bharatiya Samman, which was bestowed by the Indian government and presented by former Prime Minister Atal Bihari Vajpayee in 2004.
- In addition, Kapany holds over 100 patents and was a member of the National Inventors Council.

CHECK YOUR PROGRESS 3.3

Answer the following questions

1. Who invented the Cresco graph and what is its function?

2. In which year did C V Raman win Nobel Prize?

3. What are 'Bosons'?

4. Why was Har Gobind Khorana awarded the Nobel Prize?

5. Who was known as 'Missile Man of India'?

6. TIFR stands for?

7. Who launched the first satellite of India? Name the satellite.

RECAPITULATION POINTS

ANCIENT INDIA

- Science, medicine, surgery, mathematics were highly developed in ancient India Some famous scientists were Kanad, Varahamihira.
- Some famous mathematicians were Aryabhatta, Brahmagupta, Baudhayana, Bhaskaracharya, Mahaviracharya.
- Some famous medical persons were Charak, Susruta. Medical Science was also highly developed in ancient India.
- **Ayurveda** is the indigenous system of medicine that was developed in Ancient India. The word **Ayurveda** literally means the science of good health and longevity of life. Charak is called the father of ayurvedic medicine and Susruta the father of surgery in ancient India.
- ***Charak Samhita,*** written by Charak is a remarkable book on medicine.
- Susruta's greatest contribution was in the fields of Rhinoplasty (plastic surgery) and ophthalmic surgery (removal of cataracts).

MEDIEVAL INDIA

- Several works were written in the fields of Mathematics, Chemistry, Astronomy and Medicine.
- Most of the scientific works developed into new technologies like gearing, paper manufacturing, belt drive, gunpowder application, freezing mixture etc

MODERN INDIA

- **Dr Jagdish Chandra Bose** invented the Crescograph to measure plant growth and movements.
- **Srinivasa Ramanujan** was a mathematical genius and gave to the world marvellous mathematical work like the infinite series, Bernoulli numbers etc;
- **Satyendra Nath Bose** work in quantum physics and discovery of sub-atomic particle ‘ boson ’ named after him.
- **C.V. Raman won** Nobel Prize in 1930 for scattering of light called ‘ Raman Effect ’
- **Har Gobind Khorana** got Nobel Prize for his work on Genetic Code in 1968.
- **Subrahmanyan Chandrasekhar** gave mathematical theory on black holes and won Nobel Prize in 1983.
- **Dr. Vikram Sarabhai** launched the first Indian satellite ‘Aryabhata’
- **Dr APJ Abdul Kalam** developed several missile projects –Agni, Prithvi, Trishul, Aakash and is known as ‘Missile Man of India’.

ANSWERS TO ‘CHECK YOUR PROGRESS’

CHECK YOUR PROGRESS 3.1

1) a) Aryabhata

b) Baudhayana

c) Brahmagupta

2) Match the following

1 A

2 D

3 E

4 B

5 C

CHECK YOUR PROGRESS 3.2

1. Match the following

1 C

2 D

3 A

4 B

5 F

6 G

7 E

2. Answer the following Questions

a) Kashmir, Patna, Ahmedabad, Mysore, Aurangabad

b) In the year 1647 AD

c) Raja Jai Singh

CHECK YOUR PROGRESS 3.3

1. Dr Jagdish Chandra Bose. Function to measure plant growth and movements

2. 1930

3. Bosons are sub atomic particles named after Satyendra Nath Bose

4. Hargobind Khorana got the Nobel Prize for his work on the Genetic Code in 1968

5. Dr APJ Abdul Kalam

6. Tata Institute of Fundamental Research

7. Aryabhatta

TERMINAL EXERCISE

1. Write the contribution of medical science in Ancient India.
2. Name any two ancient mathematicians and elaborate their achievements.
3. Give the contribution in Astronomy by ancient scientists.
4. Discuss paper manufacturing in medieval India.
5. In the field of chemistry, what was achieved by medieval Indian scientists.
6. Describe a few technological inventions during medieval India.
7. Tell us about two earlier modern scientists.
8. Narrate the achievements of two Indian Nobel Laureates.
9. What were the contributions of Dr APJ ABDUL KALAM?
10. Who are two recent scientists and tell their contributions.

4 ORIGIN OF LIFE AND EVOLUTION ON EARTH

INTRODUCTION

Creationism vs Evolution has long been a source of heated discussion between religious and scientific viewpoints. Because, whereas science argues that people developed from monkeys, these religions teach that humans were created by God and sent to the world. Many people are surprised to learn that Indians explained Darwin's theory of evolution thousands of years before Darwin. Lord Vishnu's 10 incarnations, or Dashavatara, are an unmatched record of human life's progression and progress in civilisation.

The Dasha stars' relation to evolution theory is a remarkable and well-documented feature.

When viewed from a certain angle, evolutionary theory nicely connects with the 10 incarnations.

The pisiform nature of Mistaya, for example, evokes man's genesis in the water.

All of this was written down by Hindu gurus.

4.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- The progression of life
- How the Darwinism theory connects to Lord Vishnu's Dashavatara.
- The earth's genesis and scheme
- Evolutionary theories (Big bang, Lamarck, Darwin)
- The important events in life's history

4.2 DASHAVATARS THE INDIAN THEORY OF EVOLUTION

The Indian idea of Lord Vishnu's ten avatars describes the evolutionary technique. It is confirmed by the fact that evolution took place gradually. This 'Avatar' hypothesis is based on the RigVeda, the world's oldest texts. This hypothesis is closely related to Charles

Darwin's Darwinian theory of evolution. A widely accepted theory in western educational systems. This demonstrates that Indian Rishis, not to mention modern-day scientists, were aware of the theory of life evolution long before naturalists introduced it to the planet.
Life on Earth hasn't always been like this. The evolution of living creatures has long been one of humanity's most fascinating issues. What is the origin of life? What happened to species when they evolved? Science and religion are both important.

Charles Darwin's theory of evolution is one of the most widely recognised scientific theories on the subject. He discussed how organisms that lived adapted to changing environments, while those that did not may quickly become extinct. Dash avatar is a notion found in Hinduism, the world's third largest religion. It is said that Vishnu comes to earth in the form of an incarnation to restore cosmic order. You might be wondering why we're discussing both of them at the same time. This is due to their strong resemblance.

Although there are many different stories of what (and how many) Vishnu's many avatars are, the most well-known 10 are Matsya, Kurma, Varaha, Narasimha, Vamana, Parashurama, Rama, Krishna, Buddha, and Kalki.

1. Life began in the water, according to Darwin's theory. Matsya, Vishnu's first avatar, was a fish.

   Matsya was Vishnu's first avatar. He disguised himself as a fish to save a large number of Manu from the massive flood. Water, according to Darwin, is the most important factor for life to survive, and hence it is where life began.

2. According to Darwin, the species then began to emerge from the water. Vishnu's second avatar, Kurma, was an amphibian.

   Vishnu's second appearance was in the form of a tortoise named Kurma. It was able to keep the mountain that was being used to churn the cosmic ocean in place. Amphibians, Darwin hypothesised, would be the next quiet animals to emerge. As animals began to emerge and explore the land, they evolved physiological traits that allowed them to exist both within and outside of water.

3. Eventually, organisms needed to travel large distances, so they developed legs. Varaha was a boar in his third incarnation.

   The ability to travel on the bottom had to be the next natural stage in evolution. Species began to develop legs in order to achieve this. Vishnu's third form, the boar, fought Hiranyaksha in a thousand-year fight and assisted in the return of the globe from the ocean's depths.

4. Narsimha's avatar possessed both human and beastlike characteristics. This could be similar to the species from which the first humans originated.

   The notion of Homo sapiens was the next important evolutionary milestone. The fourth avatar, Narsimha, was a half-man, half-lion, indicating a sluggish progression.

5. Vamana, the fifth avatar, was a shrunk soul who resembled the short ape species from whom humans developed.

   In the theory of Charles Darwin. However, if you look at the evolution charts, you'll notice that the first apes from whom men descended were significantly shorter in stature than their modern counterparts.

6. Eventually, the short ape-like creature evolved into what we now refer to as "early man." Vishnu's sixth avatar, Parashurama, was remarkably similar to that.

   Parashurama lived in caverns deep beneath the forest and fought with stone and wood weapons (like an axe).

   Parashurama, who was known for his rage and tendency to act on whims, is said to have slaughtered and vanished the whole Kshatriya clan off the face of the earth in one such rage. within the research of evolution, of these are the traits commonly related to the cave dwelling 'early man'.

The human then learned values, ethics, and beliefs, among other things. Humans began to live in groups, civilizations, and to establish their own kingdoms, government systems, and societal hierarchies. They gradually came to symbolise heroism and leadership. Men began to defend women. Humans grew less violent, more experienced, peaceful, and respectful as their living practises and habits evolved. Rituals and traditions were established by humans. The human began to form relationships with other humans, such as those with his or her toddler (son/daughter), spouse, parent, brother, student, mentor, and so on. The mention of the 'Rama' avatar in the Rig Veda explains this. Lord Rama utilised 'astras' and 'shastras' (weapons), while Vishnu dispatched 'Sudarshana chakra' to pursue targets and, if they were hit, return to their rightful owner. This shows that the technology of guided missiles is not new to India, and it is vitally necessary.

4.3 Physical Condition of Primitive Earth and Solar system

Even if we don't know when or how life began on Earth, It is a proven fact. Except for our planet, there is no proof of life, let alone intelligence or civilisation, anywhere else in the cosmos. These two propositions have the most plausible explanation: life evolved on Earth.

The solar system began as a cloud of dust and gas known as a solar nebula 4.6 billion years ago. As the material began to spin, gravity squished it in on itself, resulting in the sun at the nebula's centre.

As the light climbed higher in the sky, the residual debris began to form a cluster. Small particles clumped together to form larger particles, which were held together by gravity. The solar wind blew away lighter components, such as sand. Lighter atoms like hydrogen and helium were blown away by the solar wind, leaving only heavy, rocky components to build smaller terrestrial worlds like Earth. The solar winds had less effect on lighter components further away, allowing them to form into gas giants. Asteroids, comets, planets, and moons are formed in this manner.

When heavy components collided and bonded together, Earth's rocky core was formed.

The crust was produced by the heavier particles, while the denser material sank to the centre. Around this time, the planet's magnetic field most likely formed. Some of the lighter components that make up the planet's early atmosphere were snatched up by gravity.

Earth was struck by a massive body early in its existence, which drove portions of the new-born planet's mantle into space. Several of these particles were drawn together by gravity to form the moon, which began orbiting its creator. Plate tectonics, or the movement of huge rock plates on the Earth's surface, is caused by the flow of the mantle beneath the crust.

Collisions and friction caused mountain ranges and volcanoes to form.

4.3.1 The Formation of the Solar System

According to current calculations, the Universe is roughly 12 or 13 billion years old. Our solar system's Sun, planets, asteroids, and comets are considerably younger, relative newcomers with an age of 4.55 billion years (4550 million years), give or take a few million years!

According to astronomers, a cloud of interstellar dust and gas lingered for billions of years in our small part of the Milky Way galaxy. A neighbouring supernova explosion then injected even more material and energy into the cloud causing it to collapse on itself by accident or design. The majority of the material concentrated in the cloud's centre to form a new star, our Sun, but just around 1% of it did not.

In a process known as accretion, due to electrostatic and gravitational attraction, dust particles collide softly and prefer to stick together. Under the bed, dust bunnies form in the same way. Dust bunnies can accumulate and compress into large solid masses, up to a kilometre in diameter. or so in diameter, around a young star. Thousands of entities the Massive asteroids will clump together into larger units that we now call planets. In a period of massive impacts, the new planets will continue to be battered by asteroid-sized objects for hundreds of millions of years. Planets have been known to be broken in large impacts, or to have fragments split off of them into space. A planet larger than Mars, for example, may have collided with the Earth early after its formation, tilting its axis to the current 23° tilt that gives us our seasons and throwing debris into Earth orbit that quickly accreted to produce the Moon. Our Solar System has taken on a life of its own. current shape about this time, with three or four large terrestrial planets in stable orbits, enormous gas giants orbiting outside them, and celestial debris such as meteorites, asteroids, and comets still orbiting in space.

In the inner reaches of our solar system, the planet Earth is one of four terrestrial (rocky) planets in the solar system. Venus and Earth are similar in size, but Mars and Mercury are somewhat smaller. They were all created in the same manner, and they were probably certainly all heavily blasted during the era of massive impacts. For a long time, all of the rocky planets would have been extremely hot, with numerous active volcanoes. They melted to the point of producing iron planetary cores and releasing gases that formed atmospheres. Their similarities ceased there, and each inner planet had its own subsequent history.

4.4 THEORIES

Many explanations have been proposed by scientists, such as inanimate concoctions giving rise to self-replicating proteins and eventually life. Other hypotheses claim that life on Earth began deep beneath the oceans, near hydrothermal vents that served as a nursery for the planet's primary life forms. Then there are theories that sound far-fetched due to a lack of proof, such as an asteroid or comet containing components required for eternal life colliding with the Earth and thereby kicking-starting evolution.

Abiogenesis is one of the most widely held hypotheses on how life began. It claims that life arose from non-living, inanimate components as a result of natural processes and events. Stanley Miller's experiment in 1953 backed up this notion. He reproduced conditions that existed approximately 4 billion years ago on Earth. He filled a container with ammonia, methane, carbon monoxide, hydrogen, and water to replicate the gaseous makeup of the early earth's atmosphere. He then used electrical sparks to simulate lightning strikes on the container. Every week, this experiment was in significant trouble, and towards the end, Miller had spotted a deposit of a red-brown substance on the container's walls. When he examined the chemical makeup of this enigmatic substance, he discovered that it comprised organic chemicals and amino acids, both of which are essential at all times. His work paved the way for future scientists to investigate abiogenesis further, and it is now considered one of the most viable competitors for hypotheses on the origin of life. The Panspermia Hypothesis is another alternative to the abiogenesis idea. According to this idea, meteors, comets, and other celestial bodies gave birth to life on Earth. These could store chemicals that are required indefinitely, such as organic molecules and water. These interstellar objects travel great distances, and one of them may have collided with the planet, kicking off the life mechanism. However, this is frequently only a guess, and there is insufficient evidence to back up this notion.

4.4.1 Explosion Theory: Evolution of Our Universe (Big Bang Theory)

Scientists, astronomers, and cosmologists today agree that the Universe as we know it started from a huge explosion that produced not only matter, but also the fundamental laws that govern our ever-expanding universe. The Big Bang Theory is the name given to this scenario. The fundamentals of The Big Bang Theory are simple. According to the Big Bang hypothesis, all of the Universe's current and past matter appeared at the same time 13.8 billion years ago.

At this time, all matter had been crushed into a tiny ball with infinite density and great heat, referred to as a Singularity. The Singularity expanded suddenly, and the cosmos as we know it started.

4.4.2 Lamarckism

Jean Baptiste Lamarck (1744-1829), a French naturalist, proposed Lamarckism. He is well-known for his evolutionary theories. Lamarck's theory of evolution was first published in the book 'Philosophic Zoologique' in the year 1809. His theory was known as the "Theory of Acquired Characters Inheritance" or "Use and Disuse Theory" or Lamarckism.
The four main principles of Lamarckism are as follows:

1. Internal vitality
2. The impact of the environment and new requirements
3. Organ usage and non-usage
4. Acquired character inheritance

1. Internal vital force: Every organism, according to Lamarck, has an internal vital force (a hypothetical force). Throughout time, the scale of living creatures and their parts tends to expand in bulk. The organism's vital internal force is responsible for this increase in size.

2. The impact of the environment and new needs: Our environment has the potential to have a huge impact. As a result, a change in the environment triggers the emergence of new demands in organisms. As described in the previous hypothesis, organisms evolve specific adaptive morphological or anatomical characteristics in order to meet new needs. The evolution of certain traits leads to changes in the functions as well. Acquired characters are the term for such variations. These organisms' adaptive characteristics could also be within the variety of the event of recent parts of the body.

3. The use and disuse theory states that an organ that is used frequently develops well and is strengthened. Organs that aren't used for a long time gradually deteriorate and eventually degenerate.

4. Theory of acquired character inheritance:
As previously stated, animals develop acquired traits in response to changes in their environment.

According to Lamarck, these characteristics are passed down through the generations because they improve the species' chances of survival.

4.5 MAJOR EVENTS IN THE HISTORY OF LIFE

A. Geological time scale: The geological time scale encompasses the period from the beginning of time to the present. The earth's age is divided into three aeons, which are listed below.

B. The Phanerozoic Eon began approximately 570 million years ago and is still going on today. Vertebrates and phanerogams emerge throughout this aeon. There are three eras in this aeon:

(i) The Cenozoic era The Cenozoic Era began 65 million years ago and continues today. It is split into two halves. There are two types of rocks: quaternary and tertiary. The Cenozoic Era gave rise to the great variety of plants and animals that we see today.

(ii)Mesozoic era

The Mesozoic era lasted 250 million years, ending 65.5 million years ago. Various sorts of hills and mountains were developed throughout this time period. The fundamental circumstances for the existence of life on land, sea, and air are said to have been produced. There are three phases in this era.

(iii) Paleozoicera

Paleozoicera began approximately 540 million years ago and concluded approximately 250 million years ago. Plants and animals were discovered to have evolved during this time period, as evidenced by investigations of fossils found in sedimentary rocks. Similarly, it is thought that there was an alteration in the atmosphere and whether. There are six phases in this era. The stages of human evolution are as follows:

a) Dryopithecus

- Both men and apes are said to have descended from these ancestors. They roamed the continents of Africa, China, Europe, and India. Dryopithecus is a genus of oak wood apes. Because the tropical lowlands where Dryopithecus lived were densely forested at the time, the individuals may have been primarily herbivores.

b) Ramapithecus

- Their remains were originally discovered in Punjab's Shivalik mountain, then in Africa and Saudi Arabia. They dwelt in grassy plains.
- Robust jaws, thickened tooth enamel, and shorter canines, as well as the use of hands for food and defence, and extrapolations of upright posture, demonstrate their Hominid status.

c) Australopithecus

- The first fossil of this genus was discovered in South Africa in 1924. They lived on the ground and used stones as weapons, and walked erect. They were 4 feet tall and weighed 60 - 80 pounds.

d) Homo erectus

- In 1891, the first Homo Erectus fossil was discovered in Java. The species was given the name Pithecanthropus erectus. These were thought to be the missing link between humans and chimps. The Peking man was another Chinese discovery. This specimen possessed huge cranial capacity and was thought to have lived in groups. Quartz-based tools were utilised by Homo erectus. Bone and wood-based tools have also been identified. Collective hunting has been documented. There's also evidence of fire being used. Homo erectus is a type of human.

e) Homo sapiens (Neanderthalensis)

- Homo sapiens evolved from Homo erectus. During the evolution of Homo sapiens, two sub-species were discovered: Homo sapiens and Homo sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sapiens sap Homo humans and Neanderthals. Neanderthals' cranial capacity increased from 1200 to 1600 cubic centimetres. There were also a few little hand axes unearthed. This hominid species was capable of hunting large mammals such as mammoths.

CHECK YOUR PROGRESS 4.1

1.Which of the following are the principles of Lamarck's theory of evolution?

A. Frequent use of an organ greatly improves them and misuse reduces the organ.

B. Transmission of the beneficial characters for survival transmitted to offspring by inheritance

C. Changing environment can bring modification to an organ.

D. All the above are correct

2.What causes the formation of solar system?

3.State Big Bang theory.

4.6 PREDICTIONS OF ANCIENT INDIAN SCIENTIST

I. The Thought of Zero: -The mathematical numeral zero, which requires minimal explanation, is one of the most important inventions of all time. A mathematician named Aryabhata was the first to develop a logo for zero, and it was thanks to his work that mathematical processes like addition and subtraction began to use the digit zero. Large numbers could also be written down with only ten symbols thanks to the concept of zero and its inclusion into the place-value system.

India invented the decimal numeration system, which is an amazing way of expressing all numbers using only ten symbols.

In this system, Each symbol was given a numerical as well as a positional value. because of the simplicity of the mathematical notation, which made it easier

II. Numeral Notations: - As early as 500 BCE, Indians devised a system of different symbols for each number from one to nine. This notation technique was adopted by the Arabs and given the name hind numerals. This notation system was adopted by the western world centuries later, and it was given the name Arabic numerals because it was brought to them by Arab traders.

III. Chakravala Algorithm Method: - The chakravala technique, which includes the Pell's equation, could be a cyclic procedure for solving indeterminate quadratic equations. Brahmagupta, one of the most well-known mathematicians of the 7th century CE, devised this approach for getting integer solutions. Jayadeva, another mathematician, eventually developed this method to a larger variety of equations, which Bhskara II perfected in his Bijaganita.

IV.A Theory of Atom: - Kanad, a well-known scientist in traditional India, is said to have devised the atomic theory centuries before Dalton was born. He proposed the existence of anu, a microscopic indestructible particle similar to an atom. Anu can exist in two states, according to him: absolute repose and motion. He also believed that atoms from the same substance interacted in a very precise and synchronised manner to generate dvyanuka (diatomic molecules) and tryanuka (triatomic molecules) (triatomic molecules).

V. The Heliocentric Theory: - Ancient Indian mathematicians used their mathematical knowledge to make accurate astronomical predictions on a regular basis. The most important of them all was Aryabhata, whose work Aryabhatiya represented the pinnacle of astronomical knowledge at the time. The heliocentric theory, according to which the Earth is round, rotates on its own axis, and circles around the Sun, was accurately proposed by him. He predicted solar and lunar eclipses, as well as the length of the day, based on the distance between the planet and the Moon.

VI. Cosmetic surgery: - Sushruta Samhita, written by Sushruta in the 6th century BC, is considered one of the most comprehensive textbooks on ancient surgery. The work discusses a variety of ailments, herbs, preparations, and remedies, as well as advanced cosmetic surgery procedures. The most well-known contribution of the Sushruta Samhita to cosmetic surgery is nose reconstruction, generally known as rhinoplasty.

VII. Ayurveda: - Charaka created the Charakasamhita, a founding treatise on the traditional discipline of Ayurveda, long before Hippocrates was born. Because Charaka, the Father of Indian Medicine, was the first physician to introduce the concepts of digestion, metabolism, and immunity in his book, the topic was brought up. For two millennia, Charaka's ancient treatise on medical practise was a regular work on the subject, and it was translated into numerous foreign languages, including Arabic and Latin.

4.7 Darwinism

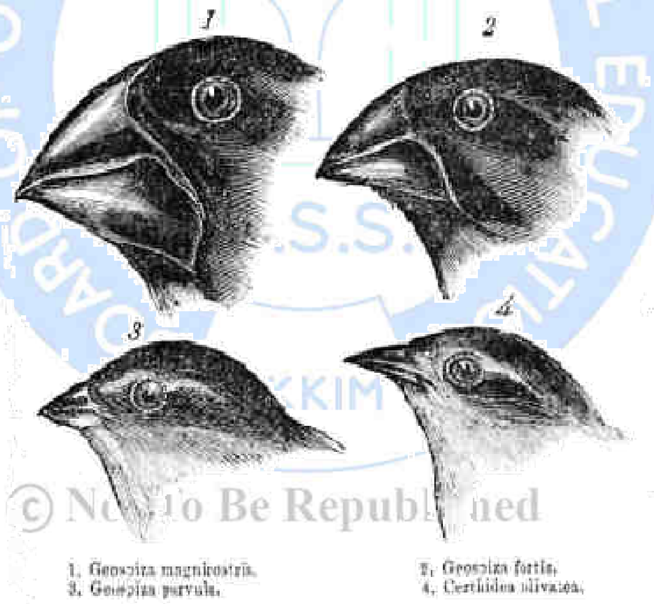
Charles Darwin, an English naturalist of the nineteenth century, spent nearly 20 years studying nature in depth. He gathered data on animal distribution and, as a result, the relationship between living and extinct animals, and discovered that current living animals have some similarities not only with each other, but also with the opposite species that existed countless years ago and among which some became extinct.

Because of his contribution to the establishment of the theory of evolution, Charles Darwin is known as the "Father of Evolution." His thesis helped to disprove all of the old beliefs that the genesis of different species was a supernatural occurrence or act of the Almighty. Darwin's survival theory provided a more reasonable explanation for the emergence of new species. As a result of adaptation to the changing environment, numerous species arose naturally from a single species.

4.7.1 Darwin and The theory of evolution

Darwin's seminal book, On the Origin of Species, set forth his ideas about evolution and **survival of the fittest**. Direct observations from Darwin's trips around the world mostly backed his theories. He was a member of a survey trip led by the ship HMS Beagle from 1831 to 1836, South America, Australia, and Africa's southernmost point were among the destinations. At stops in South America, Australia, and the southern tip of Africa, Darwin had the opportunity to examine and classify the indigenous plants and animals. At each of the expedition's locations, Darwin was able to examine and classify the indigenous plants and animals. each of the expedition's destinations.

During his travels, Darwin began to notice extraordinary patterns in the distribution and characteristics of species. We can see some of the most important patterns in the distribution of species by looking at Darwin's observations of the Galapagos Islands off the coast of Ecuador.



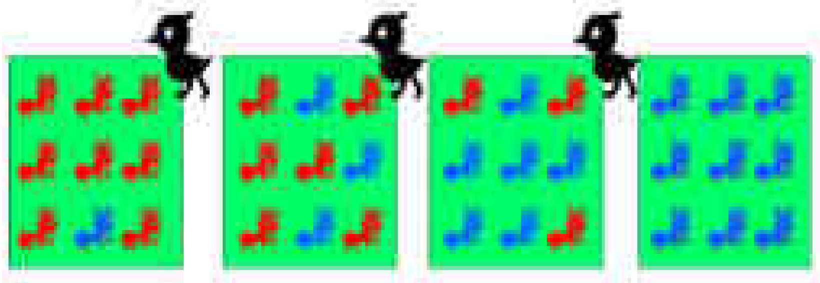
4.7.2 Darwin's Theory of Evolution

Darwin discovered that neighbouring islands in the Galápagos contained finch species that were similar but not identical. He also pointed out that each finch species was well-suited to its environment and function. Those who ate huge seeds, for example, had large, thick beaks, whereas those who ate insects had thin, pointy beaks. Finally, he noted that the finches (and other animals) found in the Galapagos were similar to those found on Ecuador's mainland, but distinct from those found elsewhere in the worldsquared.

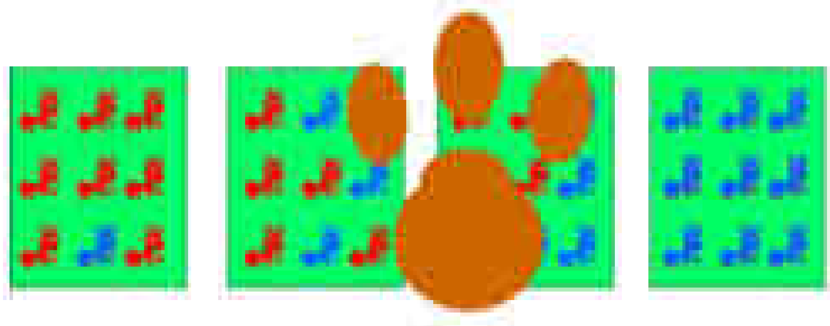
On his journey, Darwin did not figure out all of this. In fact, it wasn't until he showed his specimens to a gifted ornithologist that he realised that the finches were related but unique species (bird biologist). Gradually, though, he devised a strategy for explaining the pattern of related but unlike finches.

This pattern would add up, according to Darwin's theory, if the Galapagos Islands were once occupied by birds from the neighbouring mainland. Finches may need to progressively adjust to local conditions on each island (over many generations and long periods of time). On each island, this process might have resulted in the emergence of one or more unique species. Darwin coined the phrase "descent with modification" to describe the process through which groups of animals modify their heritable features across generations. It's now known as evolution. The diagram above shows how one species can split into two over time, and how this can happen several times within a "family tree" of closely related species, illustrating Darwin's theory.

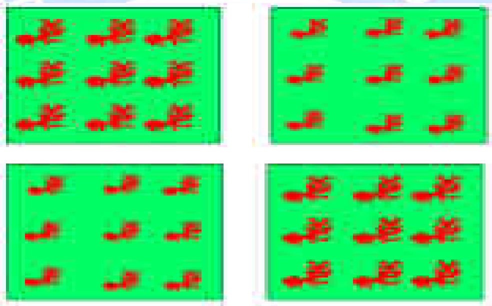
To understand how evolution takes place, let us take some imaginary examples.



Situation 1: In a thicket, a colony of red ants lives. Hunting birds enjoy eating on ants because they can easily see red ants in the green background. Some blue ants have appeared as a result of a DNA replication mistake. Blue ants against a green backdrop are invisible to hunting birds. As a result, blue ants thrive while red ants eventually become extinct. The emergence of blue ants was unintentional, but it provided the ants with a survival advantage. Finally, blue ants were able to survive and spread over the environment.



Situation 2: Some blue ants were discovered in the same group. The population of both colours of ants was nearly equal. An elephant came by one day and trampled the vegetation. The accident killed all the red ants, leaving only the blue ants. Red ants became extinct as a result of this, while blue ants were able to continue their race. The survival of blue ants was due to a freak occurrence, which resulted in natural selection.



Situation 3 A colony of red ants lived in a shrub. The ants' food supply became a concern due to the draught-like conditions. All of the ants were feeble and underweight as a result of this. The pattern continued for a few generations, with subsequent generations consisting of smaller ants. Situations changed, and there was plenty of food available. Ants grew to their normal size once more. The shift in size was a phenotypic change in this case, and so was not inheritable. Variation and evolution in the species could not be caused by a change in size.

Organisms have unlimited capacity to reproduce:

Organisms have the ability to create offspring quickly. This is crucial for survival, as having more offspring means that at least some of them will survive. Every organism must fight for survival on a daily basis. A frog, for example, can lay thousands of eggs at once. The spawn is discharged into the water and allowed to its own devices. The majority of the eggs are washed away or eaten by predators. However, a part of the spawn's eggs grow into tadpoles. Many tadpoles are eaten by predators once more, leaving only a few to develop into adults. It goes without saying that a high number of eggs are required to ensure that at least some of them mature into adults.

Natural Selection:

Individuals of the same species have diverse characteristics. Nature favours those who possess more desirable characteristics. For seeking food and locating a partner, each organism requires a unique characteristic. Those with better traits can now pass their traits on to the next generation.

Survival of the Fittest:

Only the fittest species survive, while the others perish. Many species fall extinct as a result of this, while others continue to change over time.

4.8 NEO-DARWINSM (The Modern Synthetic Theory of Evolution)

Natural selection, as proposed by Darwin, was accepted. Wallace, Huxley, Haeckel, and Weismann are all proponents of Darwinism. Darwin's theory lacked contemporary genetic concepts and processes for character emergence and persistence in populations. The idea has been updated in light of recent studies. Darwinism has been supported by a number of experimental evidences. A synthetic theory of evolution was suggested based on these facts and statistical data. This is a Darwinian theory that has been changed. T. Dobzhansky, J.B.S. Haldane, R.A. Fisher, Sewall Wright, G.L. Stebbins, and Ernst Mayr are among the evolutionary biologists who advocated Neo-Darwinism.

It describes the evolution of life in terms of population genetic changes that lead to new species emergence. The genetic population, also known as the Mendelian population, as well as the gene pool and gene frequency, are all included. Natural selection, genetic differences, reproductive and geographical isolation, and genetic differences are all important parts of this idea.

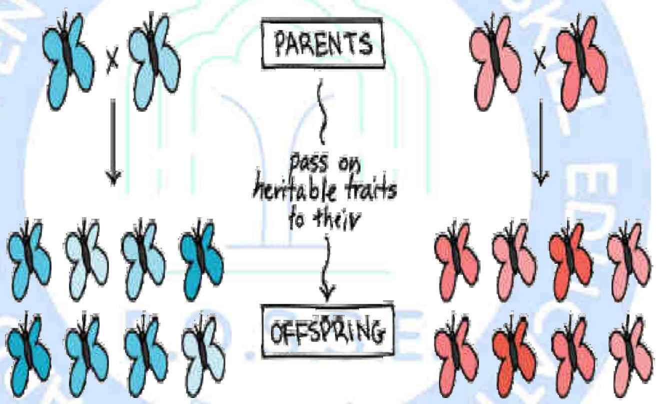
The Modern Synthetic Theory of Evolution revealed a number of changes in the way people think about evolution and the evolutionary process. The theory proposed a new definition of evolution: "changes in allele frequencies among populations," emphasising evolution's genetic component.

4.9 How Evolution Took Place

Natural selection was also proposed by Darwin as a process for evolution. This concept was simple and logical, and it explained how populations might change through time to become more adapted to their circumstances (by descent with modification).

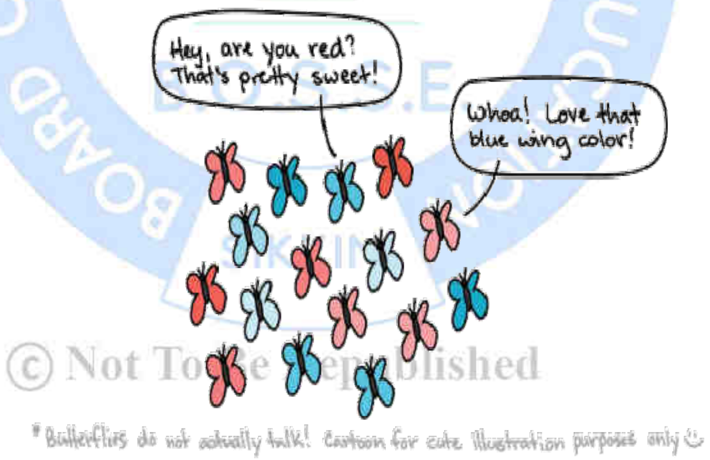
Darwin's natural selection theory was founded on many crucial observations:

- Traits are commonly passed down over generations. Many characteristics are inherited or passed down from parent to offspring in living beings. (Even though Darwin had no knowledge that traits were passed down through genes, he realised this.)



- There are more offspring than can live. Organisms have the ability to produce more offspring than their surroundings can sustain. As a result, each generation competes for limited resources

- **Offspring vary in their heritable traits.** Each generation's offspring will differ slightly in terms of qualities (colour, size, shape, and so on), and many of these characteristics will be heritable.



Based on these simple observations, Darwin concluded the following:
Some persons in a group will be born with characteristics that will aid them in surviving and reproducing (given the conditions of the environment, such as the predators and food sources present). Individuals with these features will leave more children in the following generation than their contemporaries because the favorable traits make organisms more effective at surviving and reproducing. The traits will become more prominent (present in a bigger percentage of the population) in the next generation since positive characteristics are

heritable and organisms with these features generate more offspring. Humans will adapt to their surroundings throughout generations (as individuals with traits helpful in that environment have consistently greater reproductive success than their peers).

. Darwin's natural selection theory allowed him to explain the patterns he observed on his travels. If the Galápagos finch species had a common ancestor, it was only natural for them to look alike (and mainland finches, who likely shared that common ancestor). If groups of finches were separated for several generations on different islands, each group would have been exposed to a different environment, resulting in different heritable features, such as different beak sizes and shapes for different food sources, being favoured. These causes may have caused separate species to evolve on each island.

CHECK YOUR PROGRESS 4.2

1. Choose the correct answers.

(i) Who had given the theory of evolution of species by natural selection?

A. Darwin
B. Mendel
C. Dalton
D. Morgan

(ii) Which of the following are Darwin's theory of evolution's postulates?

A. Natural variation exists within any population.

B. Despite the fact that all species produce a significant number of offspring, populations are inherently stable.

C. In populations, the struggle for existence eliminates the unfit people.

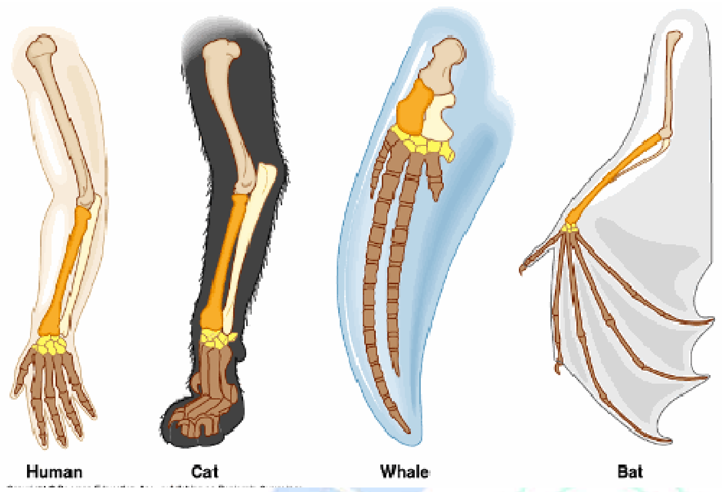
D. The answers to all of the foregoing questions are correct.

4.10 Tracing Evolutionary Relationship

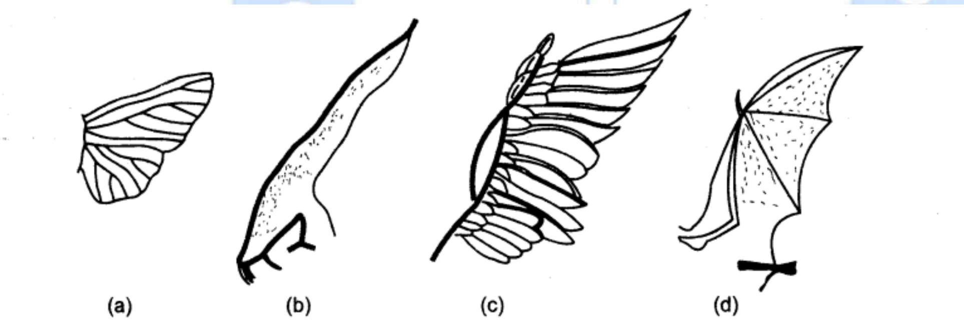
Evolutionary relationship means how closely related two organisms are in evolution. Now the question is how do we come to know about this relationship, the answer lies in the wealth of Scientific evidences. The various sources that help in tracking relationship are

1) Homologous organs,
2) Analogous organs, and
3) Vestigial Organs
4) Fossil records
5) Genetic Sequencing
6) Natural Selection

Homologous Organs The organs that are similar in structure and
origin but differ in function are called Homologous Organs. For eg.This does not mean that they share the same ancestor.



Analogous Organs
Analogous Organs- The organs that are similar in function but differ in structure and origin are called Analogous Organs. For eg.

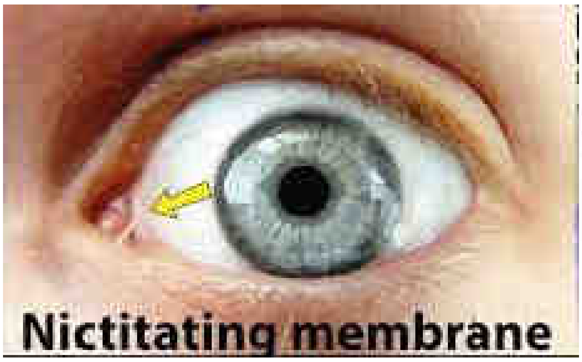


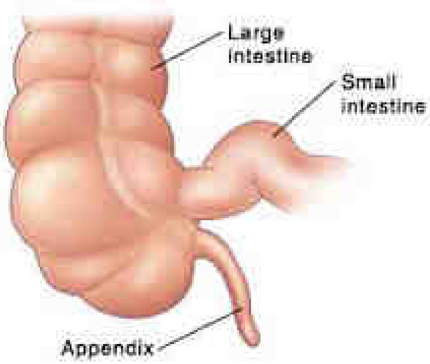
Analogous organs (a) Wing of insect (b) Wing of *Pterodactyl* (c) Wing of bird (d) Wing of bat

The presence of similar organs in fossils helps us comprehend that the two species reside (d) in the same habitat and have evolved to live there.

VESTIGEAL ORGANS

These are theorgans or parts of human, plant, and animal bodies that are functionless now but were performing the respective function in the ancestors. For example, the appendix in human intestine was used in digestion earlier but has now become functionless.
Vestigial organs are proof that all living organisms have evolved over time and are also helpful in explaining adaptation. Some of the examples of vestigial organs are





Nictitating membrane

Appendix

Wisdom teeth in humans

Dewclaws in dogs

Wings of a female cockroach

External Ear.

Fossils

Fossil are an important link in knowing the process of evolution.

They are the remains of dead plants and animals that remain buried under the Earth's crust for several years. The fossils on in the above layers are comparatively newly formed then the ones found in deeper layer. Fossils show a progression of different life forms over time. This shows that organisms have changed over time, which is what evolution predicts. Additionally, fossils can show how different species are related to one another can help to date different events in history, which can help to verify the theory of evolution.

For example, Archaeopteryxis considered as a transitional fossil between dinosaurs and modern birds. It possesses both avian and reptilian features. It was long viewed as the earliest known bird. Discovered in 1860 in Germany, it's sometimes referred to as Urvogel, the German word for "original bird" or "first bird."

DNA Sequencing

Genes are genetic units that carry DNA from parents to their children. The nucleotide (A, G, C, and T) sequences of genes from various species are usually remarkably similar, indicating that they have a common ancestry.

Progress cannot be equated with evolution

Evolution is defined as a process of formation of new species through slow and steady changes which took place over millions of years. The process of Natural Selection has immensely contributed to process of evolution. Owing to various reasons, an individual is able to exhibit changes in his phenotype or physical characteristics Only those organisms are able to survive who are best suited to their surroundings, that is survival of the fittest. These organisms have more chances to survive, resist diseases and avoid predators.

Evolution cannot be equated with progress because it is not always the development from lower to higher forms or organisms but sometimes even lower form organisms keep on evolving and surviving.

For example:

Human Beings are developed and complex but minute organisms like bacteria are still surviving with great degree of efficiency in extreme conditions and performing all the vital functions.

Evolution does not mean that complex body organisms are on higher pedestrial or are of more importance rather it is a process where each and every organism is living and progressing in its own best possible manner.

CHECK YOUR PROGRESS 4.3

1. (i)Define genetic drift
   (ii) What is mutation?

2. What are the stages of human evolution?
3. Differentiate between homo erectus and homo sapiens.

RECAPITULATION POINTS

- Dashavataris related with the theory of evolution of Darwinism.
- The third planet from the sun, Earth, was created as gravity drew spinning gas and dust close. Earth, like its other terrestrial planets, has a solid crust, a rocky mantle, and a central core.

- Abiogenesis theory states that life originated from non-living, inanimate materials through natural processes and occurrences
- Big bang theory suggests that the universe was created as a result of an extremely large explosion.
- The modified Darwinism theory is known as Neo-Darwinism or modern synthetic theory which gave a new definition of evolution as “the changes occurring in the allele frequencies within the populations,” that depends on many factors like variation, genetic drift, mutation.
- According to Darwin, evolution is based on natural selection.
- All the organisms have a common ancestor that proved from many evidences like vestigial organs, Homologous organs, Analogous organs, Fossil records, Genetic Sequencing, Natural Selection.

TERMINAL EXERCISE

1. Multiple choice questions

(i). Which of the following are the sources which provide evidences for evolution?

A. Homologous organs

B. Analogous organs

C. Fossils

D. All the above

(ii). What are the names of the organs with similar appearances and functions but differing fundamental structures?

A. Organs with comparable functions

B. Organs that are homogeneous

C.A and B are both correct.

D. Neither A nor B are true.

2. VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

a. Who is known as Father of Evolution?

b. What do you mean by the term gene?

c. Write the names of two types of chromosomes found in an organism.

d. How many chromosomes are found in an egg and ovum?

e. List the main components in Darwin's theory of Natural Selection?

f. Who are the carriers of factors and genes?

g. What will be the sex of a child if he inherits X chromosome from his/her father?

h.Who gave the theory of inheritance of acquired characters?

i. Define mutation.

j. What are fossils?

3. SHORT ANSWER TYPE QUESTIONS (2 MARKS)

a. Why off springs differ from parents?

b. Do genetic combination of mother helps in determining sex of a child?

c. What is the importance of Variation?

d. What is contribution of Mendel to genetics?

e. Define Genetics.

f. With suitable example, highlight how temperature has an effect on sex determination in the animal world.

g. How will you determine the age of a fossil?

h. Define the scientific words that are used to denote the following:

(i) A field of biology that investigates heredity and variation;

(ii) The transmission of qualities from parents to offspring;

(iii)Differences in human traits;

(iv)A distinguishing feature of an organism.

(v) List any two differences between Recessive and Dominant traits.

i. Why did Mendel choose pea plants for his research.

4 SHORT ANSWER TYPE QUESTIONS (3 MARKS)

Q1. What are advantages of tissue culture?

Q2. Explain how the following are instances of evidence in favour of evolution in organisms:

Homologous organs

(a)analogous organs (b) fossils (c) and homologous organs.

Q3. Describe three ways in which a population of people having a given attribute may grow.

Q4. Homologous Organs: What Are They? Is it possible to consider the wings of a butterfly and the wings of a bat to be homologous? Why?

Q5. Define the phrase.

a) Speciation b) Natural Selection

D. LONG ANSWER TYPE QUESTIONS (5 MARKS)

Q1. In evolutionary terms, can we say which among bacteria, spiders and chimpanzees have a better body design?

Q2. Explain the importance of fossil in deciding evolutionary relationship.

Q3. Describe why sexual reproduction produces more viable variety than asexual reproduction.

Q4. How does this affect the evolution of sexually reproducing organisms?

Q5. Describe Darwins Theory of Evolution .

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 4.1

1. -D
2. The Sun and the planets both emerged from a cloud of gas and dirt called the solar nebula 4.6 billion years ago. The collapse of the solar nebula was most likely triggered by an undulation caused by a nearby supernova explosion. The planets formed during a thin disc revolving around the Sun, which formed within the core.
3. The Big Bang hypothesis might explain how the universe began, as well as how the collections of stars (known as galaxies) that we observe today. There were no stars, atoms, shape, or structure when the cosmos began, and it was very popular, tiny, and dense (called a "singularity"). The prevalent cosmological model for the universe from the earliest known times to its following large-scale development is the Big Bang hypothesis.

CHECK YOUR PROGRESS 4.2

(i) Darwin

(ii) D. All the above are correct.

CHECK YOUR PROGRESS 4.3

Q1. (i) When there is a change in a gene variant in a population due to random sampling is called genetic drift. It is more likely to happen in small populations. It results in the change of frequency of an allele in the isolated population.

(iii)Mutation is a permanent change in the nucleotide sequence of genome of an organism, virus, or extra chromosomal DNA or other genetic elements, which can be transferred from one generation to other. The mutation are heritable.

2. Homo neanderthalensis → Ramapithecus → Australopithecus → Dryopithecus

3. Difference between Homo erectus and Homo Sapiens

Homo erectus	Homo Sapiens
An extinct archaic human species that existed for the majority of the Pleuston geological era.	Modern humans are a member of the primal species.
Refers to a man who is upright.	Modern man can think
A species that has been extinct	Currently, there are flourishing species.
Facial features similar to apes	. Facial features similar to modern man
Brain size was 850cc -1100cc	Brain size is 1300cc
Comparatively less intelligent	They are intelligent
Had large teeth	Have small teeth

5 CELL

INTRODUCTION

Every living organism takes birth, grows and meets its end for which cells play a decisive role in the whole life process of any living organism. Different types of cells are present in different organs of living organism performing different types of functions in the living body. But whatever is the cell, where they are present the components of a cell have almost similar structure and function. The living organisms originated since the time immemorial. They have undergone a continuous process of evolution. As a result of differentiation in the appearance, shape and size of higher organisms took place a drastic process of change. But the structure and function of the unit of living organism i.e. the cell remains the same. Hence, cell is known as the structural and functional unit of living organism. The cells assembled in a specific way to form tissue, body part or the organ and at the end the body of the living organism. The living organism, either plant or animal functions in a particular way to differentiate themselves from that of a non-living thing.

5.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Explain about the of plant cell and animal cell
- Differentiate between unicellular and multicellular organisms
- Identify cells with different shapes and sizes
- Understand structure and function of different parts of cell
- Justify the process of different parts of cell and cell organelles
- Compare plant cell and animal cell
- Justify cell as structural and functional unit of living organism

- Draw diagrams of plant and animal cells
- Draw the diagram of various cell organelles

5.2 ORIGIN AND STRUCTURE OF PLANT CELL AND ANIMAL CELL

5.2.1 Cell- Its origin and discovery

Robert Hooke, British Scientist, in 1665 was working with cork slices (developed from plant barks under the primitive microscope in laboratory. He discovered honey comb like structure of the tiny boxes in the slices of the cork. He named those structure as 'cells' measuring a small room space. Each box is separated from each other by thin walls or partitions. Anton Van Leeuwenhoek first discovered free living algae, Spirogyra, cells in water in 1674 with the improved microscope. In 1831, Robert Brown discovered a structure within the cell of orchids and many other plants, that he termed the 'nucleus' of the cell. In 1839, Czech physiologist, J.E. Purkinje coined the term 'protoplasm' for the fluid substance of a cell. The classical cell theory i.e. all organisms are made of cells, cells are basic unit of life of plants and animals, cells come from pre-existing cells that have been multiplied (Theodor Schwann, 1839, Matthias Jacob Schleiden, 1838 and Rudolf Virchow, 1858). Further discoveries led to form 'modern cell theory' i.e. the DNA is passed between cells during cell division, the cells of all organisms within a similar species are mostly the same both structurally and chemically and finally that the energy flow occurs within the cells.

5.2.2 Cork cells and cells of an onion peel:

Cork cells: Robert Hooke in 1665 observed very thin slices of cork (derived from the bark of a tree) under the primitive magnifying device. He found partitioned boxes of tiny cells in the cork slices.

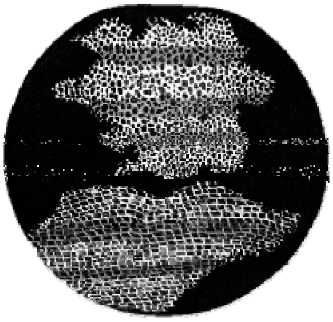


Fig. 5.1 Tiny cells in the cork

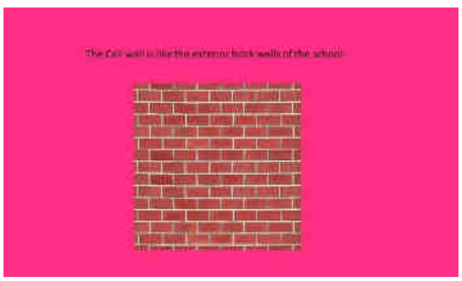
The boxes looked like honey comb and separated from each other by partition. Each box was named by Hooke as cell present in the cork. The cells present in the cork are dead cells as bark of a tree is dead.

Onion peel: In the following way you can prepare stained temporary mount of onion peel in your study centre:

Pour little distilled water into a watch glass

Peel of a skin (epidermis) from the onion leaf of an onion using the forceps which is transparent Put the epidermis in the water collected in watch glass Use the stain safranin to stain the peel Observe under simple microscope magnifying glass.

Brick wall



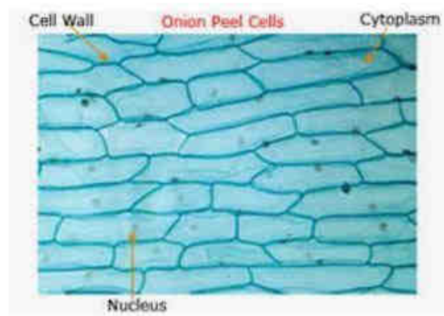


Fig. 5.2.a. Brick wall

Fig. 5.2.b. Cells of epidermis of an onion peel

The cells are clearly visible in the peel arranged like bricks on a wall.

Inside the cell, you can find clearly very small spots, which are known as nucleus.

5.3 UNICELLULAR AND MULTICELLUAR ORGANISMS:

The cells in an onion peel together form the leaf of the onion. Likewise, whole bulb of onion is being formed. Even many organisms have different types of cells and the total number of cells in a living body is unaccountable. These organisms are called multicellular living organisms; it may be a plant or animal. There are living organisms having only one cell. The organisms maintain their body functions with a single cell and they are known as unicellular organism.

In multicellular organisms different group of cells perform a variety of functions and in unicellular organisms body functions are conducted by the single cell.

Look at the unicellular organism in figure 4.3 (a & b)

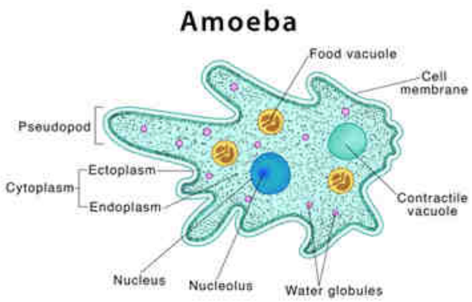


Fig. 5.3 (a) Amoeba

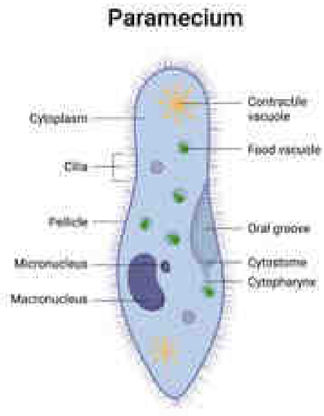


Fig. 5.3 (b) Paramecium

Amoeba, a single celled organism, captures and digests food, respires, excretes, grows and reproduces. Paramecium and other unicellular organism performs the similar functions by the single cell also.

Amoeba has no definite shape unlike other organisms. It keeps on changing its shape and size for locomotion (movement) and ingestion (process of food taken in and digestion through mouth). The protruding projections of various lengths out of the body are known as pseudopodia (Pseudo means false and podia means feet). These pseudopodia reappear and disappear as per the need of the amoeba.

Like Amoeba, Paramecium is also a unicellular organism with a shape resembling the sole of a shoe. It ranges from 50 to 300 µm in size which varies from species to species. It is mostly found in fresh water environment. It makes movement with cilia to gather food through the oral groove. It also uses cilia to move from one place to another in water.

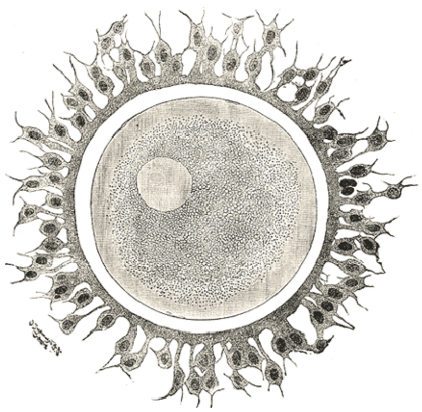
5.3.1 Shape and size of plant and animal cell:

a) Size of cell: The size of cells in living organisms may be very small. It may be as small as one millionth of a meter (micrometer or micron) and also may be as large as few centimeters. Cells of multicellular eukaryotes (cells having definite nucleus) have a size range of 5-100µm. Erythrocytes (RBC) are 7-8µm in diameter, lymphocytes are still smaller 6µm. Muscle and nerve cells are comparatively very large. Generally, the unicellular organisms are microscopic like bacteria but a single cell like an egg is large enough to touch. The largest cell is an egg cell of ostrich (130mm to 170mm). The largest cell in human body is ovum. The longest cell is the nerve cell.

b) Shape of a cell in living organism: Description of the shape of a cell is called the cell morphology. Usually the cells are round, elongated or spherical. There are also some cells which are long and pointed on both ends. Such cells exhibit spindle shape. In some cases, cells are very long like plant cells. The unicellular animal, amoeba, has no definite shape. Its shape is irregular and it keeps on changing its shape.

These projections are called pseudopodia. These projections appear and disappear during amoeba's locomotion for food.

Example of round cell is human ovum, elongated cell in nerve cells, spherical cell in RBC and spindle shape cell in muscle cells.



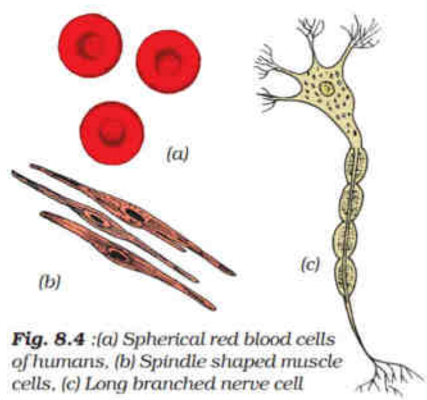


Fig. 5.4 (a) round shaped cell, picture of ovum Fig. 5.4 (b) elongated cell, Fig. 5.4 (c) Spherical cell, Fig. 5.4 (d) Spindle shaped cell.

Besides these also there are many other differing shaped cells. The different shapes are related to their specific functions. All the components of the cells are enclosed within a membrane called cell membrane. This membrane provides shape to the cell.

Plant cells have a definite shape which is mostly rectangular cubes and bigger than animal cells. These cells have fixed shape because of the presence of a rigid cell wall around the cell components. Cell wall becomes rigid because of the presence of cellulose which provides a regular shape to the cell.

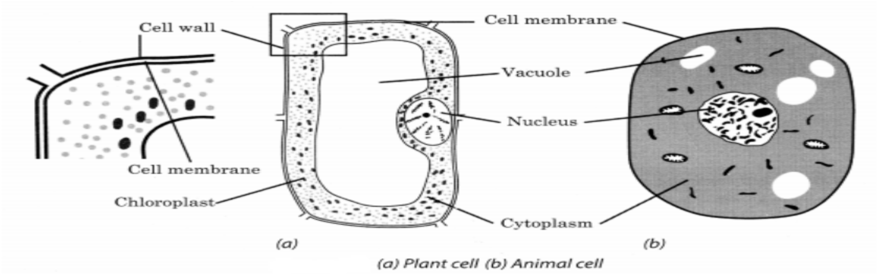


Fig. 5.5 Labeled diagram of plant cell and animal cell

5.3.2 Structural and functional unit of living organisms:

The cell is the basic structural unit of living organism. Cells are independent. Like multicellular organisms, even the single cell organisms take in nutrients, excrete wastes, detect and respond to their environment, move, breathe, grow and reproduce. The different components of the cell perform certain functions. If one of the components seizes to function, the whole organism gets affected. Now let us understand the functions of cell components. The functional unit refers to performing various life processes which are required to sustain the whole body system.

Let us analyze the structure and function of each cell component.

You are aware that each living body consists of many organs and each organ carry many cells. For example, the respiratory organ performs the function of respiration and excretion of gaseous wastes like carbon dioxide. Similarly, in plants leaves, as you know, are responsible for synthesis of food, stem helps in transportation of water and food materials to different parts of the plant. Likewise, animals and plants do have many organs and they perform different activities in respective body systems. Organs are made up of tissues and tissues consist of cells. The cells are structural and functional unit of living organism. This helps the living organism to perform all the activities discussed above for its survival.

Activity 5.2

A permanent slide of an onion peel can be shown in study centre and both the figures can be drawn by each leaner.

Activity 5.3.a

Permanent slides of amoeba and paramecium may be shown to learners under the microscope.

Activity 5.3.b

Compare slides of amoeba and the onion peel on the points learnt so far.

Activity 5.3.1.a

Observe the projections of varying lengths protruding out of body of amoeba under the microscope.

Activity 5.3.1.b

Permanent slides of plant cell and animal cell to be observed under the microscope and diagrams to be drawn.

CHECK YOUR PROGRESS 5.1

1. Choose the correct answer

a. Who discovered cell?

i. Robert Brown

ii. Robert Hooke

iii. Anton Van Leeuwenhoek

iv. J. E. Purkinje

b. According to cell theory finally where does the energy flow occurs?

i. Within the cell

ii. Outside the cell

iii. Within the tissue

iv. Outside the tissue

c. In amoeba which is the locomotory body part?

i. Cell membrane ii. Cell wall

iii. Nucleus iv. Pseudopodium

d. Which is the unicellular organism from given below?

i. Cell membrane ii. Cell wall

iii. Nucleus iv. Paramecium

2. Which cell in human body is round in shape?

3.Egg of a pigeon is what type of cell?

4. Which type of cells is longest in size?

5. If the plant cell would have no cell wall what problem plant would face?

Activity 5.2

A permanent slide of an onion peel can be shown in study centre and both the figures can be drawn by each leaner.

Activity 5.3.a

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Observe the projections of varying lengths protruding out of body of amoeba under the microscope.

Activity 5.3.1.b

Permanent slides of plant cell and animal cell to be observed under the microscope and diagrams to be drawn.

5.4 PLASMA MEMBRANE OR CELL MEMBRANE:

Let us now know the basic components of the structural and functional unit i.e. the cell of living organism.

Plasma membrane is the outermost covering of a cell. It is found in all cells and separate the interior components from outside environment. The membrane is selectively permeable or semipermeable which controls entering and exiting of some of the materials inside or outside of the cell.

Let us find out how does the transport of materials take place?

Substances like carbon dioxide or oxygen can move across the semipermeable membrane. This process is known as diffusion which permits a substance to move from a region of higher concentration to a region of lower concentration. Carbon dioxide is a cellular waste which needs to be excreted out from the cell. The concentration of gas inside becomes higher and it moves through the semipermeable membrane out of the cell (to the region of lower concentration of carbon dioxide).

Similarly, oxygen enters from higher concentration (outside the cell) to lower concentration into the cell (available inside the cell). This indicates diffusion plays a very important role in gaseous exchange inside of a cell to outside environment.

The transport of water and minerals also takes place through another process similarly known as osmosis. Water dissolves minerals and it reaches to the cell and the concentration of the same becomes high in outside environment of the cell. As the inside concentration of the same materials is less inside the cell the transport of water with the materials take place from outside environment to inside the cell through the same semipermeable cell membrane.

Summary of the functions of the cell:

- Cell membrane is a barrier keeping intact the inside of the cell components (protection)
- To be a barrier or gate allowing transport of gas (diffusion), liquid (osmosis)into or out of the cell of essential materials or waste materials to outside environment in case of animals.

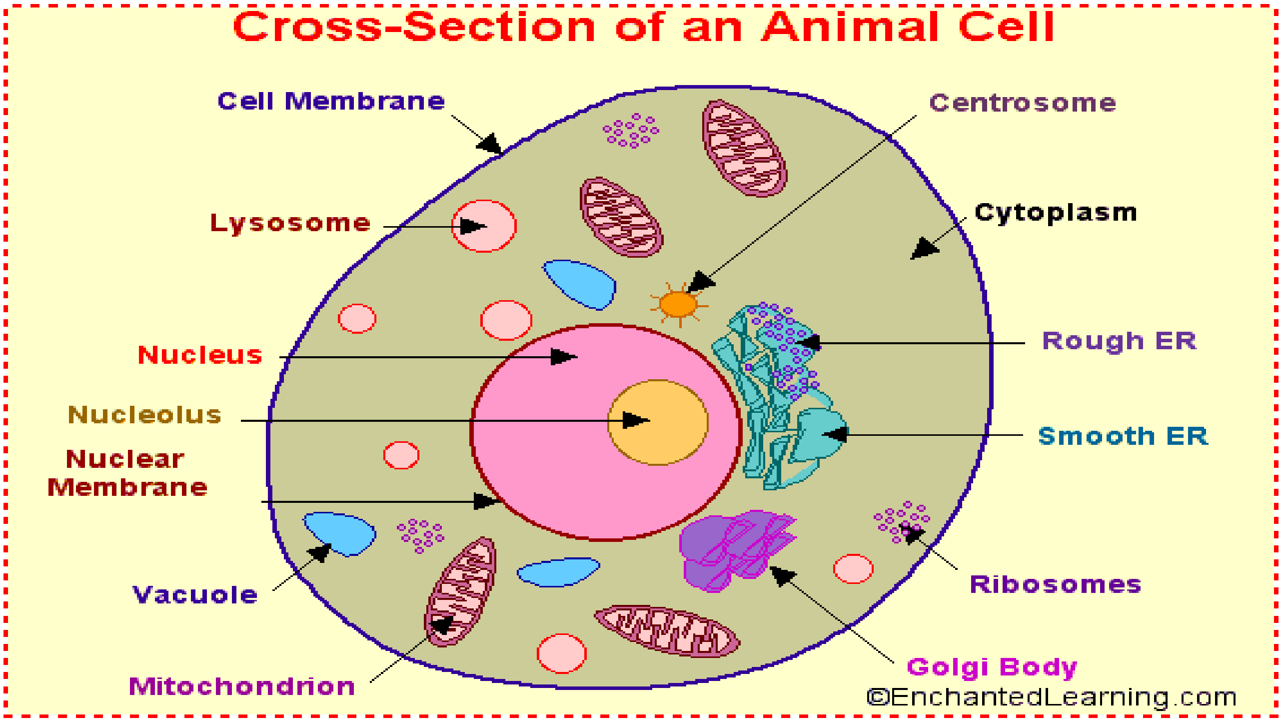


Fig 5.6.a A labeled diagram of animal cell

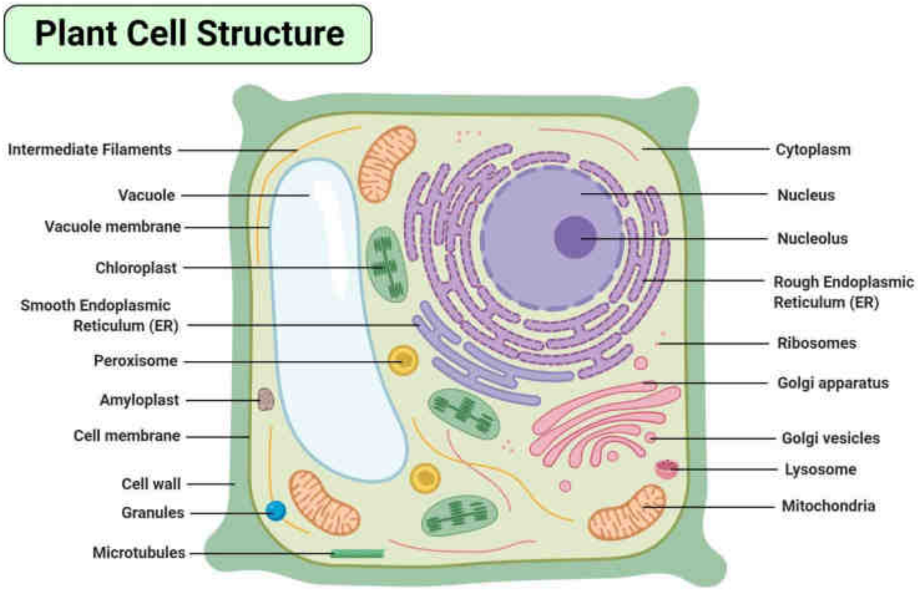


Figure: Plant Cell Structure, Image Copyright © Sagar Aryal, www.microbenotes.com

Fig 5.6 b A detailed labeled diagram of plant cell

5.4.1 Cell wall:

Cell wall is a structural layer surrounding plant cell. It is just outside the plasma membrane. It is rigid and tough. It provides mechanical strength, serves as food reservoir, maintains the shape of the cell, regulates intercellular transport and protects from outside environment. It is mainly composed of cellulose which is a complex substance and provides structural strength to plants.

Through 'plasmolysis', cell loses water causing shrinkage of the cell away from the cell wall. This happens due to osmosis.

The animal and plant cells lose water through the process of osmosis in a 'hypertonic' solution. Water goes out of the cell to outside environment. The reverse process is 'deplasmolysis' where water moves from outside environment into cell i.e. in a 'hypotonic' solution resulting in an outside lower osmotic pressure and a net flow of water into the cell making it turgid. In an 'isotonic' solution there will be no net movement of water into or outside the causing no change in the size.

Why do plants require cell wall in addition to cell membrane?

It is required for protection of inner part of the cell. Plants cannot move. It is almost static in a place. It suffers from variation of temperature, high wind speed, atmospheric moisture etc. Rigid cell wall provides mechanical strength to the plant body.

5.4.2 Cytoplasm: If you observe the permanent slide of a cell under the microscope you will find jelly like substance between the cell membrane and nucleus and that is known as cytoplasm. As you know the membrane gives shape to the cell, various other cell components or cell organelles are present in the cytoplasm. You will be able to know the names of the organelles as you proceed.

In prokaryotes the absence of a distinct nuclear region indicates the absence of cell organelles also. But in eukaryotic cells, there is distinct presence of nuclear membrane as well as presence of cell organelles. Viruses lack any membrane and hence do not show characteristics of life until they enter a living body and use its cell machinery to multiply.

5.4.3 Nucleus: In your study centre, when you are shown a permanent slide of plant or animal cell what do you find in the centre of the cell? The cell is stained by the help of safranin/iodine/methylene blue solution what do you see?

Different region of the cell coloured differently.

The darkly coloured spherical structure near the centre is called nucleus. The nucleus has a double layered covering called nuclear membrane. Surrounding the nucleus the light coloured jelly like structure is cytoplasm. The nuclear membrane is porous which allows the nuclear materials to move between the nucleus to cytoplasm and cytoplasm to nucleus.

Further, another spherical smaller body is visible, with higher magnification called nucleolus. Moreover, nucleus contains chromosomes which are visible as rod shaped structure only when the cell is about to divide.

Chromosomes composed of proteins and DNA (Dyoxyribo Nucleic Acid) molecules, the information for inheritance of features from parents to next generation. The DNA molecules contain the information necessary for constructing and organising the cells. Functional segment of DNA is called genes that do not divide. In a cell which is not dividing, the DNA is present as a part of chromatin material.

The role of nucleus is very crucial when the cell divides. It also plays a crucial role with environment in determining the way the cell will develop and what form it will exhibit at maturity.

The entire cell content of a living cell is known as protoplasm. It includes the cytoplasm and the nucleus. Protoplasm is called the living substance of the cell.

In organism like bacteria the nuclear region of the cell is poorly defined due to the absence of nuclear membrane. It contains only nucleic acids called nucleoid. These organisms are known as 'prokaryotes' (pro means primitive and karyote means karyon). Together they are called as nucleus, whose cells have nuclear membrane and known as 'eukaryotes' also most of the cytoplasmic organelles are present in it. Most of the functions of the organelles in prokaryotic cells are performed by poorly organised cytoplasm.

CHECK YOUR PROGRESS 5.2

1. Differentiate between
    a. Cell wall and cell membrane
    b. Cytoplasm and protoplasm
    c. Osmosis and diffusion

d. Eukaryotic and prokaryotic cells

2. The underlined segment may be corrected in the following sentences:
   a. In isotonic solution water will leave from the cell.
   b. The nuclear membrane is single layered and has no pore.
   c. Nucleolus is present inside the nucleolus.
   d. Bacteria is an Eukaryotic cell.

3. Match the column 'A' with column 'B'with correct interrelations.

a. DNA	a. Prokaryotic
b. Cell wall	b. Turgidity
c. Hypotonic solution	c. Cellulose
d. Semi permeability	d. Cytoplasm
	e. Chromosome
	f. Isotonic

Activity 5.4.1. a: The experiment need to be conducted in study centre.

If a cell is placed in a 'hypertonic' solution, water will leave from the cell and the cell will shrink (more solute and less solvent -water).

In 'isotonic' environment, there is no net water movement. So there is no change is size of the cell (No difference in solvent concentration).

When cell is placed in a 'hypotonic' environment, water will enter into the cell and the cell will swell (less solute and more solvent).

All these happen due to the process of 'osmosis'.

Activity 5.4.1.b

Make notes on the benefits of cell membrane and cell wall.

Activity 5.5

List the differences between prokaryotic and eukaryotic cells.

Activity 5.6

Observe the cell under the microscope carefully. Draw whatever you see on an observation sheet.

5.5 Cell organelles

The eukaryotic cell contains some structure present in the cytoplasm which are responsible for many chemical activities to support different complicated structure and functioning. Such activities are performed by cell organelles such as endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, plastids and vacuoles.

Let us discuss the function of each organelle.

5.5.1 Endoplasmic reticulum (ER):

The endoplasmic reticulum is a wide network of membrane bound tubes and sheets. It looks like long tubules or round or oblong bags (vestibules). The membrane of ER is similar in structure to the cell membrane. Two types of endoplasmic reticulum i.e. **Rough Endoplasmic Reticulum** (RER) and **Smooth Endoplasmic Reticulum** (SER). RER looks rough as ribosomes are attached to its surface. Ribosomes are the sites of protein manufacturer present in all active cells. The proteins are sent to all places of cell depending on the need using the ER. Fat molecules or lipids are manufactured by the help of SER. The fat molecules are responsible for cell function. They are useful to build cell membrane, enzymes and hormones. The ER varies greatly in different cells but the functions remain the same.

ER also acts as a cytoplasmic framework for some biochemical activities of the cell. In liver cells of many animals (vertebrates) ER plays a crucial role in detoxifying toxins and drugs.

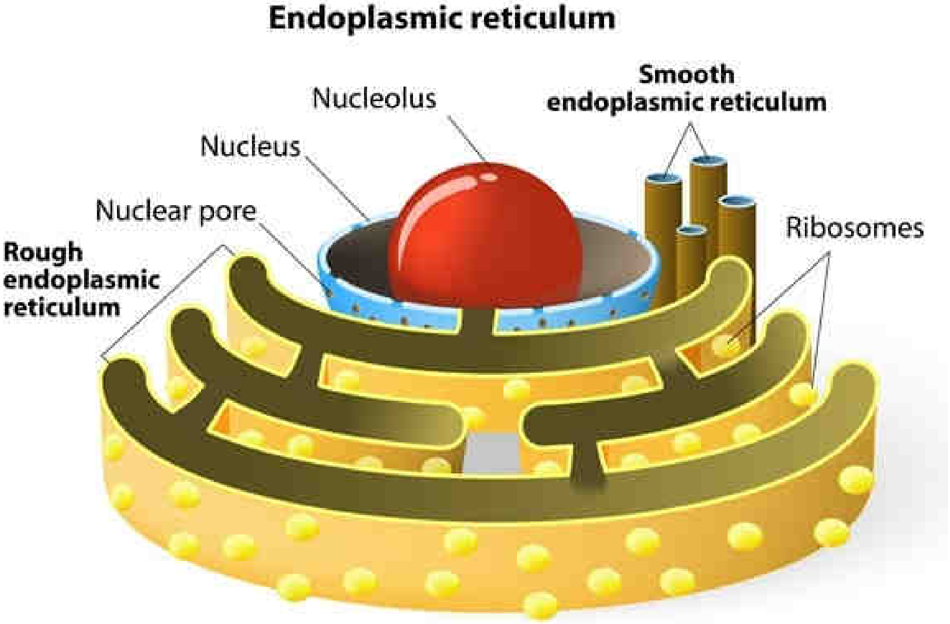


Fig 5.7 Fig. of endoplasmic reticulum

5.5.2 Lysosomes:

Lysosomes mostly work as waste disposal organelles of the cell. It helps the cell to clean by digesting any foreign materials worn out materials such as old organelles, unused food and bacteria and virus etc. to make an entry into the cell. The lysosomes break them initially into tiny pieces through powerful digestive enzymes. When the cell gets damaged lysosomes bursts and release enzymes and digests its own cell. Therefore, they are known as **suicide bags** of the cell. Lysosomes are membrane bound sacs filled with digestive enzymes and these enzymes are made by Rough Endoplasmic Reticulum (RER). The self-destructive process is known as programmed cell death, or opoptosis.

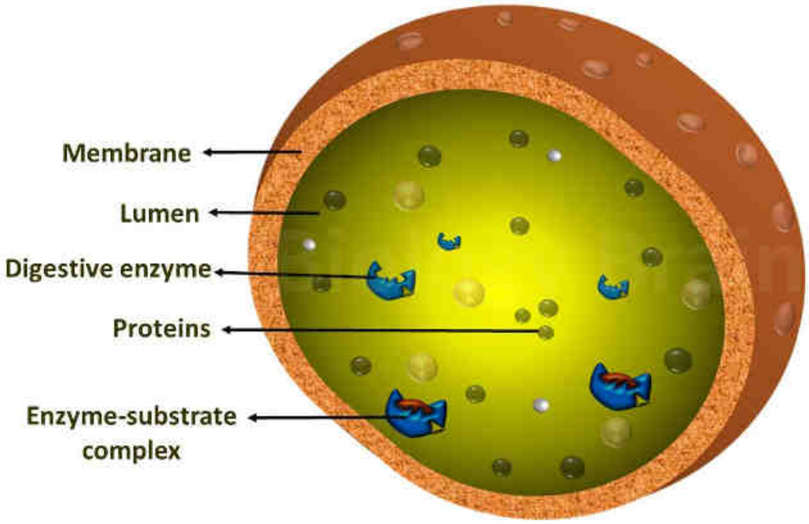
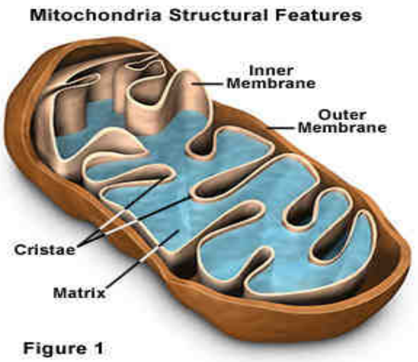


Fig 5.8 Lysosomes

5.5.3 Mitochondria:



Mitochondria is a double membrane bound organelles of the cell. They generate most of the cell's supply of ATP (Adenosine Triphosphate) subsequently utilised as a source of chemical energy. The outer membrane of mitochondria is very porous and the inner membrane deeply folded. These folds create wide surface area for ATP generating chemical reactions. They help their own DNA and ribosome which help them to make some of their own proteins.

Fig. 5.9 Mitochondria

5.5.4 Golgi apparatus:

Golgi apparatus is also known as the Golgi complex or Golgi body or simply the Golgi. Golgi apparatus is part of the endomembrane system. The membranes often have connections with the membranes of Endoplasmic Reticulum (ER) in the cytoplasm. It gathers simple molecules and combines them to form more complex molecules. These big molecules are packaged in vesicles and either store for later use or sends them out of the cell. It also builds lysosomes which are cell digestion machines.

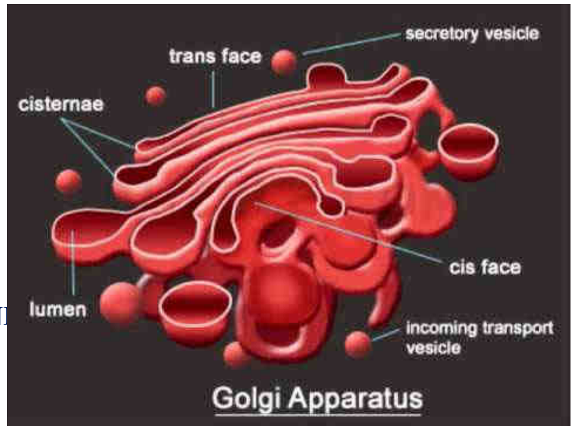


Fig. 5.10 Golgi apparatus

5.5.5 Plastids:

Plastid is a membrane bound organelle found in the cell of plants, algae and few eukaryotic cells. Like mitochondria, plastids have also their own RNA (Ribonucleic Acid) and ribosomes. There are four types of plastids such as chloroplast, gerontoplast, chromoplast, and leucoplast.

i. **Chloroplast:** Biconvex, semiporous, double membrane found in plant cell. The chloroplast synthesize food by the process of photosynthesis. They carry various types of orange or yellow pigments in addition to chlorophyll.

ii. **Gerontoplast:** These are basically chloroplasts that go with ageing process. They have high amount of green pigment. They have three membrane systems. It is the sight of light dependent reactions of photosynthesis.

iii. **Chromoplast:** These are usually found in coloured portion of flowers, ageing leaves and fruits. Chromoplasts are coloured plastids. They help in pollination and dispersal of seeds and fruits.

iv. **Leucoplast:** Colourless (white) plastids present in underground roots and stems. They are responsible for storage of starch, fat and protein granules.

Plastids are similar to mitochondria.

Internal structure of plastids consists of many membrane layers embedded in a material called stroma. They are responsible for manufacturing (Chloroplast and gerontoplasts), storing (leucoplast), for colour of the plants (chromoplast). Like mitochondria, plastids also have their own DNA and ribosomes.

(Ribosomes: They are cellular particles made of RNA and protein. They serve as the site for protein synthesis in the cell)

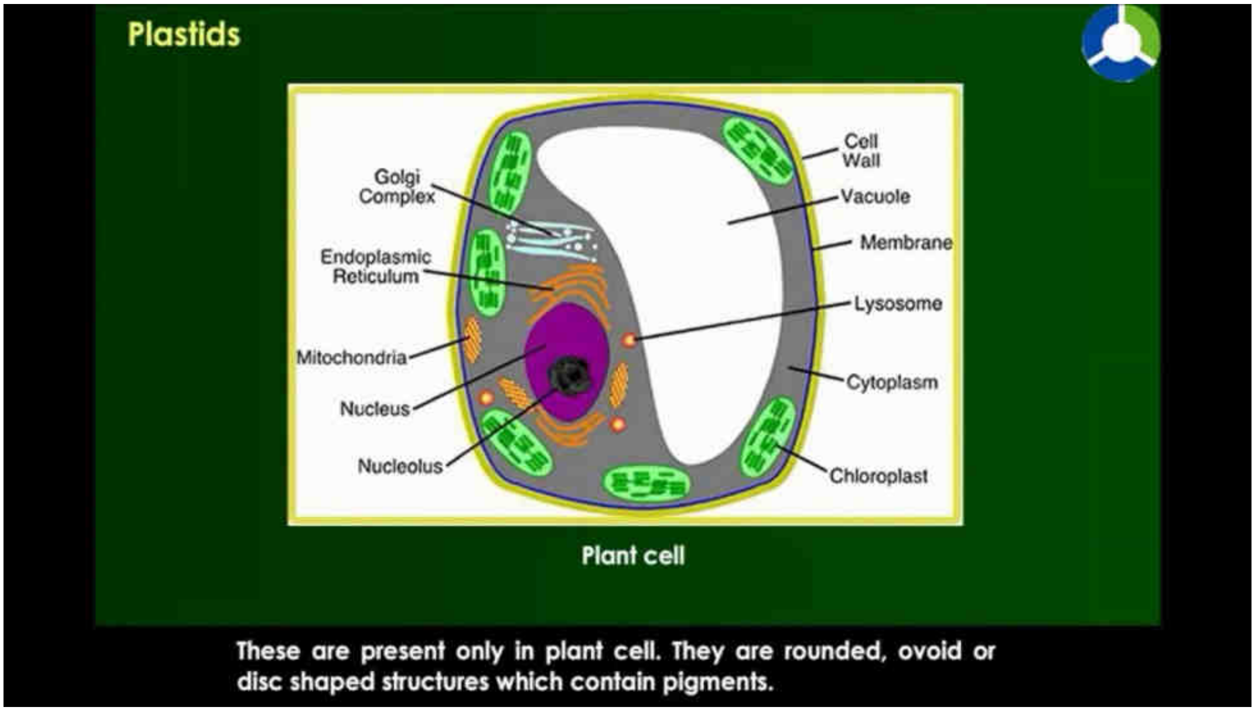


Fig. 5.11 Plastids

5.5.6 Vacuoles: A vacuole is a membrane bound organelle, which is present mainly in plant cells. Vacuoles are small sized in animal cells and are very large in plant cell. In some plants, cell vacuoles occupy 50-90% of the cell volume. It was discovered by Antony Van Leeuwenhoek.

Vacuoles are storage sacs for solid or liquid contents. In plants, vacuoles are full of cell sap and provide turgidity and rigidity to the cell. It might store food or any variety of nutrition for survival of the plant. In single cell animals like amoeba, the food items that amoeba assimilates, after being digested, products would be sent out of the cell by vacuole. In plant cells, vacuoles help to maintain water balance when a plant has been without water for a long time. The central vacuoles loose water, the cells loose shape and the whole leaf wilts. The cell sap carries water and a variety of substances like minerals, organic acids, pigments and metabolic wastes.

Each cell thus acquires its structure and functional ability because of organisation of its membrane and organelles in specific ways. The cells have a basic structural organization helping it to perform functions like digestion, respiration, excretion and forming new proteins. Thus the cell is structural and functional unit of living organism. It can also be treated as basic functional unit of life.

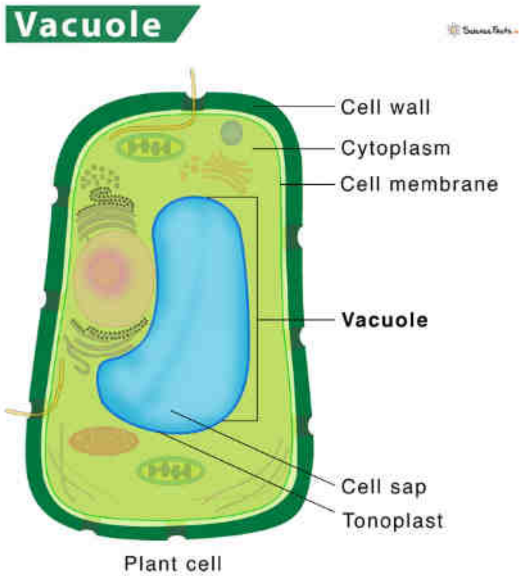


Fig. 5.12 Vacuole

CHECK YOUR PROGRESS 5.3

1. Where are the cell organelles found in a cell?
2. What is the contribution of chromoplast to the plant?
3. Why does the Endoplasmic Reticulum look rough to be known as the Rough Endoplasmic Reticulum (RER)?
4. Which organelle is responsible for waste disposal of the cell?
5. In a plant, in which place you will find leucoplast?

RECAPITULATION POINTS

- Robert Hooke discovered cell in cork in 1665.
- Anton Van Leewenhoek discovered cell in living organism in 1674.

- The classical cell theory: All organisms are made up of cells, cells are basic unit of life, of plants and animals, cells come from the preexisting cell that have multiplied (Theodor Schwann, 1839, Matthias Jacob Schleiden, 1838, Rudolf Virchow, 1858).
- Modern cell theory: DNA is passed between cells during cell division, the cells of all organisms within a similar species are mostly the same both structurally and chemically and finally that the energy flow occurs within the cell.
- Unicellular organism- Amoeba, paramecium, bacteria etc.
- Multicellular Organism-Higher animals and plants.
- Shape of a cell- Spherical, elongated, round, spindle shaped and very long.
- Amoeba has no definite shape. It has pseudopodia for locomotion and nutrition.
- Largest cell- Egg of ostrich.
- Cell membrane provides shape to animal cell.
- Cell wall is seen in plant cell which is rigid and provides shape to it.
- Cell is a structural and functional unit of living organism.
- Body of living organisms consists of many organs and all the organs are made of tissues and tissues are made up of cells. Different organs perform different functions or life processes like respiration, excretion, digestion, food synthesis, transportation etc.
- Cells consist of different components such as cell membrane/plasma membrane, cytoplasm, nucleus, protoplasm and cell organelles. Plant cells do have cell wall in addition to plasma membrane.
- In cytoplasm there is presence of cell organelles. Different cell organelles are there like endoplasmic reticulum, lysosome, mitochondria, golgi apparatus, plastids and vacuoles.
- Plant cells have plastids and large vacuoles.
- There are four types of plastids like chloroplast, gerontoplast, chromoplast, and leucoplast.

Cell in Living Organism

Plant
(Components)

- Cell Wall
- Plasma Membrane
- Nucleus
- Cytoplasm
- Cell organelle
- Endoplasmic Reticulum
- Golgi apparatus
- Lysosomes
- Mitochondria
- Plastids
- Vacuoles

Animal
(Components)

- Plasma Membrane
- Nucleus
- Cytoplasm
- Cell organelles
- Endoplasmic Reticulum
- Golgi apparatus
- Lysosomes
- Mitochondria
- Vacuoles

Cell and its components types at a glance

TERMINAL EXERCISE

1. Why cells are considered as structural and functional unit of living body?
2. Draw a labelled diagram of plant cell and animal cell.
3. If amoeba would have been a plant cell what problems the organism would have faced?
4. In which the cell organelle 'plastids' are helpful to plant body?
5. In which way the individual cell organelles are helpful to body of the living organism?
6. If plant cells would not have cell wall and mal cell would have cell wall what problems and benefits the organisms would have faced?
7. Suppose in a cell either lysosomes, or mitochondria, or Golgi apparatus is not there what problems the organism face?
8. If chromoplasts and leucoplasts are present in reverse places in a plant what abnormalities will be observed in it?

ANSWER TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 5.1

1. a. Robert Hooke
   b. Within the cell
   c. Pseudopodium
   d. Paramecium
2. Ovum
3. Unicellular
4. Nerve cell
5. Plant may not be able to stand straight or erect.

CHECK YOUR PROGRESS 5.2

1. a) Cell wall is a structural layer around the cell membrane in plant cells. Cell wall provides mechanicalstrength, serve food reservoir, maintain shape of the cell, regulate intercellular transport protects from outside environment.

Cell membrane is outermost coverage of animal cell and below the cell wall in plant cell. It separates the inner components of cell from outside environment. It is semipermeable and controls the movement of gas and liquid substances into and outside the cell. Provide shape to the animal cell.

b) Cytoplasm is jelly like substance carrying all components inside the cell membrane within the cell.

Protoplasm is colourless material comprising the living part of a cell, including the cytoplasm nucleus and cell organelles.

c) Osmosis is a process where the exchange of liquids from higher concentration to lower concentration takes place through a semi-permeable membrane.

Diffusion is a process where the exchange of gaseous substances from higher concentration to lower concentration takes place through a semi-permeable membrane.

d) Eukaryotic organisms have cells with enclosed nuclear membrane.

Prokaryote organisms whose cells lack nucleus and other organelles with a relatively simple structure.

2. a. water does not move

   b. with double layer and has pores

   c. cytoplasm/ protoplasm

   d. prokaryotic

3.

Colm A	Colm B
a	e
b	c
c	a
d	b
e	d

CHECK YOUR PROGRESS 5.3

1. Cytoplasm.
2. Provide colour to flowers, ripe leaves and fruits.
3. The surface of RER is rough because of the presence of ribosomes.
4. Lysosomes
5. Vacuoles

SUPPLEMENTARY STUDY MATERIAL

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6 TISSUE

INTRODUCTION

In the process of growth and development every living organism undergoes a definite process. In the previous chapter you have learnt that cell is the basic structural and functional unit of living organism. Hence, cell is the base which plays a strategic role in forming tissues. Different functions are performed by different organs of the body as per the requirement. In unicellular organisms, a single cell performs all basic functions. For example, in amoeba and paramecium, a single cell carries out all functions like locomotion, ingestion, excretion, reproduction, respiration etc. But in multicellular organisms, specialized functions are carried out by different group of cells in the form of organs. The effectiveness of the function is found in multicellular organisms as sepcialised cells/organs are involved in performing specialized functions. Cells present in respiratory system do effectively the work of respiration likewise for each function like digestion, excretion, blood circulation, nerve cells for carrying messages etc. So also, in plants, water and minerals are absorbed from soil, food is synthesized in green parts of plants and transportation of food is done by specialized cells and so on. This indicates a particular type of function is performed by a group of cells at a definite place in the living body. Highest possible efficacy is found as long as the organism is alive and those group of cells in different parts of the living body is known as tissue. Thus a group of cells having similar shape and function that act together to perform a specific function is known as tissue. These tissues act in a specialized way in the form of organs to make the living being survive in the environment.

6.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Define a tissue
- Differentiate between a cell and a tissue
- Describe the type of plants and animal tissues.
- Narrate the structure and function of plant and animal tissues
- Justify the importance of tissue in a body of living organism
- Draw different figures of cells and tissues of plants and animals

6.2 TISSUE- WHAT IS IT?

In living organism, body is made up of cells. Different cells perform different functions in the body during living processes. A unicellular organism, whatever function is essential for survival, is able to perform through the help of single cell. But in multicellular organism, does it happen in the same way? Let us see how a particular group of cells perform the particular function together. When they having the similar structure and function together act as a unit they form a tissue. Hence, it can be said that tissue is a group of cells that have similar structure and that function together as a unit. For different kind of functions, tissues have different shapes and accordingly the organ is formed ultimately in the living body.

6.3 TISSUES OF PLANTS AND ANIMALS

Is it that tissues of plants and animals behave in the same way? Let us find.

It is understood that the function of living process are same irrespective of plants or animals. But the analysis of functional processes shows significant differences between the processes of plants and animals. The functions like respiration, digestion, excretion, blood circulation (liquid) clearly indicate difference in tissues and organs in the shapes, sizes and function of animals in specific manner. Likewise, in plants also conduction of water from soil to different parts of plants and the transportation of the synthesized food from leaves to different parts of plants take place in a very systematic way by different types of tissues. Though we find no difference in the growth and development processes in plants and animals still in other complex processes the differences are quite conspicuous in plants and animals. The plant tissues and animal tissues perform their tasks in different ways.

Structure and functions of plant and animal cells:

Some questions arise when you consider these two aspects. Do plants and animal cells have similar structure internally as well as externally? Do plants and animal cells perform similar function? Let us identify some noticeable aspects for comparison like locomotion, support for strength to stand erect on the ground, pattern of growth, structure and organization of organs.

Locomotion and support for strength to stand erect: You have experienced that plants are stationary and fixed. Plants involve movement of body parts such as roots, flowers, branches etc. In animals the entire body moves from one place to another. Animals move on their own with the help of their limbs. But higher plants cannot move from one place to the other on their own. Most of the tissues in plants are supportive which provides to plant the structural strength. Most of these tissues are dead and the dead cells can provide mechanical strength with least maintenance.

But animals move in search of food, mate and shelter. Most of the tissues they carry are living and require more energy for the purpose.

Pattern Of Growth: In plants growth is limited to certain regions. There are some tissues that divide throughout the life of the plant. Based on the dividing capacity of the plant tissues, they are divided as growing tissues or meristematic tissues and permanent tissues.

But the growth pattern is completely different in animals. The growth pattern is affected to whole body. There is no demarcation in animal tissues as in plants. In plants there are two types of tissues in general. They are dividing and non-dividing regional tissues.

Structure and organization of organs

It is an established fact that the structure and organisation of organs and organ system have no similarity between plants and animals. They are more complex specialized and localised in certain animals than in very complex plants. These complex differences reflect different modes of life processes performed by plants and animals. The differences are remarkable in their process of feeding modes, reproduction, excretion, transport of materials inside the body etc. Based on the differences, for example, made them to adopt for sedentary existence of plants and active locomotion in animals.

6.4 PLANT TISSUES TYPES

As we have learnt previously with regard to growth, there are two types of plant tissues i.e. meristematic and permanent tissues.

6.4.1 Structure and function of meristematic tissues: As we know the growth plants occurs only in certain specific regions. This happens because of the presence of meristematic tissues in this region. Depending on the location of the meristematic tissues at certain region, they are classified as apical, lateral and intercalary. The dividing or meristematic tissues consisting of meristematic cells that are localised and not distributed throughout the plant body. The growth due to meristematic cells occurs by an increase in number of cells but not by increase in volume of existing cells. This helps in increasing the length and thickness of the plant. These tissues are present at the tips of roots, stem and branches. These tissues have got the capacity to divide actively throughout the life of the plant.

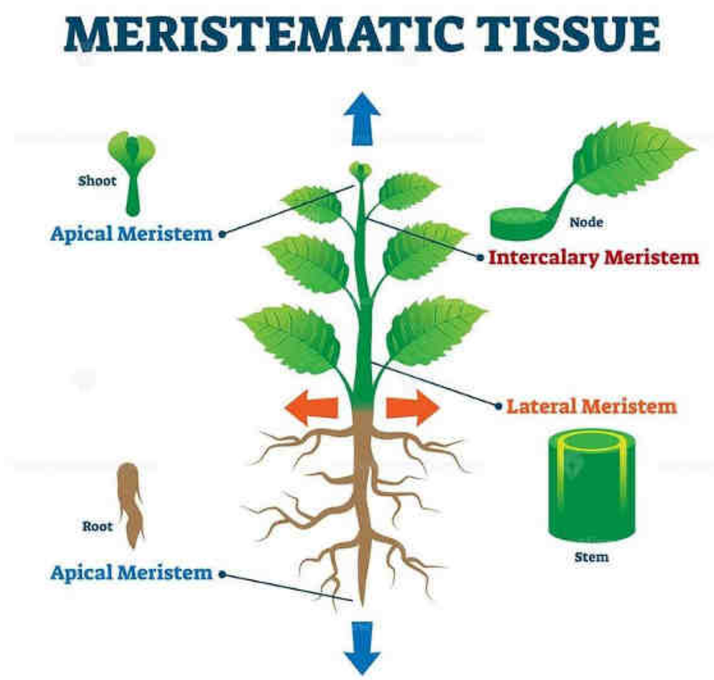


Fig. 6. 1(a) Meristematic tissue in plant body

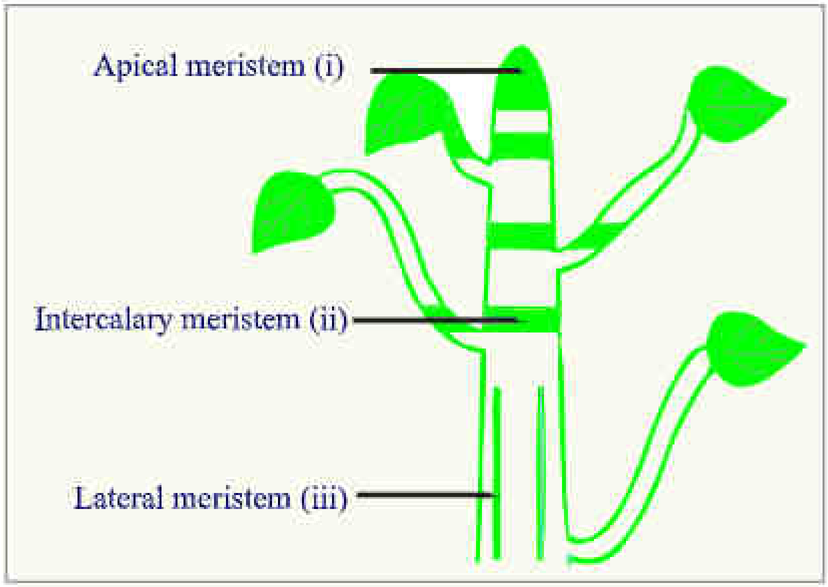


Fig. 6. 1 (b) Location of meristematic tissues in the plant body

The region where these tissues exist is known as meristem. Th e tissues from specialised structures such as buds of leaves and flowers, tips of roots and shoots. The apical tissues are present at the tips of the stem and roots and increases their length. The intercalary or basal tissues are present at the base of the leaves or internodes or either side of the node on twigs. The girth of the stem and root increases due to lateral meristem (cambium)

Due to very active cells of meristematic tissues the cells have very dense cytoplasm, thin cells walls and prominent nuclei. They lack vacuoles.

6.4.2 Structure and function of permanent tissues

Let us find out how permanent tissues emerge from meristematic tissues. Meristematic tissues that become matured and lost the capacity to divide further (grow) and take up specific role are called permanent tissues. As a result they form permanent tissues. The permanent tissues are fully grown, bigger in size and have a certain shape. Permanent cells are divided from meristematic tissues.

Types of permanent tissues:

Permanent tissues are also of different types. Let us know them. Depending upon their structure, origin and function permanent tissues are classified as

- Simple permanent tissue
- Complex permanent tissue

- Secretory tissues

Let us study now about simple permanent tissue.

6.4.3 Simple permanent tissue

Simple permanent tissues are made up of cells from the same origin, which have similar structure and functions. They are also called homogeneous tissues. Simple permanent tissues are classified into three types

- Parenchyma
- Collenchyma
- Sclerenchyma

Parenchyma- Parenchyma is found all through the plant body and made up of living cells with thin cell walls. Those are loosely packed with intracellular space. They are generally round and oval in shape. They consist of chlorophyll and take part in photosynthesis and storage of food. The cells have cell wall, vacuole and nucleus.

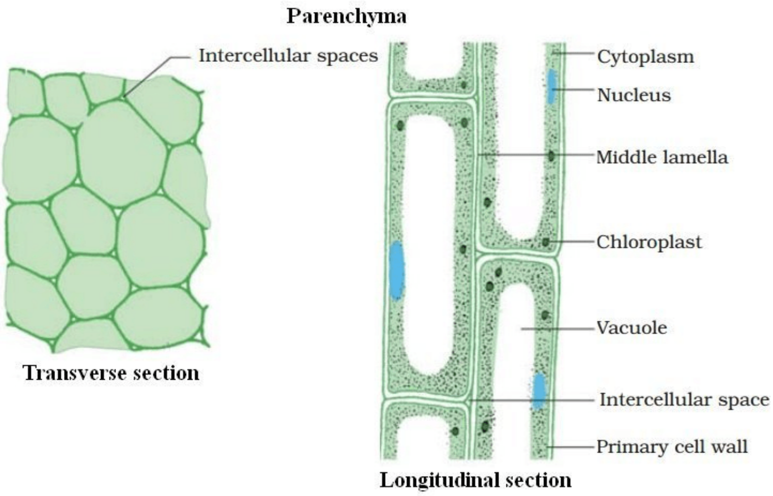


Fig. 6. 2 Parenchyma tissue

Collenchyma- Collenchyma consists of thick cell wall. These cells are compactly packed leaving very less intracellular space. It contains less amount of chlorophyll. It is mainly found in the hypodermis (the bottom layer) of the leaves and stems of dicots and not found in monocots and roots of plants. It provides mechanical strength, elasticity and tensile strength to the plant body. Also it is found in leaf margins to prevent the leaf from tearing by the wind. Participate in manufacturing of food and storing of starch.

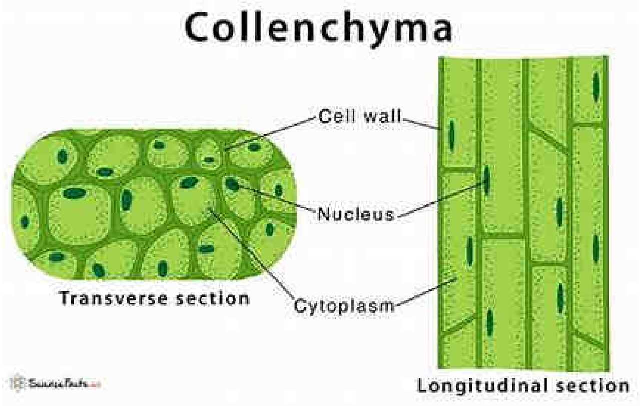


Fig. 6.3 Collenchyma tissue

Sclerenchyma: Sclerenchyma tissues are composed of dead cells and have thick cell wall with negligible protoplasm. The cell walls provide mechanical support to the plants. There is complete absence of intracellular space between the cells. Due to rigid thickness of outer cell walls it is impermeable to water.

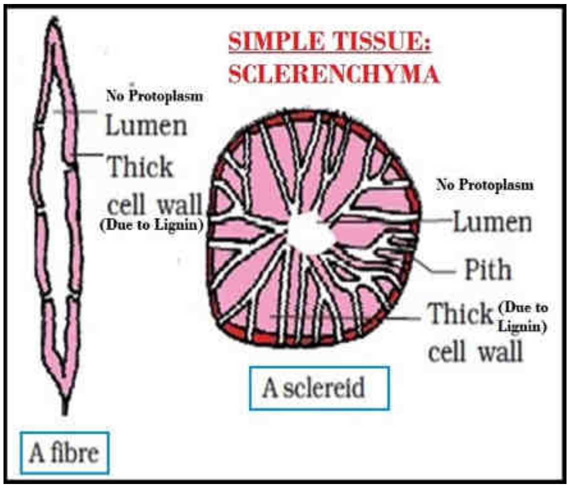


Fig. 6. 4 Sclerenchyma tissue

This type of tissue makes the plant hard and stiff. The cells of these tissues are dead. They are long and narrow and the thickness is due to ‘lignin’, a chemical substance which acts as cement and makes it quite hard. The hard covering of seed, veins of leaves are also examples of sclerenchymatous cells.

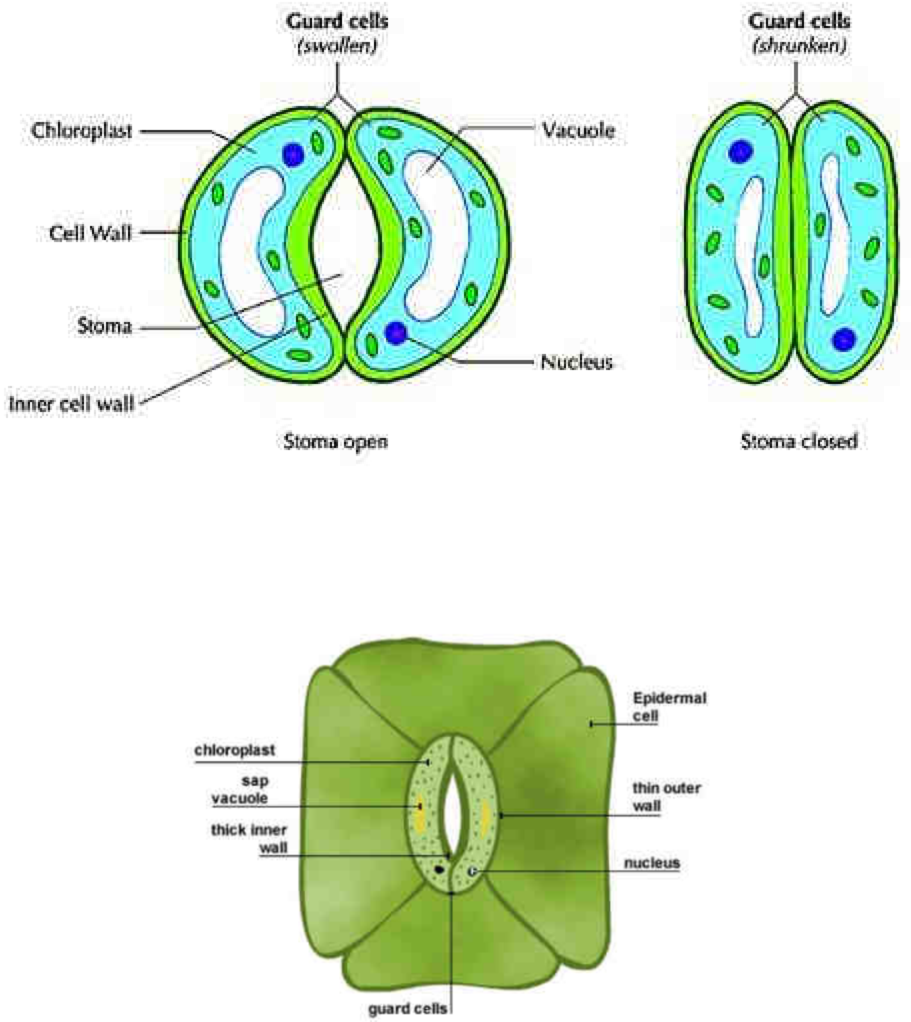


Fig. 6. 5 Guard cells, stomata, epidermal cells Protective tissue

Epidermis: In addition to these permanent tissues, there is protective tissue present in plant known as epidermis. The hard outermost layer of cells is known as 'epidermis'. Epidermis is the protective layer. It mostly prevents loss of water. The aerial part of epidermis mostly secretes waxy material and is water resistant. It protects plants from mechanical injury and fungi attack. There is almost absence of intercellular spaces and is relatively flat. The outer wall is mostly thicker than inner wall.

If the leaf epidermis is observed under the microscope the small pores called stomata are seen. Each stomata is enclosed by two kidney shaped cells called, guard cells. During photosynthesis, the exchange of gases to atmosphere takes place through stomata by the process of transpiration. Plants also release moisture to the atmosphere through stomata.

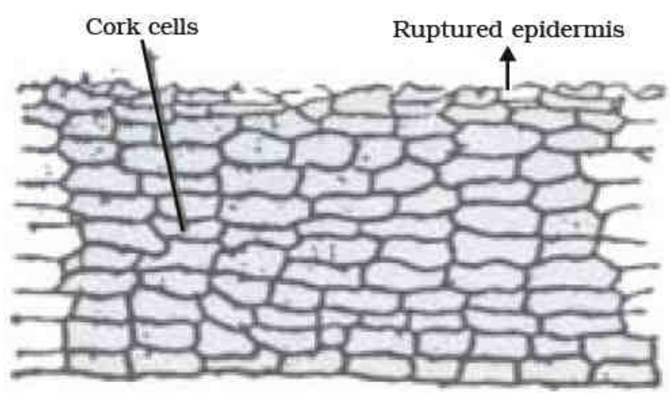
The presence of epidermal cells of the roots is mainly for absorption of water from soil. The root system bears many hair like structures known as root hairs which enlarge the surface area of absorption.

What happens with desert plants? How cork cells are made?

Mostly in desert plants the epidermis has more thick waxy coating known as cutin. It is a chemical substance with water proof quality that prevents water loss. Let us now know if the outer layer of a branch of a tree is the same as that of outer layer of a young stem.

As the young plant becomes older the outer layer of the stem undergoes certain changes. A strip of secondary meristem replaces the epidermis of the stem. The cells of the outer layer are cut off from the inner layer. Gradually, this form the thick layer of bark or leading to formation of cork. The outermost layer get ruptured and the cork cells are dead and thickly arranged causing no inter cellular space. Because of the presence of a chemical 'suberin' in plant, cell walls functions as physical barrier, preventing water loss from the tissue. It also works as a wound healing process in plants, provide protection against pathogens.

Fig. 6. 6 Protective tissue



Protective tissue

Now let us study about the complex permanent tissues in plants.

6.4.4 Complex permanent tissue:

The above discussed simple permanent tissues are having similarities. Now other type of tissues are there in plants which are structurally dissimilar performing a common function. The complex tissues are made up of more than one type of cells. All these cells coordinate to perform a common function. The complex tissues are engaged in the function of transportation in plant. These are mostly known as conducting tissues.

They are of two types:

(i) Xylem which transports water and minerals from soil to leaves for synthesising food.
(ii) Phloem which transport food material from the leaves to different parts of the body of the plant.

(i) Xylem: The Xylem tissues are responsible for the conduction of water and minerals through roots (soil) to the leaves and stem. It also provides support to the plant. Both xylem and phloem together constitute a vascular bundle. It is a distinctive feature of the complex plants which made possible survival of plant in the terrestrial environment.

Xylem has four elements:

They are:

- Tracheides
- Vessels
- Xylem parenchyma
- Xylem fibres

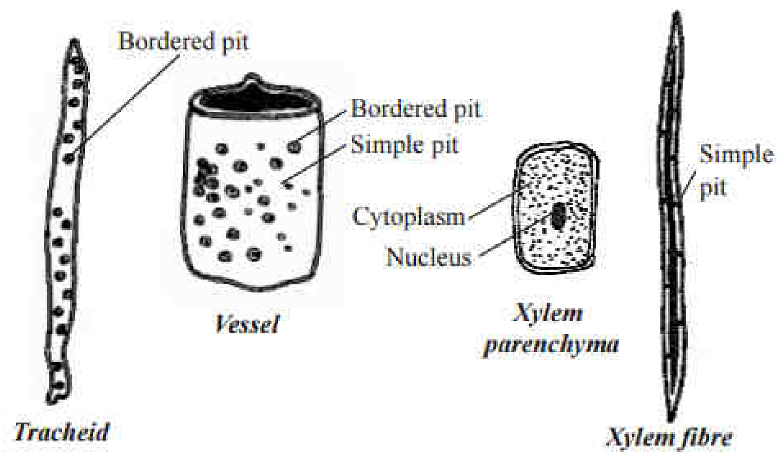


Fig. 6. 7 Tracheid, Vessel, Xylem parenchyma and xylem fibre

All the cells have thick wall and many of them consists of dead cells.

- **Tracheids:** Tumbler structure helps water and minerals to be transported vertically. It is long and tapered lignified cell. The tissue also provides support to the plant
- **Vessels:** Function in conduction of water and minerals from soil through root to leaves.
- **Xylem parenchyma:** This cell stores food and help in the sideways conduction of water. Xylem parenchyma cells are closed connected to tracheids and vessels throughout growth called tyloses.

- Xylem fibres: Fibres are mainly supportive in function. These cells are having highly lignified walls.

(ii) Phloem: The Phloem tissues are main pathway for the long distance transport of assimilates. Phloem tissues conduct synthesised food made from leaves and green stems to other parts of the plant. Phloem is composed of various specialised cells such as sieve tubes, companion cells, phloem fibres and phloem parenchyma. Most of the cells are alive where as in xylem the reverse i.e. dead.

- Sieve tubes: They are long tube like structure arranged longitudinally with perforated end so its cytoplasm connects one cell to the next.
- Companion cells: Transport of substances in the phloem requires energy. One or more companion cells attached to each sieve tube provide this energy. A sieve tube is completely dependent on its companion cell (s).
- Phloem parenchyma: It consists of dead cells. Phloem parenchyma cells are called transfer cells and located near the finest branches and termination of sieve tubes in leaf veinlets. They help in transport of food materials, storing of food and other substances like resins, latex and mucilage. Phloem parenchyma is usually absent in monocots.
- Phloem fibres: Phloem fibres are dead cells at maturity and are spindle shaped having a narrow lumen and thick walls. It is responsible for providing tension strength without limiting flexibility.

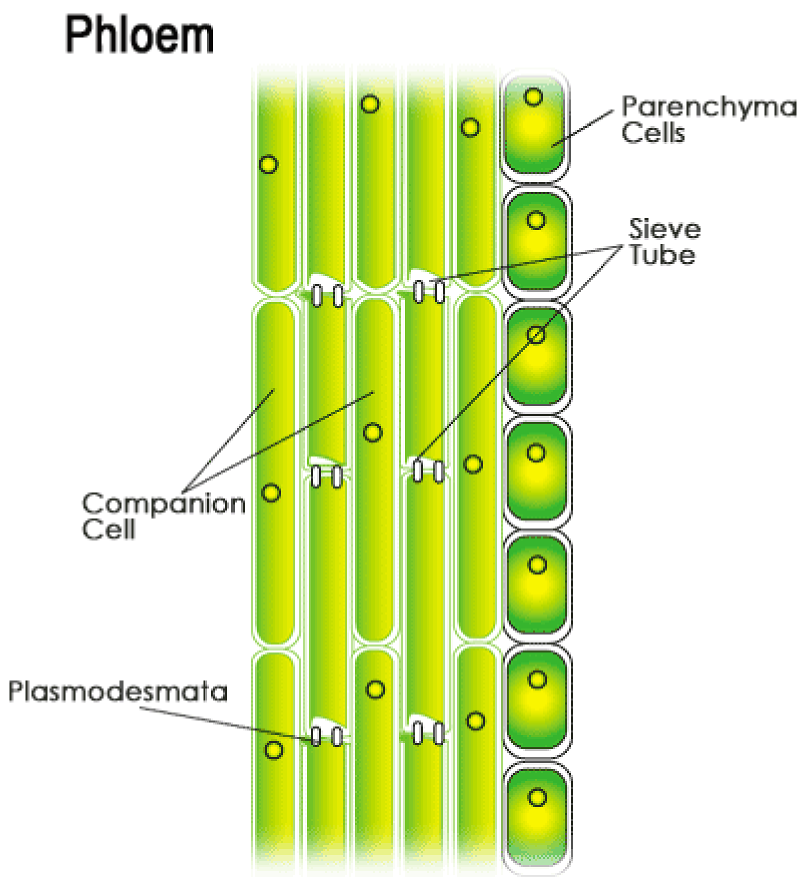


Fig. 6. 8 Figure of sieve tube, companion cell, phloem parenchyma and phloem fibres

6.4.5 Secretory tissues

As the name indicates the tissues that are concerned with the secretion of gums, resins, volatile oils, nectar latex etc. in plants are known as secretory tissues. These tissues are present in most vascular plants. There are four types of secretory or specialised tissues such as laticiferous tissues, glandular tissues, hydathodes and tyloses

- **Laticiferous tissues:** Laticiferous tissue is composed of thin walled, elongated, branched and multinucleate tube like structures. The tissues contain colourless, milky juice called latex.
- **Glandular tissues:** A gland is a specialised group of cells which have the capacity to secrete or excrete products. The glands may be external or internal.
  External glands are found on the epidemic of stems, leaves and flowers.
  Example- Glandular hairs, nectarines and digestive glands.

Internal glands occur within the tissues of the plant body.
Example- Resin, duct glands, mucilage etc.

- **Hydothodes:** These are water secreting structure found along the margins of leaves of the plants that grow in humid places. Water escapes through hydothodes in the form of liquid. The process is known as guttation.
  Example of plants- tomato, herbs, grasses, after warm days and cool nights.
- **Tyloses:** In plants when xylem parenchyma cells develop balloon like protrusions into treacheary elements (Cells in the xylem that are highly specialised for transporting water and minerals). These protrusions are known as tyloses. They are formed when xylem elements becomes inactive or when they are injured. They prevent the conduction of water and minerals and even the movement of fungal hyphae (hypha is long, branching, filamentous structure of a fungus).

CHECK YOUR PROGRESS 6.1

I. Choose the correct answer

a. In complex tissues which of the following carry fibres?

A. Xylem only
B. Phloem only
C. Both xylem and phloem
D. Secretory tissues

b. Which of the following tissue is responsible for transporting water and minerals from roots to leaves?

A. xylem
B. phloem
C. glandular tissue
D. sclerenchyma

c. Which as the following process produces water from leaf margin?

A. transpiration
B. osmosis
C. diffusion
D. guttation

d. Laticiferous tissues belongs to which type of tissue

A. simple permanent
B. complex permanent
C. secretory
D. Meristematic

II. a. Differentiate between cell and tissue
b. Meristematic tissue and permanent tissue

III. Correct the statement at the underlined given below:
a. Tissue is the structural unit of living organism.
b. Through the process of digestion, living organism expels out the waste material from the body.
c. Through the process of growth and development, a living organism multiply its number.
d. Cell walls of the cells provide mechanical strength to the animal body.
e. Apical merstematic tissues are located at the leaf base of the plant body.

IV**. Match the words in column A with column B**

'A'	**'B'**
A. Parenchyma	a. Protection against pathogens
B. Stomata	b. Mechanical strength
C. Suberin	c. Guard cell
D. Sclerenchyma	d. Thin cell wall
	e. Xylem

V**. Answer in one word or in one sentence:**

a. What is the function of xylem?

b. What is the function of phloem?

c. What is the function of stomata?

d. Why collenchyma is present in leaf margin?

Activity-A

Activity 6.4.1

Collect a small portion of branch and roots of a big plant and a baby plant. Prepare slide and observe the internal structure of both under microscope. List the different types of Meristematic tissues. Draw the diagram of the respective tissues.

Activity 6.4.2

Draw the figures of different simple permanent tissues.

6.5 ANIMAL TISSUES

You have learnt plant tissues so far, now let us study about animal tissues. As you know animal cells or eukaryotic cells that have both a membrane bound nucleus and other membrane bound organelles. These organelles carry out specific functions that are needed for the normal functioning of the cells.

A group of cells having similar function form tissue. Different parts of the organ form different types of tissues and collectively perform a particular function. The respiratory organ having different muscle tissues perform different actions at different parts of the organ. The tissues in the nostril, tissues at thetrachea, tissues at the tracheoles and alveoli or air sacs perform on the whole exchange of gases like oxygen and carbon dioxide to prepare oxygenated blood (blood having oxygen) and deoxygenated blood (clearing blood free from carbon dioxide) in the whole process of respiration. The muscle at the thoracic chamber helps in expansion and contraction of lungs and making the respiration system complete or functional.

Animal tissues are grouped into four basic types: epithelial, muscle, nervous, connective and blood. The tissues covers all organismal surfaces that come in contact with external environment such as the skin, the respiratory channel, the digestive tract, the blood circulatory pathways, the excretory path ways etc. inside the body of an animal. The structure, function and origin of these tissues are all different. Let us know about them.

6.5.1 Structure and function of animal tissue

(i) Epithelial tissue: This type of tissue forms the outer layer of the body and also lines many of the body cavities where it has a protective function. It also forms a barrier to keep different body systems separately.

These tissues form the skin, the lining of the alimentary canal, the lining of the blood vessels, lung alveoli and kidney tubules. In this type of tissues cells are tightly packed and form a continuous sheet. The tissues have a small amount of concentrating materials between them and have least intercellular space between the cells. Naturally, any material passing over the epithelium must cross at least one layer of the same. As a result, permeability of the cells of various epithelia play an important role in regulating the exchange of materials between the body and external environment and different parts of the body.

All epithelial cells are usually separated from the underlying tissues by an extracelular fibrous, basement membrane. Structurally and functionally usually there are four types of epithelial tissues. These are squamous, stratified squamous, columnar (ciliated) and cuboid.

Simple squamous epithelial tissue:

Found in cell linings, blood vessels and lungs alveoli where transportation of substances occurs through a selectively permeable surface. These epithelial tissues are simple flat kind of epithelium. These are extremely thin and flat which form a delicate lining.

The oesophagus and lining of mouth are covered with squamous epithelium. The skin which covered the whole body and protect it from external environment is also made of squamous epithelium.

Stratified squamous epithelial tissue:

The skin epidermal cells are arranged in many layers to prevent wear and tear. The tissues are arranged in a specific pattern of layers. Hence, the epithelium is called stratified.

Columnar epithelium tissue:

These tissues are present in the places where absorption and secretion occur. For example, in the inner lining of the intestine (small and large both), in respiratory tract.

This columnar or pillar like epithelium facilitates movement across the epithelial barrier. In respiratory tract, the presence of cilial hair like structure, on the outer surfaces of epithelial cells creates a wave like motion to expel out the excretory materials. You must have seen full grown paddy field. When wind moves over it the tips of paddy plants move in one direction creating a wavy scenery. Similarly, the ciliated epithelial cells create a wave unidirectionally to help the waste materials come out of the respiratory tract.

CUBOIDAL EPITHELIUM:

These epithelial cells are cube shaped forming the inner of the kidney tubular and ducts of salivary glands. It provides mechanical support, often these cells acquire additional specialization as gland cells which can secrete substances at the epithelial surface. Sometimes a portion of the epithelial tissue folds inwards and a multicellular gland is formed. This is 'glandular epithelium'. It is a type of epithelial tissue which covers the glands (both exocrine and endocrine) of our body. Both the exocrine and endocrine glands produce their secretion through the glandular epithelium via goblet cells.

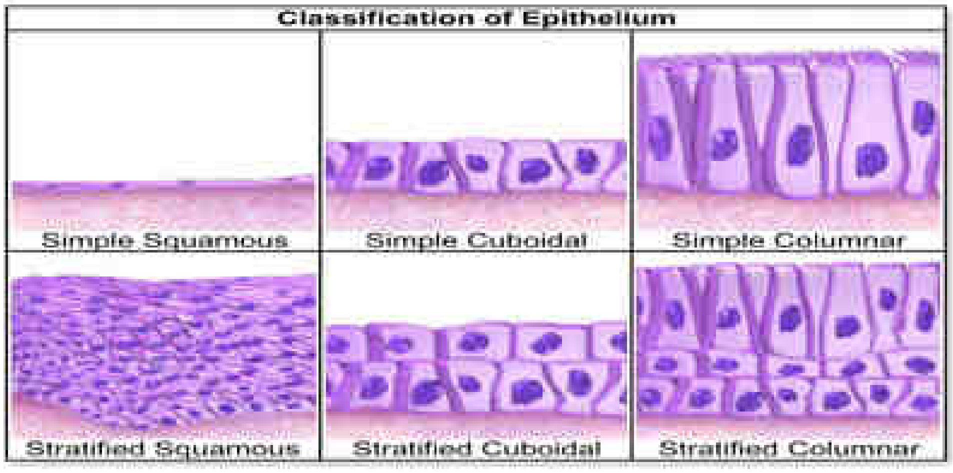


Fig. 6.9 Squamous, stratified squamous, columnar, cuboidal and glandular epithelium

(ii) Muscle Tissues: Muscle tissue is composed of cells that have special ability to contract in order to produce movement in body parts. They are consisting of elongated cells. Muscles contain specialities which contract and relax to cause body movement. There are five main functions of to muscle system such as movement, support, protection, heat generation and blood circulation.

All muscle tissues have five characteristics in common i.e. excitability, contractility, extensibility (stretchable), elasticity (return to normalcy after stretching) and adaptability. When muscle cells are stained and observed under microscope, muscles show alternate light and dark bands or striations due to which they are known as striated muscles. The cells of these tissues are long, cylindrical, unbranched and multinucleate (having more nucleus in a cell).

There are three types of muscles such as skeletal, smooth and cardiac.

a. Skeletal muscle: The specialised tissue that is attached to bones by tendons and allow movement of body part. They are striated. These are long, thin, multinucleated fibres. The skeletal muscles are bound together by connective tissues and communicate with nerves and blood vessels.

b. Smooth muscles: Located in various internal structures including the digestive tract, uterus and blood vessels such as arteries and veins etc. These are spindle shaped and have a single centrally located nucleus and lack striations.

c. Cardiac muscles: The muscles specific to the heart. These muscles show rhythmic contraction and relaxation throughout life. These muscles are cylindrical and uninucleate. Cardiac muscles have branching fibres.

VOLUNTARY AND INVOLUNTARY MUSCLES

There are two types of muscles with respect to their contraction and relaxation. The skeletal muscles are voluntary muscle i.e. whenever it is wanted the tissues starts contraction and relaxation causing the concerned body part to move.

Involuntary muscles contracts slowly and automatically. It constitutes much of the musculature of internal organs like digestive system, respiratory system, circulatory system, uterus etc. Smooth and cardiac muscles are involuntary muscles.

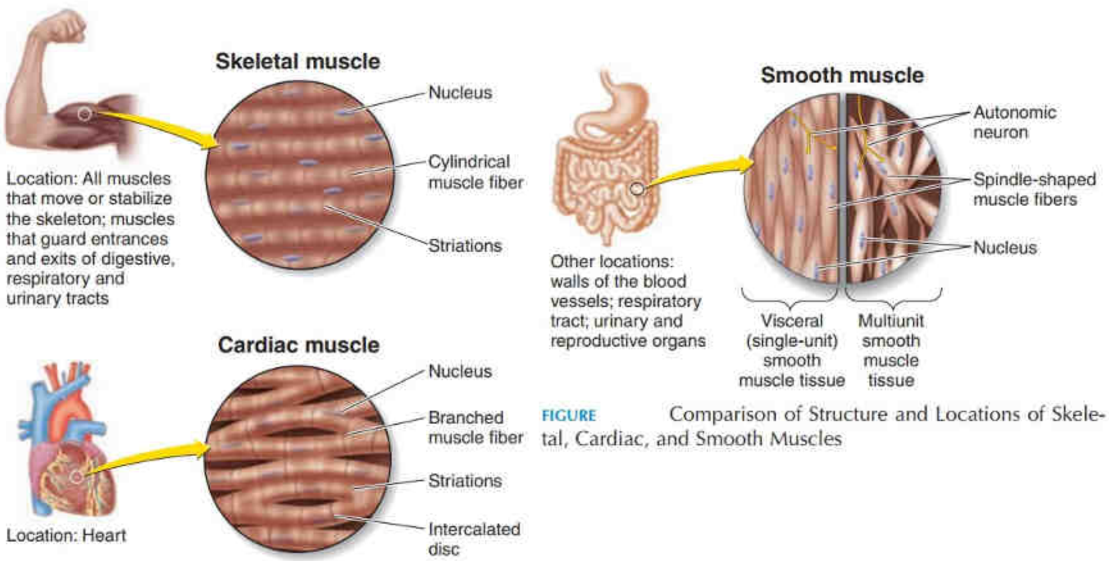


Fig. 6.10 Skeletal, smooth, cardiac muscles

(iii) Connective tissues: Tissues that support, protect and gives structures to other tissues and organs in the body are called connective tissues. Blood is both a tissues and fluid in our body. We know blood carries similar specialised cells which carry oxygen and food materials through its floating cells to the cells at body parts. It helps in excretion of toxic materials through liver and kidney. It also carries carbon dioxide from the cells of different parts of the body and expels through lungs (respiratory system). The WBC, RBC and blood platelets are the cells which floats and moves throughout the body to perform the action of connective tissues.

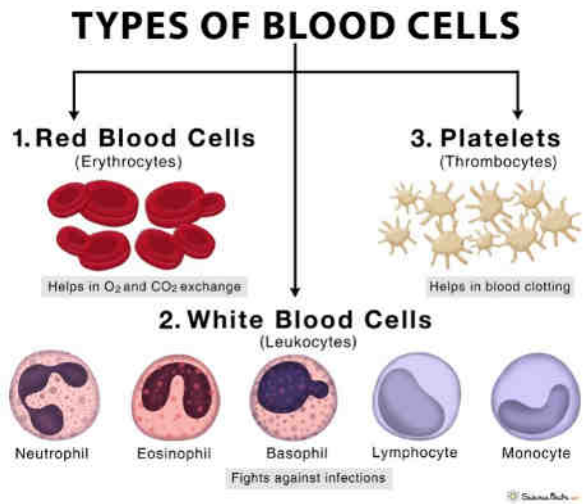
The types of other connective tissues include bone, cartilage, fat and lymphatic tissues. The cells of connective tissue are loosely spaced and embedded in an intercellular matrix. The matrix may be jelly like fluid, dense or rigid. The nature of matrix differs in conformity with the function of the particular connective tissue.

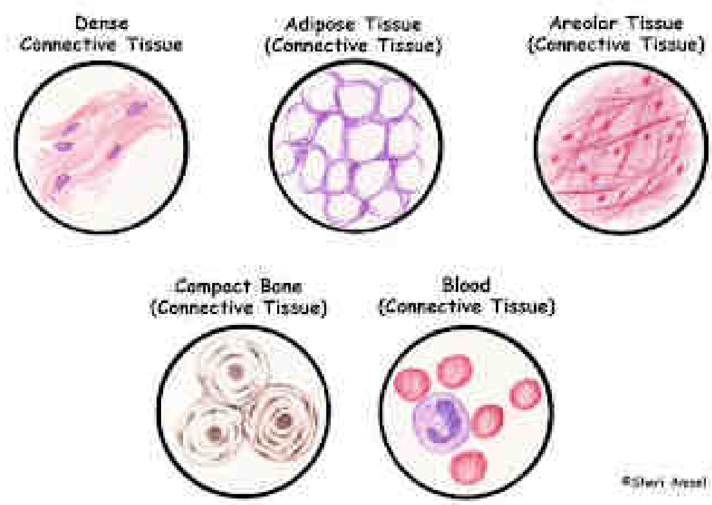
Major functions of connective tissues include

- binding and supporting
- protecting
- insulating
- storing reserve fuel
- transporting substance within the body.

Let us try to understand different connective tissues such as blood, bone.

- **Blood:** Blood has a fluid (liquid) matrix called plasma in which WBC, RBC, blood platelets are suspended. The plasma contains protein, salt and hormones. Plasma transports gases, digested food, hormones and waste materials to different parts of the body for its regular functioning.
- **Bone:** Bones form the framework of the body. Bones also anchor the muscles and support the main organs of the body. Bones are strong and nonflexible tissues. Bone cells are embedded in a hard matrix that is composed of calcium and phosphorus.
- **Ligament compounds:** Two bones can be connected to each other by another type of connective tissue, the ligaments. A ligament is the fibrous connective tissue that connects bones to other bones and maintains position of organs. Ligaments contain very little matrix. **Tendons** connect muscles to bones and are another type of connective fibrous tissue. They are attached with bones with great strength but limited flexibility. Tendons also attach muscles to structures such as the eye ball, elbow, heel, knee, shoulder and wrist.
- **Cartilage:** Cartilage has widely spaced cells. The solid matrix is composed or proteins and sugar. Cartilage smoothen bone surfaces at joints and is also present in the nose, ear, trachea and larynx. Cartilage can be bent but not the bones. Cartilage is a non-vascular type of supporting connective tissue that is found throughout the body but bone is highly vascularised, and its calcified matrix makes it very strong. It is found in joints between bones e.g. the elbows, knees and ankles, ends of ribs between the vertebrae in the spinal cord.
- **Areolar connective tissue:** Found between the skin and muscles, around blood vessels and nerves and the bone marrow. It fills the space inside the organs, supports internal organs and helps in repair of tissues.
- **Fat (adipose tissues)**: It is mainly composed of fat cells called adipocytes. It stores energy, causes hormones production, insulates body from extreme temperatures, cushions vital organs.


TYPES OF BLOOD CELLS
1. Red Blood Cells
(Erythrocytes)
Helps in O_2 and CO_2 exchange
3. Platelets
(Thrombocytes)
Helps in blood clotting
2. White Blood Cells
(Leukocytes)
Neutrophil
Eosinophil
Basophil
Lymphocyte
Monocyte
Fights against infections


Dense
Connective Tissue
Adipose Tissue
(Connective Tissue)
Areolar Tissue
(Connective Tissue)
Compact Bone
(Connective Tissue)
Blood
(Connective Tissue)

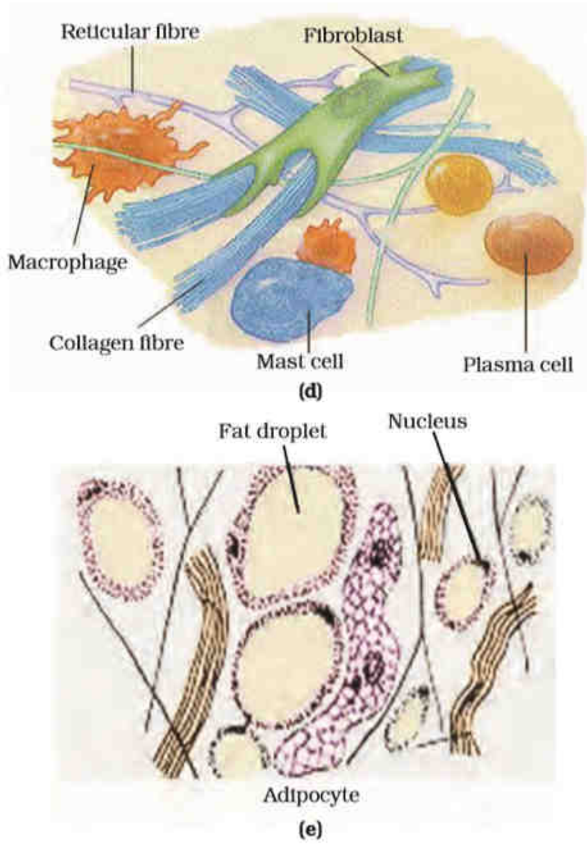


Fig. 6.11 Blood cells, bones, cartilage, areolar, adipose cells

(iv) Nervous tissue: Living body possesses the ability to respond to stimuli. Nervous tissues are responsible to help to respond to stimuli. Nervous tissues are highly specialised for being stimulated and then transmitting the stimuli very promptly from one place to another within the living body. Nervous tissue is found in the brain, spiral cord and nerves connected to sense organs. The tissues are responsible to generate and conduct impulses by the help of nerve cells or neurons. These cells have three principal parts. The dendrites (branched parts), the cell body with a nucleus and cytoplasm, usually each neuron has a single long part, called the axon. Many nerve fibres are bound together by connective tissue and make up a nerve.

Nerve impulses allow to move our muscles as and when required. The four main function of the nervous system are:

- Control of body's internal environment to maintain homeostasis (Example- regulation of body temperature)
- Programming of spinal cord reflexes (Example- the stretch reflex)
- Memory and learning
- Voluntary control of movement of body parts.

Nervous tissue is grouped into two main categories: neurons and neuroglia. Neurons transmit electrical impulses, while neuroglia do not. Neuroglia mainly functions to support and protect neurons.

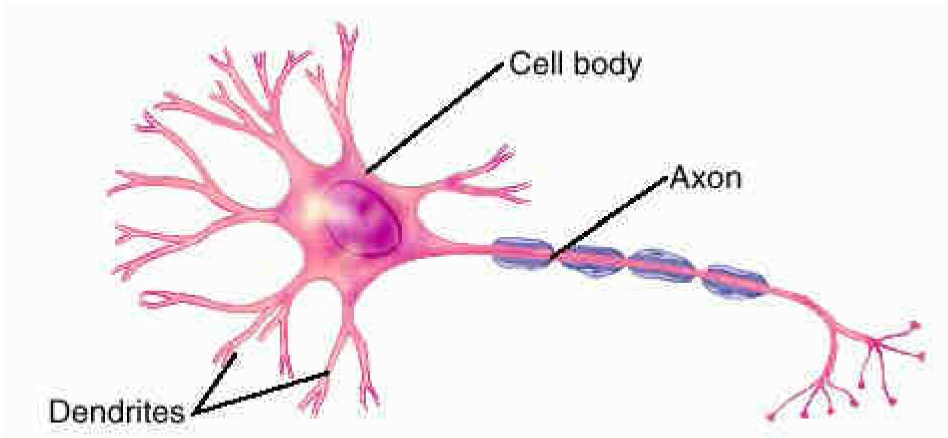


Fig. 6.12 Nerve cells

CHECK YOUR PROGRESS 6.2

1. a. Why does the tissue of respiratory organ show movement?

   b. Through blood circulation what are supplied to cells by blood?

   c. In blood, who carries oxygen and digested food materials to the cells?

   d. Which cells of the blood carry carbon dioxide from cell to alveoli?

   e. Which tissue protects living organism from outside environment?

2. Tick the correct option:

(i) Which of the following forms the lining of kidney tubules?

A. Squamous epithelial tissues

B. Glandular epithelial tissues

C. Cuboidal epithelial tissues

D. Stratified squamous epithelial tissues

(ii) Which is the fluid connective tissue in living human body?

A. Blood

B. Cartilage

C. Bone

D. Adipose

(iii) Nerve cells is otherwise known as ……………….

A. Neuroglia

B. Neuron

C. Stimuli

D. Dendrites

(iv) Muscle tissues are present in ……………of the living organism

A. limbs

B. Heart

C. Elementary canal

D. Liver

3. Match the facts in Colum ‘A’ with that of column ‘B.

	‘A’	‘B’
i.	Neuron	a. Around blood vessels
ii.	Heart	b. Inner lining of intestine
iii.	Areolar tissues	c. Rhythmic contraction and relaxation
iv.	Ciliated columnar epithelial cells	d. Dendrites
v.	Squamous epithelium	

4. Name the following:

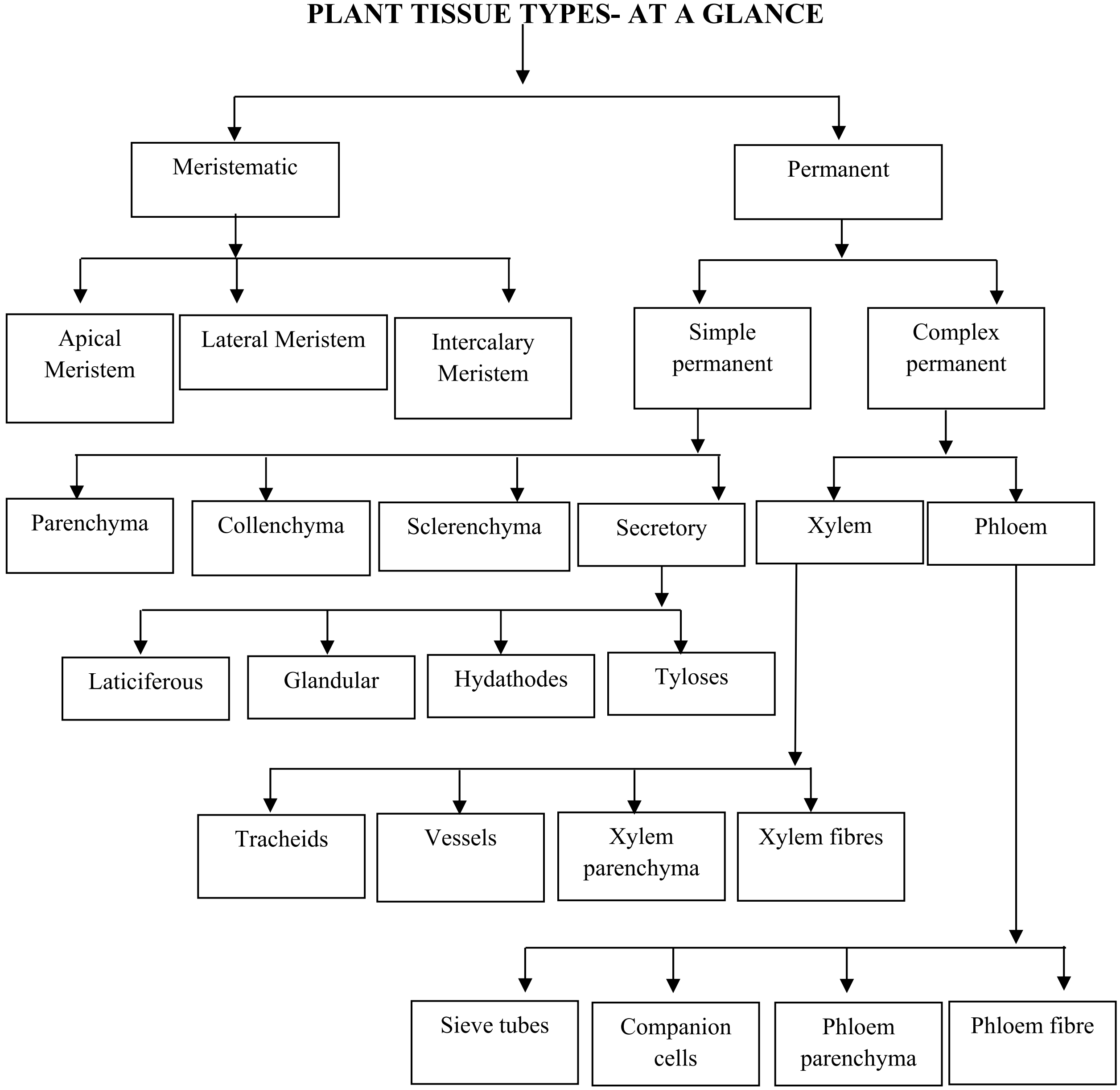
a. Tissue that forms the inner lining of our mouth.
b. Tissue that connects muscle to bone in human
c. Tissue that store fat in our body
d. Tissue that is present in the brain

RECAPITULATION POINTS

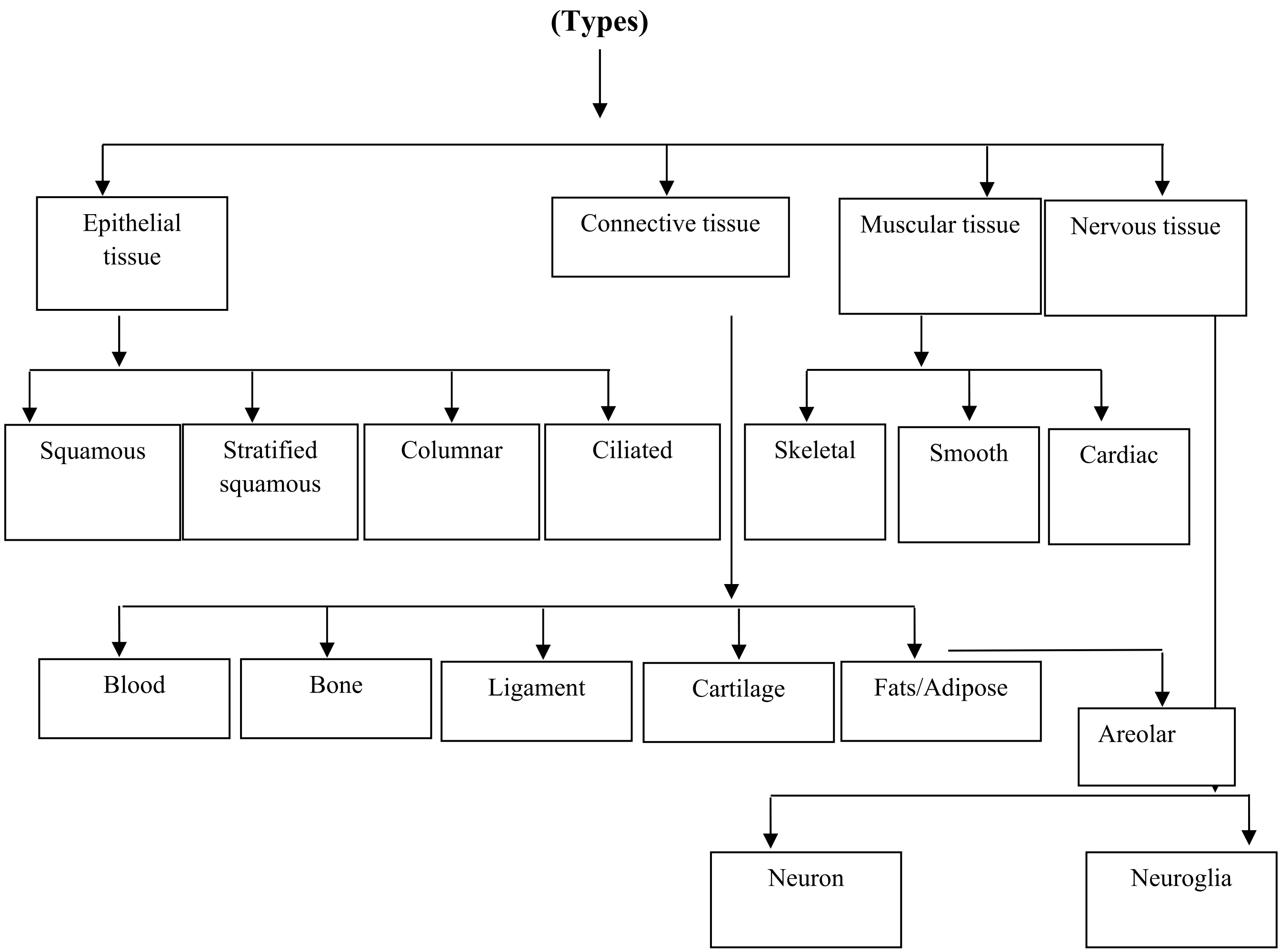
- Tissue is a group of cells similar in structure and function.

- Plant tissues are of two types- meristematic and permanent
- Meristematic tissue is the dividing tissue present in growing regions of the plant.
- Permanent tissues are derived from meristematic tissues once they lose the ability to divide. They are classified as simple and complex tissues.
- Parenchyma, collenchyma and sclerenchyma are three types of complex tissues.
- Secretory tissues are laticiferous, glandular, hydathodes and tyloses tissues.
- Animal tissues can be epithelial, muscle, connective and nerve tissues.
- Depending on the shape and function epithelial tissue is classified as squamous, stratified squamous, columnar, cuboid, glandular.
- Striated, unstriated and cardiac are three type of muscle tissues.
- The different type of connective tissues in our body includes blood, bone, tendon, ligament, cartilage and adipose tissues.
- Nervous tissues are made of neurons that receive and conduct impulses.

PLANT TISSUE TYPES- AT A GLANCE



ANIMAL TISSUES



Animal tissue types- At a glance

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 6.1

1. a. – C
   b. – A
   c. –D
   d. – C

2. a. Cell-Structural functional unit of living body.

   Tissue-A group of cells having similar structure and function form tissue.

b. Meristematic tissue- Having growing cells, gets divided into many resulting growth of the plant

Permanent tissue- End product of meristem tissues and does not help in growth of the plant. Rather perform the function of support and in other survival process of the plant.

3. a. Cell
   b. Excretion
   c. Reproduction
   d. Plant
   e. Tip of the shoots

4. Column 'A' Column 'B'

Column 'A'	Column 'B'
'A'	'd'
'B'	'c'
'C'	'a'
'D'	'b'

5. a. Transporting water and minerals to leaves and stem.
   b. Transporting synthesised food material form leaves to different parts of the plant body.
   c. Exchange of gas (carbon dioxide) into the plant body and release the gas (oxygen) to the atmosphere.
   d. Providing mechanical strength to the leaf and preventing it from easily being torn.

CHECK YOUR PROGRESS 6.2

1. a. Due to contraction and relaxation of cells/tissues.
   b. Oxygen and digested food materials
   c. Plasma
   d. RBC
   e. Epithelial tissues

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

3. Column 'A' Column 'B'

Column 'A'	Column 'B'
'i'	'd'

‘ii’	‘c’
‘iii’	‘a’
‘iv’	‘b’

4. a. Epithelial
   b. Connective
   c. Adipose
   d. Nerve

TERMINAL EXERCISE

Answer the following:

i. Write meaning of the following:
   Cell, tissue, meristematic tissue, permanent tissue, epithelial tissue, nervous tissue
ii. How are simple tissues different from complex tissues in plants?
iii. Differentiate between parenchyma, collenchymas and sclerenchyma on the basis of their function.
iv. It stomata would not have been there on the leaves what problems would have occurred?
v. Diagrammatically show the difference between different types of epithelial tissues.
vi. Differentiate between striated, unstriated and cardiac muscles on the basis of their structure in the body.
vii. Draw a labelled diagram of a neuron.
viii. Identify the type of tissue in the following:
   skin, bark of a tree, bone, inner lining of trachea, vascular bindle.
ix. If a plant devoid of phloem tissue what problem, it would have to come across?
x. What benefit we get because of fluid connective tissue in our body?

SUPPLEMENTARY STUDY MATERIAL

1. NCERT (2008). Science Text Book for Class VIII.
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3. Aggarwal, S. (2021). ICSE Biology Book 1 for Class IX. Viva Education, New Delhi.
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15. https://www.thoughtco.com

7

DIVERSITY IN LIVING WORLD

INTRODUCTION

When you move around either inside or outside your house you must have observed different types of living organisms may it be plants or animals. There are much dissimilarities starting from small to large extent. The differences may be in shape, size, other external features, behaviour etc. In plant as well as animal kingdoms conspicuous differentiation are observed which raises a lot of questions in your mind. Moreover, the differentiation we observe, as they are visible to us. In previous chapters you have learnt that there is existence of microscopic organisms which you can see only under the compound microscope. They are measured in terms of 'micron' that may be very difficult to see even under the microscope. These microscopic organisms are also not similar and a lot of differentiations are there which you are already aware of.

This indicates that you are not unknown to these diversities among the living organisms. To deal with the diversities it is very difficult to establish their characters and classify them as per their qualities which are very essential. It is true that many organisms are beneficial to human beings and some are not at all useful.

Therefore, it becomes essential on our part to classify the diversities existing in the living world to benefit for which efforts are being made since the dawn of civilization. The taxonomy of the world of living organisms are being established based on morphological characteristics and behaviours. The living organisms are classified based on various scientific means. To begin with they are seen from prokaryotes to eukaryotes. Again, the much more diversified eukaryotes are classified as plants and animals, unicellular and multicellular. The diversification of plants is based on three levels such as well differentiated plant body with distinct components, presence of special tissues for transport of water and minerals and ability to bear uncovered seeds and enclosed within fruits.

Again animals, unlike plants, do not have cell wall and most of them are mobile. Their diversifications are further classified based on the extent and type of the body design differentiation.

7.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Explain the need of various bases of classification of living organism
- Differentiate between the term evolution and classification
- Describe the process of developing the hierarchy in classifying the groups among the living organisms
- Identify the organisms prior to the evolution of Plantae and Animalia
- Differentiate between the kingdoms of living organisms
- Draw the classification chart of different types of organisms
- Classify the Plants based on different levels
- Draw the complete classification chart of different types of Plants
- Describe the characteristics of animals belonging to different phyla
- Draw a classification chart of animals

7.2 VARIOUS BASES OF CLASSIFICATION OF LIVING ORGANISMS:

There are innumerable types of living organism that live in this world. Efforts have been made to classify the living organisms to know and understand them. To begin with different types of living organisms were classified based on their habitat. Aristotle had classified the organisms based on their habitats. It is an artificial system of classification in which very distantly related or superficial characters are considered on the basis of classification. In the 18^{th} century, Carolus Linnaeus also proposed binomial (two word) nomenclature and formalized the two kingdom system of classification. He is considered to be founder of modern taxonomy. His work is the beginning of modern botanical and zoological classification with the binomial naming system.

The need of classification occurs due to following reasons:

i. Easy identification
ii. Study of organisms of other places
iii. Study of fossils
iv. Helps study of all types of organisms, while it is most difficult to study individually all of them
v. Brings about similarities and dissimilarities. They help in knowing relationships among different groups.
vi. Evolution of various taxa that can be known.

Since time immemorial till now biologists use several characters for classification system. These are morphology, anatomy, cytology, physiology etc. But day by day something new about organisms from their fossils being discovered and by the help of advanced technological classification it keeps changing. Hence, it is clear that the system of classification is modified even now and then.

In course of discoveries of various organisms it was tried by many researchers to classify them. In the process, the science of naming, describing and classifying organisms developed a science known as taxonomy. Taxonomy is the science of naming, describing, classifying the organisms which include all plants, animals, microorganisms of the world. The characters like morphological, behavioural, genetic and biochemical observations of taxonomists developed the scope of identifying, describing and arranging all species into the fold of classifications. Even the new species discovered are identified and enumerated into the system. So far the taxonomists have named about 1.8 million species of organisms, yet the total number of groups is estimated between 5 and 30 million.

Now, it is clear that characteristics of the organism are bases for classification. The characteristics of different types of organisms having similarities with other organisms form a group. The characteristic is of a particular form or a particular function. It becomes a base to build up a hierarchy of mutually related characteristics to be used for classification. The interrelated characteristics starting from the nature of the cell used for classifying all living organisms. The following examples would create better understanding:

- The prokaryotic cell has no definite nucleus and cell organelles. Because of this the cell follows a biochemical process from that of eukaryotic cells. The eukaryotic cells have definite nucleus with defined nuclear membrane. Moreover, the cell organelles are membrane bound which allows cellular processes to be carried with efficiency in isolation from each other. This has an effect on every aspect of cell design. Even the eukaryotic cells have the capacity to participate in making multicellular organisms as they can take up specialized functions which the prokaryotic cells cannot. Therefore, the presence of definite nucleus and membrane bound cell organelles is considered to be a basic characteristic of classification.
- The organism like amoeba and fungi differ from each other as per their body structure. The unicellular cell amoeba performs all body function by the help of the single cell. But the fungi is a multicellular organism having more than one cell i.e. many cells. All the cells do not perform the biological processes in the same way. A group of cells functions differently from other group of cells indicating a clear division of labour among the group of cells. The biological processes can be completed jointly by all group of cells. Therefore, these two organisms differ from each other in their body design and function of cells indicating a basic character of classification.
- When the functions of nutrition occur, it is found that all the organisms differ to a broad aspect of preparing/synthesizing their own food or collecting the prepared food by some other organisms. The process of photosynthesis is carried out by a large group of organisms (plants) and the other group (animals) is dependent on plants for such activity indicating a basic character of classification.

All these examples clearly indicate the presence of differentiation among the organisms in body design, biological processes, presence of some special characteristics etc. Like this many other characteristics present among the organisms made the pathways of creating hierarchy among them which become the base of taxonomy.

7.3 EVOLUTION AND CLASSIFICATION:

Evolution and classification are two branches of Biology. Evolution of organisms indicates the very slow process of changes that take place with organisms as a result of which new species are born from old ones. The change occurs in the heritable characteristics of biological populations over successive generations. This process gives rise to biodiversity at every level of biological organisation. It is the sequence of gradual changes over millions of years in which new species are produced.

Classification of organisms is the process of classifying the organisms, systematic arrangement in groups based on established criteria. Classification helps us to understand diversity better. It helps us in the identification of living organisms as well as understanding the diversity found in them. The features, similarities and differences that exist with them help us to identify the living organism easily. On the whole it can be said that the method of arranging organisms into groups on the basis of similarities and differences is classification.

When the relationship between evolution and classification is looked at it is found that evolution is the sequence of gradual changes over millions of years in which new species are produced whereas classification is the division of the organisms on the basis of their characteristics into groups. In the process of evolution, it is found that some are older organisms and some are younger organisms. There is a possibility the complexity in design will increase over evolutionary time. When both the older and younger advanced organisms are composed younger organisms shows more complexity in body organisation over the older ones.

Thus, it is established that both evolution and classification are the branches of Biology. One deals with figuring out how organisms evolve; how new species are born from older ones. Classification deals with figuring out how closely related the two species are.

7.4 HIERARCHICAL CLASSIFICATION – GROUPS

Hierarchical classification is a system of grouping organisms according to a hierarchy or levels. The categorization of species is an example of hierarchical classification. It includes the sequence of categories in a decreasing or increasing order. Biologists use hierarchical classification to organise living things into groups so that the organisms are easily studied. It helps in the identification of living organisms as well as in understanding that diversity exist among them. It also enables us to understand how complex organisms evolve from simple organisms.

Carolus Linnaeus (1707-1788) proposed the binomial nomenclature to provide universal identification to the living organisms. R.H. Whittaker (1959) gave the five kingdoms- Monera, Protista, Fungi, Plantae, Animalia which is widely used. The groups are formed on the basis of their cell structure, mode and source of nutrition and body organisation. Further, Carl Woese (1977) tried to modify “Monera” into Archaebacteria or Archaea and Eubacteria for Bacteria which is also in use.

Further, classification is done by naming the sub-groups of various levels since 1990 as given in the following-

Living organisms

Prokaryotes (Domain)

Monera

Eukaryotes (Domain)

Eubacteria	Archaebacteria	Protista	Fungi	Plantae	Animalia
Examples:	**Examples:**	**Examples:**	**Examples:**	**Examples:**	**Examples:**
Strep,	Methanogens,	Amoeba	Mushroom	Ferns	Sponges
Staph	Halophiles	Paramecium	Yeast	Liverworts	Molluscs
E. Coli.		Algae	Molds	Cone bearing plants	Arthropoda
		Slime mold	Rust	Flower bearing plants	Fish
		Giant kelp	Mildews		Reptile
					Birds
					Amphibians
					Mammals

Domains and Kingdoms:

New discoveries have been made, the system of classifications and modifications took place in course of time. Since the time of Linnaeus, many changes have been made in classifying living organisms. All living organisms fall in the 2-Domains and 6- Kingdoms systems which have been shown in the hierarchical classification.

The hierarchical classification of living organisms which is known as taxonomic hierarchy. Taxonomic hierarchy is the pattern of arranging various organisms into successive levels of biological classification either in decreasing or increasing order from domain to species and vice versa. Each of the level of hierarchy is known as category or rank. In biological classification, taxonomic rank is the relative of an organismic group in a taxonomic hierarchy. Example of taxonomic rank are:

- Domain
- Kingdom
- Phylum for animals/Division for plants
- Class
- Order
- Family
- Genus
- Species

Taxonomic rank order

Examples of classification (taxonomic levels) of a plant *Solanummelongena* (Brinjal) is as follows:

Domain- Eukaryote

Kingdom- Plantae

Division- Angiospermae

Class- Dicotyledonae

Order- Solanales

Family- Solanaceae

Genus- Solanum

Species- Melongena

Examples of classification (taxonomic levels) of an animal Homo Sapiens (human being) is as follows:

Domain- Eukaryote

Kingdom- Animalia

Phylum- Chordata

Sub-phylum- Vertebrata

Class- Mammalia

Order- Primate

Family- Hominidae

Genus- Homo

Species- Sapiens

The examples of above hierarchies show that separating organisms on the basis of taxonomic levels into smaller and smaller groups it is clear that the basic unit of classification is species. A species includes all organisms that are similar enough to breed and continue.

Viruses which do not belong to neither Plantae nor Animalia are made up of genetic materials housed inside a protein shell. The genetic material or 'genome' of a virus may consist of single stranded or double stranded DNA or RNA and may be linear or circular in form. Most viruses vary in diameter from 20 nanometres (nm) to 50 nm and about 70-100nm in length. When viruses enter into living host cells they multiply themselves very quickly. Rapid virus production can result in cell death and spread of viruses takes place to nearby cells. They enter into living cells of plants, animals and bacteria. In 1892, Russian scientist, Dmitry Ivanovsky talked about viruses, though the name virus was coined by Martinus Willem Beijerinck.

Viruses are considered as organisms as they are not free living. They cannot reproduce without a host cell. They contain either DNA or RNA and protein. They are not included in taxonomic classification of living organisms. Viruses do not contain protoplasm. It shows the characteristics of living and non-living body. Hence, it can be called as 'half living body'.

Corona virus (COVID-19) cause acute respiratory illness, first discovered in Biological Laboratory, Wuhan, China in the year 2019. Five variants of concerns- Alpha, Beta, Gamma, delta and Omicron. WHO (World Health Organisation) has said that Omicron will not be the last variant (07.02.2022). The International Committee on Taxonomy of Viruses (ICTV) takes care of classification and nomenclature of viruses.

7.4.1 Eubacteria (Otherwise known as Bacteria)

Eubacteria are prokaryotic microorganisms consisting of single cell. They do not have nucleus and containing DNA which is a single circular chromosome. They are enclosed by a cell wall. They take on one of the three shapes such as bacilli (rod shape), cocci (spherical) and Spirilla (spiral or wave shape). As they do not have the nucleus and membrane organelles the life processes take place in the cytoplasm. They are autotrophs and collect their energy through photosynthesis.

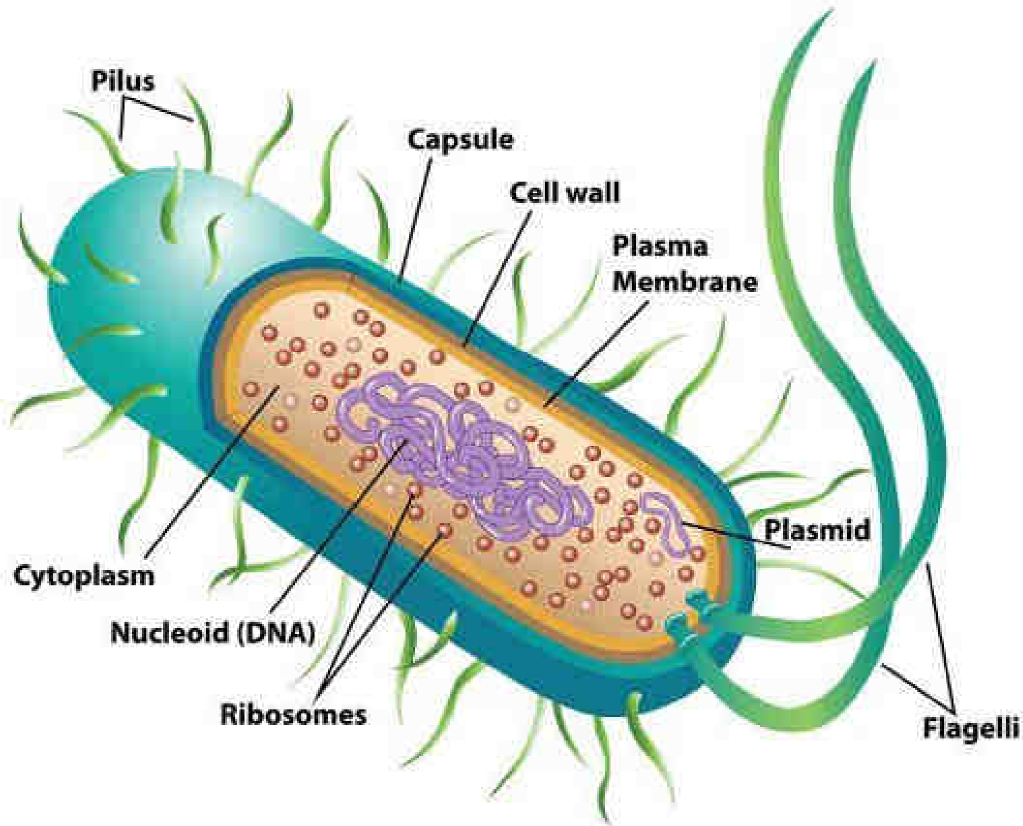


Fig. 7. 1 Figure of Eubacteria

7.4.2 Archaebacteria or Archaea

Archaebacteria are a group of microorganisms considered to be an ancient form of life. They evolved separately from the bacteria. They are unicellular and do have cell wall outside the cytoplasmic membrane and provide security from environment. Archaea reproduce asexually by binary or multiple fission, fragmentation or budding. Archaea are available in the volcanic vents or at the bottom of the sea. They have autotroph mode of nutrition.

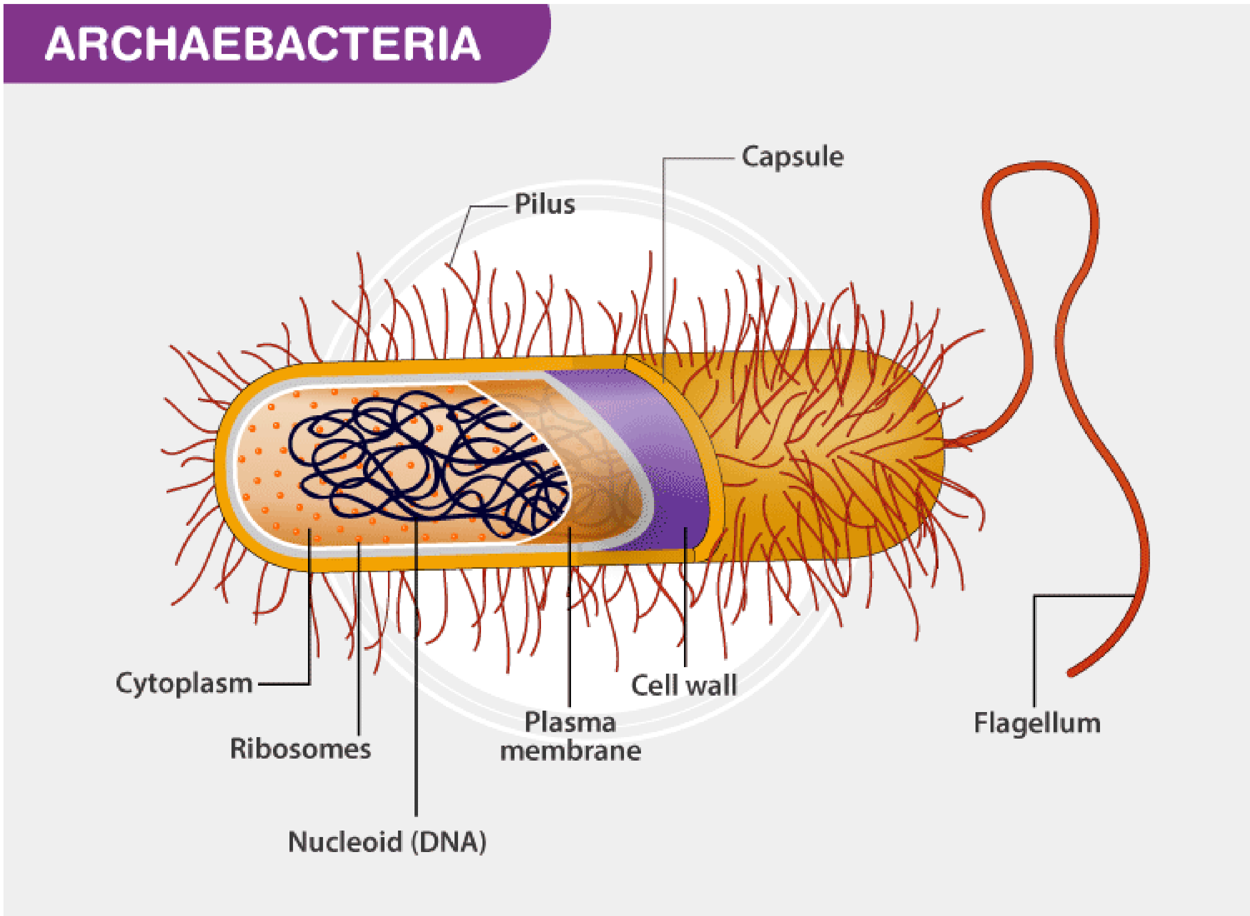


Fig. 7. 2 Figure of Archaebacteria

7.4.3 Protista

The group includes many kinds of unicellular organisms. A Protista is a eukaryotic organism. This is not an animal, plant or fungus. Some of these organisms use appendages like cilia (paramecium) or whip like flagella (euglena) for locomotion. The cells contain single nucleus or many nuclei. Protista may have animal like cell membranes, plant like cell walls. Their size ranges from microscopic to thousands of metres. Some Protista are autotrophic and some are heterotrophic. Mode of reproduction is asexual binary fission. They are found in moist areas and tree trunks.

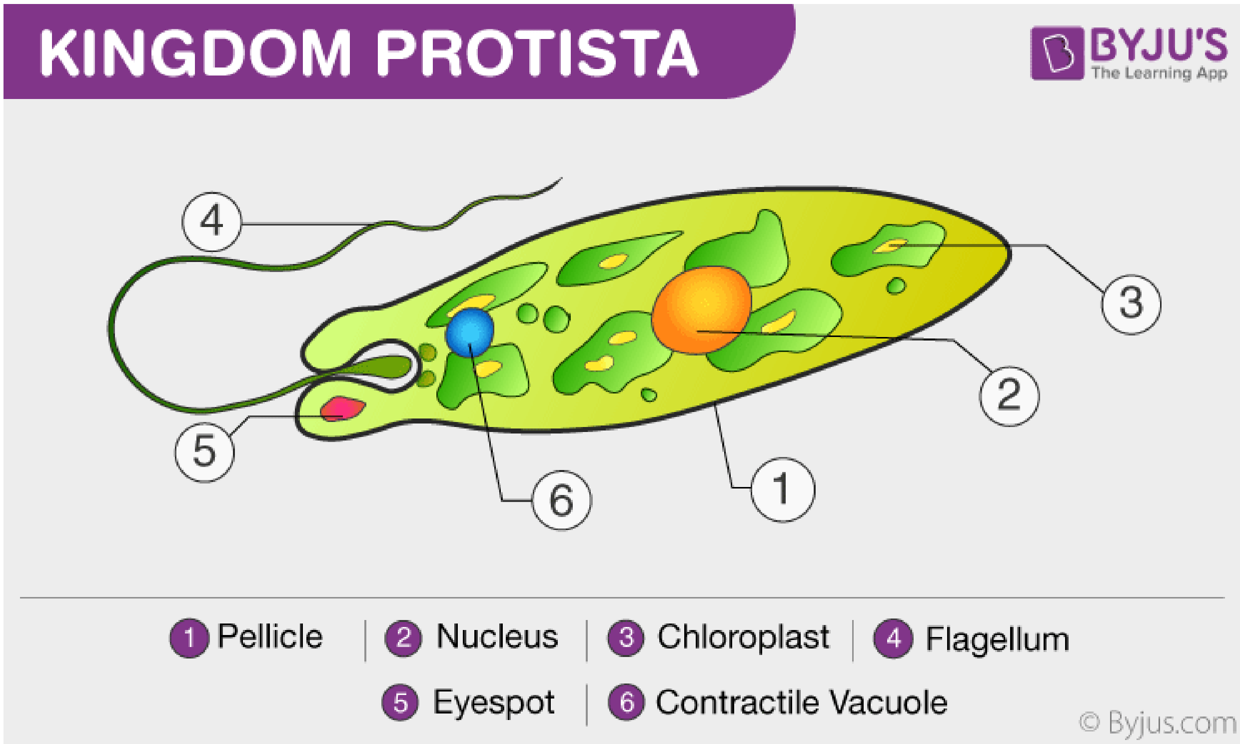


Fig. 7. 3 Figure of Protista

7.4.4 Fungi

Fungus (Plural: Fungi or funguses) is heterotrophic eukaryotic organism. It includes microorganisms such as yeast and molds as well as more familiar mushrooms. Fungus is differentiated from other protists by the presence of 'chitin' in the cell wall. It is also called 'saprophyte' as they use decaying organic materials as food. Fungus reproduces asexually by fragmentation, budding or producing spores (mushrooms). Funguses are either unicellular (yeast) or multicellular (mushroom). They have nucleus and a cell wall.

Some fungi species form lichen, a complex life form that is a symbiotic partnership with algae. The dominating partner is the fungus which gives the lichen the majority of its characteristics. Lichens grow on bark, wood, mosses, rock, soil, glass, metal, plastics and even on cloth.

Fig. 7. 4 Figures of Fungi and lichen

7.4.5 Plantae

Plantae are mostly multicellular, eukaryotic with cell walls. They synthesise food through the presence of chlorophyll, hence autotrophs. Few are heterotrophs also. All plants have been included in this kingdom. Plants have been classified into subgroups based on the plant body, vascular system and seed development. These groups are Thallophyta, Bryophyta, Pteridophyta, Angiosperms and Gymnosperms. Some algae are unicellular.

7.4.6 Animalia (Metazoa)

The Kingdom Animalia is most evolved and divided into two large groups such as invertebrates and vertebrates. These are multicellular, heterotrophic, eukaryotic with aerobic respiration, sexual reproduction and ability of independent movement (locomotion). They have membranous nucleus and cell organelles. Animal cells do not have cell wall.

To begin with the animals, we will study about the invertebrates. They neither possess nor develop a vertebral column which is derived from notochord. The invertebrates do not possess a skeletal system of bones either internal or external. They are considered under many Phyla which we shall study now.

CHECK YOUR PROGRESS 7.1

1. **Choose the correct answer.**
   i. The need of classification occurs due to the following:
      A. Easy way of estimating the number of organisms
      B. Easy way of deciding the taxonomy
      C. Easy identification of the organism
      D. Easy way of identifying the fossil

   ii. **So far the taxonomists have named about ……….. million species of organisms**
      A. 1.8
      B. 3.8
      C. 2.8
      D. 5.8

   iii. **Which one of the following is a very slow biological process of changes through which new species are born from old ones?**
      A. Classification
      B. Evaluation
      C. Taxonomic differentiation
      D. Evolution

   iv. **Who proposed the binomial nomenclature to provide universal identification to the living organisms?**
      A. R. H. Whittaker
      B. Darwin
      C. Carolus Linnaeus
      D. Mendel

2. **Answer in one or two words:**
   a. Cell having membrane bound organelles and distinct nucleus is known as …………
   b. Why amoeba and a worm are different from each other in their body design?
   c. Why are plants and animals having different modes of nutrition?
   d. What is the counterpart name of Phylum (animals) in case of plants?

3. **Match the following with Column 'A' with that of 'B'**

Column A	**Column B**
a. Basic unit of classification	i. Phylum
b. Animals	ii. Yeast
c. Protista	iii. Species
d. Ferns	iv. Plantae
	v. Paramecium

4. Write the taxonomic level of 'Human being'.

Activity A

Activity 7.2

Collect different types of plants at random and try to classify them on your own and discuss with your peers and superior at the study centre.

Activity 7.4

Prepare list of four from each group shown in the box.

Activity 7.4.3

Draw the sketches of Bacteria or Protista or Fungi

7.5 CLASSIFICATION OF PLANTAE

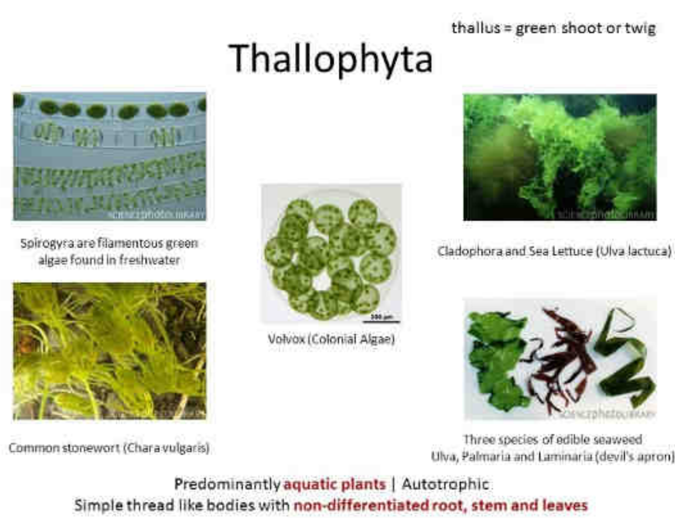
Let us study detailed classification of Plantae.

The levels of classification of plants are as given below:

- Whether the plant body has well differentiated distinct components
- Whether the plant body has special tissues for the transport of liquid (water and minerals)
- The ability to bear seeds
- Whether the seeds are enclosed within fruits

7.5.1 Thallophyta

These plants lack differentiated stems, leaves and roots. This type of plant body is known as 'Thallus'. They are unicellular or multicellular. The mode of nutrition is autotrophic. They are commonly called 'algae'. All of them are aquatic in nature.



Examples: Spirogyra, Ulothrix, Cladophora, Chara, Ulva.

Fig. 7.5 Figures of Different Thallophytic plants

7.5.2 Bryophyta

These plants prefer moist habitats and even they can survive in drier environment. Hence, they are called amphibian plants. They contain non-vasuclar tissues. They reproduce through spores. The body is commonly differentiated as stem and leaf like structure. No differentiated tissue for conducting water. They are autotrophs.

Examples- Mosses, Liverworts, Marchantia, Riccia.

Fig. 7.6 Different Bryophytic plants

7.5.3 Pteridophyta

Pteridophyte is a vascular plant with xylem and phloem that produces spores though it does not produce neither flowers nor seeds. This plant body is differentiated by roots, stems and leaves. It has specialized tissues for conducting water and minerals from one part of the body to the other parts. Pteridophytes are free and independent living organisms. They are autotrophs. These are terrestrial, growing in moist and shady places. Some are aquatic.

Examples: Marsilea, horsetails, ferns, lycophytes.

Fig. 7.7 Figures of Different Pteridophytic plants

Cryptogams: The plants discussed above have certain common characteristics. These characteristics are:

- All are lower plants
- These plants do not bear flowers, seeds and fruits
- The process of their reproduction can be through vegetatively, sexually and asexually.
- Instead of seed, spores are used for their reproduction.

Examples: Algae, Lichens, Mosses and Ferns (Algae, Bryophyte and Pteridophytes). These plants reproduce with the help of spores and known as 'Cryptogams' which implies hidden reproduction.

Phanerogams: Other type of plants that are seed bearing known as 'Phanerogams'. They produce special reproductive structures i.e. flowers, fruits, seeds. Like cryptogams these plants are eukaryotic. All are multicellular. They are well differentiated into true roots, stems and leaves. Well-developed vascular tissues (xylem and phloem) are present which form the vascular system. After fertilization, the embryo develops from the fertilized egg. The seeds enclose embryos and store food. The plants contain well differentiated reproductive tissues.

7.5.4 Gymnosperms

Gymnosperms are seed producing plants with unclosed or naked seeds. That means the seeds have no seed covering (coats) and open, without any protection. They are usually perennial, evergreen and woody. Strobilus or cone is the reproductive structure. Both male and female cones can be present on the same (in Pinus) or on different trees (in Cycas).

Examples: Pinus, Cycas, Deodar, Firs. These plants do not produce flowers. They are found in colder region. Seeds are not formed inside a fruit, develop needle like leaves.

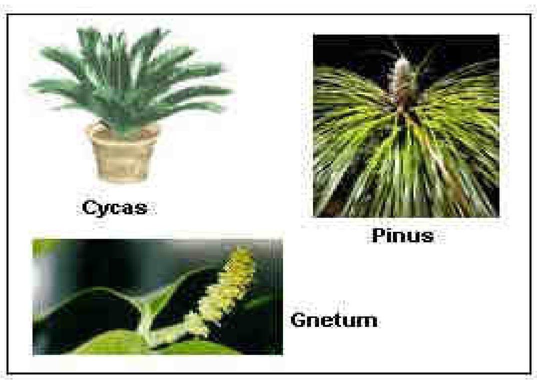


Fig. 7.8 Figures of Gymnosperms

7.5.5 Angiosperms

Angiosperms are flower bearing plants. The plants produce seeds enclosed within seed coats or fruits. Plant embryos are in seeds within the cotyledons or the seed leaves. After the embryo germinates the cotyledons take the form of leaves. The pistil is the female reproductive structure consisting of stigma, style and ovary. The pistil produces female gametes within ovules and the stamen (filament and anther) produces male gametes or pollen. The angiosperms are divided into two groups on the basis of the number of cotyledons present in the seed. Plant seeds having one cotyledon are known as monocotyledonous. And plant seeds having two cotyledons are called dicotyledonous. Pollination and fertilization are the two important events in reproduction to produce a progeny of an angiosperm.

Fig. 7.9 Figures of Angiosperms

CHECK YOUR PROGRESS 7.2

1. Choose the correct answer?
   (i) The plantae are classified based on the ……………….
   A. Whether the plant body has special tissues for the transport of water and minerals
   B. Whether the plant body bears green or non-green tissues
   C. Whether the plant body is multicellular
   D. Whether the plant body has leaves

   (ii) Algae belongs to which type of plantae
   A. Pteridophyta
   B. Bryophyta
   C. Thallophyta
   D. Gymnosperms

   (iii) Looking at the ability to bear seeds what type of classification has been made?
   A. Pteridophyta

B. Cycas
C. Bryophyta
D. Gymnosperms

(iv) Mango plant belongs to which type of plant?
A. Monocotyledonous
B. Dicotyledonous
C. Gymnosperm
D. Pteridophyta

2. Find the relation with the words given in Column A with that of Column B.

Column A	Column B
a. Thallophyta	(i) Rice
b. Monocot	(ii) Body differentiated into stems & leaf like structure
c. Pteridophyta	(iii) Naked seed
d. Bryophyta	(iv) plant body differentiated into root, stem & leaves
	(v) Spirogyra

3. Answer the following questions
a. What is the role of cotyledons in seeds?
b. What is the role of spores in Crytogams?
c. Differentiate between Crytogams and Phanerogams
d. What is the role of pistil in plants?
e. Where can you locate embryo?

Activity B

Activity-7.5.3. a

Collect ferns, observe body parts and draw the complete Fern plant

Activity- 7.5.3.b

List out 10 examples of Phanerogams and Cryptogams.

Activity- 7.5.5

Soak some gram seeds and maize seeds and Fern spores till these germinate. What prediction you can do looking at the germinated seeds and spores? Allow them to grow for about 15 days. What inferences can you draw on the type of plants considering their body structure?

7.6 ANIMALIA – INVERTEBRATA

So far, we learnt about classification of plantae. Now let us see how Animalia have been classified. All organisms (Animalia) are eukaryotic, multicellular and heterotrophic. Animal cells are differentiated from plant cell with the absence of cell wall. Usually, animals are mobile. They are classified based on their extent and type of the body design differentiation. To begin with the classification of animals we will study about the invertebrates. They neither possess nor develop a vertebral column which is distinct from notochord. The invertebrates do not possess a skeletal system of bones either internal or external. They are considered under many phyla which we will study now.

7.6.1 Porifera

Porifera means organisms with holes, multicellular with no distinct tissues or organs. Body full of holes and channels allowing water to circulate through them, allow to bring food and oxygen. Canal system performs the function of food gathering, respiratory exchange, removal of waste, transfer of sperms. They are attached to some solid support. They are mainly found in marine habitats. They mainly consist of jelly like mesophyll sandwiched between thin layers of cells

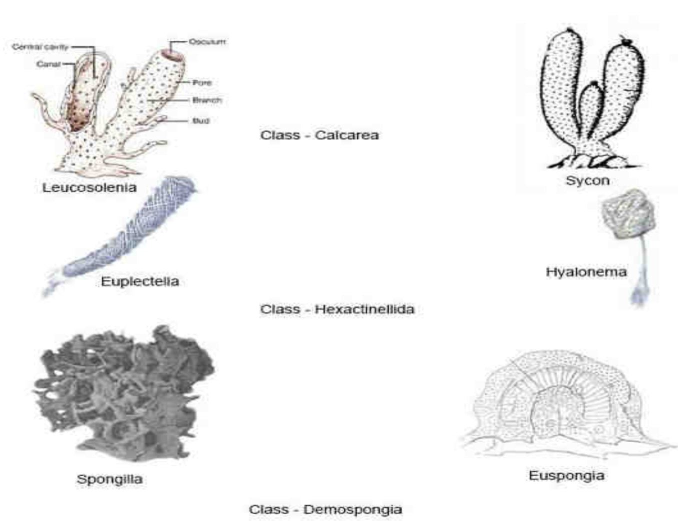


Fig. 7.10 Figures of Different types of Porifera

The animals are covered with a hard outside layer. The examples are sponges, (Sycon, Spongilla, Euplectella).

7.6.2 Coelenterata (Cnidaria)

Coelenterata refers to the hollow body cavity. They have very simple tissue organisation, with only two layers of cells. They are aquatic, mostly marine and few are fresh water. Some of these live in colonies (corals) while others are solitary. The body has a single opening known as hypostome, surrounded by sensory tentacles. The tentacles are equipped with either nematocysts or colloblasts to capture mostly planktons.

Examples: Hydra, Sea anemone, Corals, Jelly fish

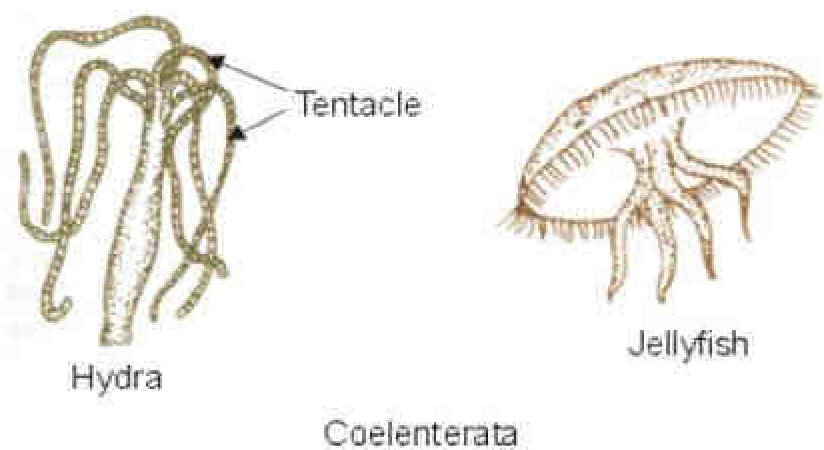


Fig. 7.11 Figures of Different types of Coelenterata

Porifera and Coelenterata are diploblastic i.e. having two germ layers i.e. ectoderm and endoderm. They lack a true mesoderm.

7.6.3 Platyhelminthes

The body of Platyhelminthes is far more complexly designed. The left and right halves are having same design which indicates the body is bilaterally symmetrical. They are otherwise known as flatworms. The body is usually much flattened. Most of them are parasitic in nature indicating some degree of tissue formation. They are triploblastic. The body has a soft covering with or without cilia. Their body is dorsoventrally flattened without any segments. They are hermaphroditic (having both male and female organs). They reproduce both sexually and asexually. There is no true internal body cavity or coelom.

Examples- Tape worm, Planaria, Liver fluke, Polycladida.

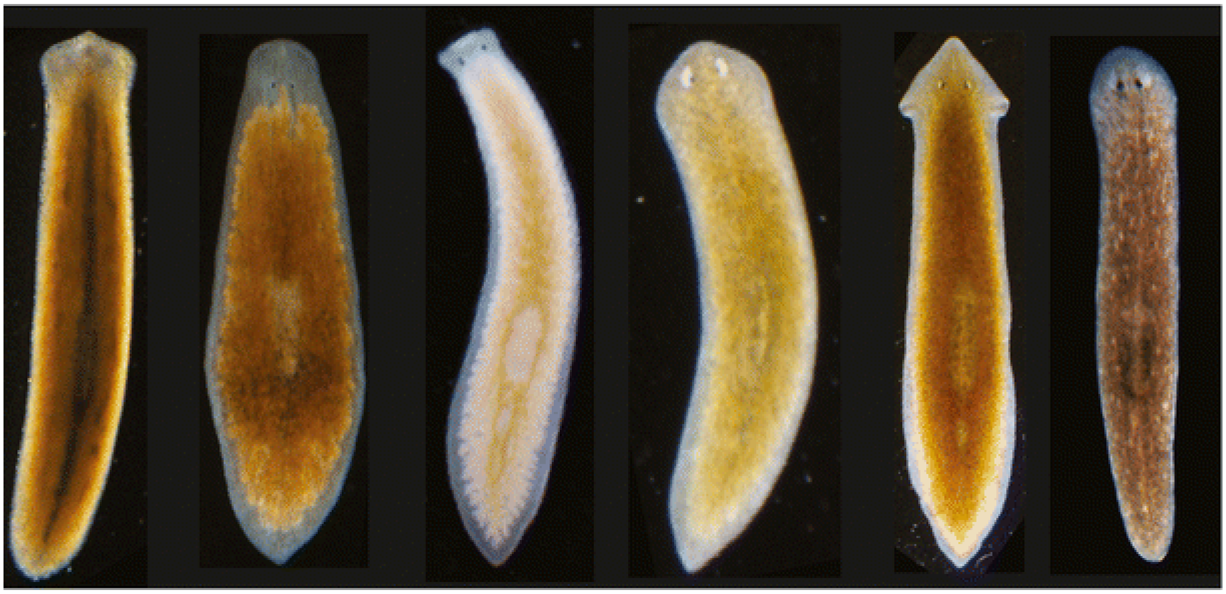


Fig. 7.12 Figures of Flatworms

7.6.4 Nematoda

Nematoda or roundworms are bilaterally symmetrical. They are surrounded by a strong, flexible noncellular layer called cuticle. They are triploblastic, cylindrical in shape, exhibit tissue level organisation. Their body has a cavity or Pseudocoelom with digestive system. They are parasitic in animals or plants or free living in soil or water. Free living nematodes feed on bacteria and fungi which decompose organic matter and help in recycling of nutrients in soil. Parasitic roundworms live in every habitat in fresh water in the seas and on land and even in human intestines.

Example- Ascaris, Filarias, Whipworms, Enoplea, Wuchereria

Fig. 7.13 Figures of Roundworms

7.6.5 Annelida

Annelids commonly called segmented worms are bilaterally symmetrical, triploblastic, caelomate (true body cavity) organisms. They also have a parapodia for locomotion with segmented body. There is extensive organ difference from that of Nematoda. This differentiation is in a segmental fashion which lined up one after the other from mouth (head) to anus (tail). The habitat is fresh water, marine water and land. Annelids have a closed circulatory system with muscular pumping heart in the anterior segments. They can reproduce only sexually. They respire through body surface. Nephridia are the excretory organs through which excretion of the body waste matter get excreted out.

Reproductive System-

a. Monoecious: Earthworm, leech (male and female are not separate)

b. Dioecious: Nereis (male and female sexes are separate)

Example- Earthworms, Leeches, Lungworm, Nereis

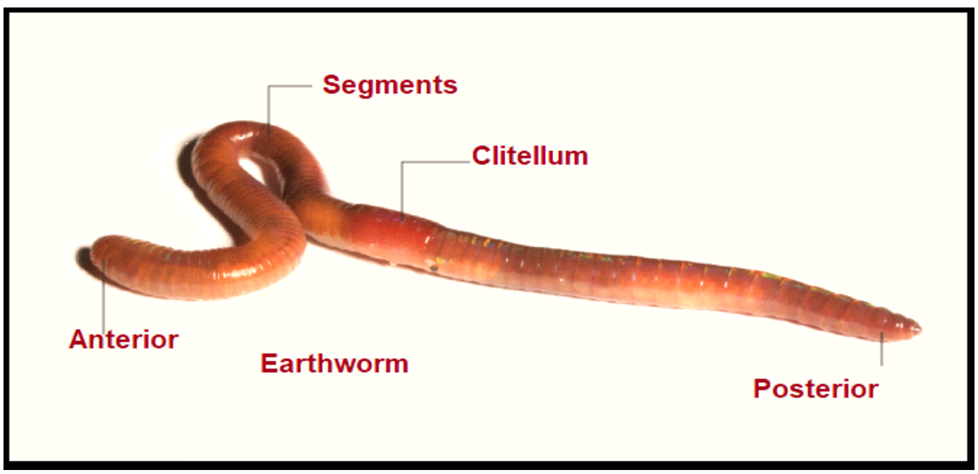


Fig. 7.14 Figure of Roundworm

7.6.6 Arthropoda

Arthropoda is probably the largest phylum in the animal kingdom. These animals are bilaterally symmetrical and internally and externally segmented bodies having exoskeleton. Jointed appendages and open circulatory system and blood does not flow in well-defined blood vessels. The coelomic cavity is present. The cuticle of jointed legs are made of chitin. Because of attributes of exoskeleton, small body size, ability to fly, swim, high reproductive potential with separate sexes and adaptability in an ever-changing environment, arthropoda are quite successful in their survival process. Arthropoda can survive in marine, fresh water and terrestrial ecosystem. Almost all arthropoda lay eggs.

All the major senses are found in Arthropods due to various sensory organs having receptors. These are Antenna, simple and compound eyes and statocysts (balance organs).

Examples: Prawns, insects, crabs, scorpions, ants, spiders, locusts, butterfly.

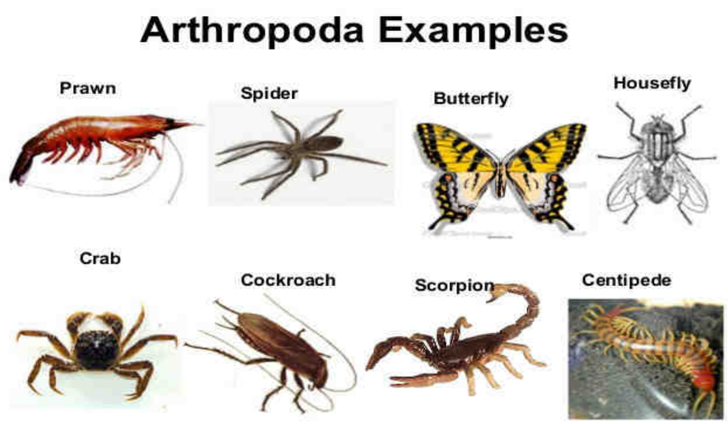


Fig. 7.15 Figures of Arthropoda

7.6.7 Mollusca

Having bilaterally symmetrical body. This Phylum is having second largest animals. The mantle (Pallium. Plural Pallia) is a soft covering formed from the body wall. The outer covering sometimes is strengthened by calcified plates. The coelomic cavity is reduced. They have an open circulatory system and kidney like organs for excretion. Some molluscs secrete shells. They are primarily of separate sexes and have reproductive organs. Mostly found in marine and fresh water. The body is divided into head, visceral mass, muscular foot and mantle. The head comprises of tentacles and compound eyes.

Example: Snail (Pila), Oyster, Octopus, Squid, Clams, Unio, Chiton

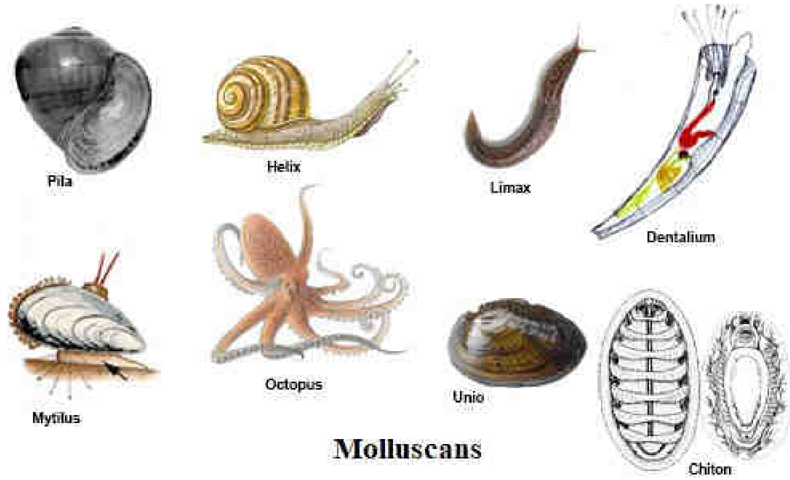


Fig. 7.16 Figures of Mollusca

7.6.8 Echinodermata

Echinoderms have a spiny endoskeleton. They have radial symmetry as adults but bilateral symmetry as larvae. They have a unique water vascular system which also helps in nutrition with tube feet which help them for free movement. They are triplobastic (three embryonic layers i.e., ectoderm, mesoderm and endoderm) and have a coelomic cavity. They are star like, spherical or elongated appearance. Echinoderms are exclusively marine animals. They exhibit organ system level of organisation. Reproduction by external fertilisation: free eggs and sperms in water fertilise.

Examples: Starfish, Sea anemone, Sea cucumber, Sea lily, Sea urchin, Brittle star, Feather star.

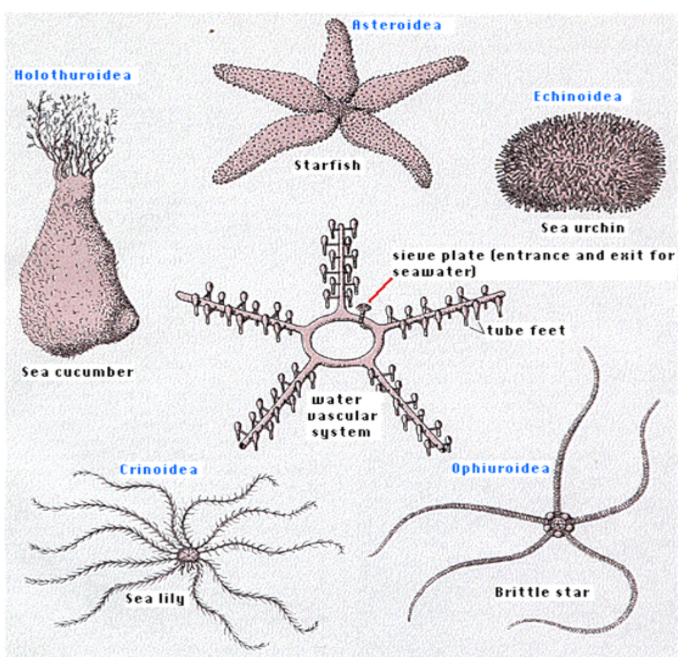


Fig. 7.17 Figures of Echinodermata

7.6.9 Protochordata

The body of protochordata is bilaterally symmetrical, triploblastic and has a coelom. They are mostly marine aniamls. At a certain stage of their lives, their body develops a rod like structure extending along the dorsal side for providing support to the body, known as ‘notochord’. It provides a place for muscles to attach for ease of movement. They exhbit organ system level of oragnisation. Protochordates are described as invertebrates but are closely related to vertebrates. Adults are hermaphrodite (having both male and females sex organs) but self sterile and reproduce by external fertilization.

Examples- Balanoglossus, Amphioxus, Salpa, Doliolum, Hardmania, Saccoglossus.

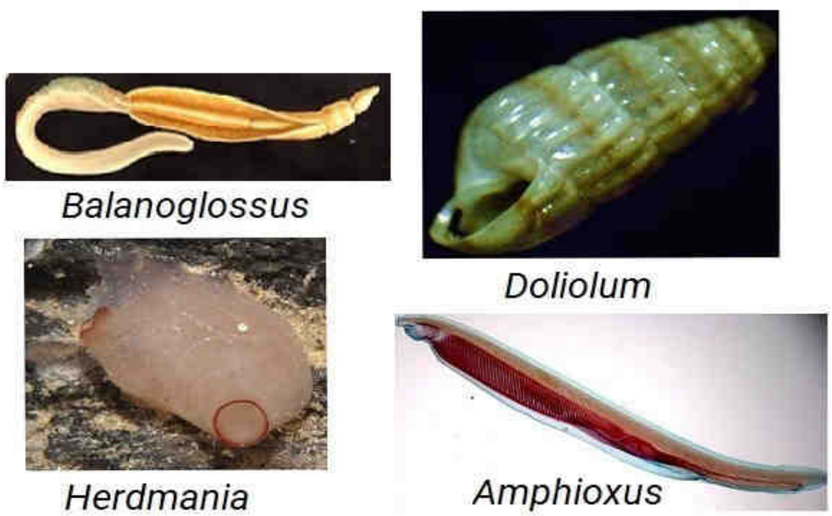


Fig. 7.18 Figures of Protochordata

CHECK YOUR PROGRESS 7.3

I. Choose the correct answer

a) Invertebrates are those who ……

A. Are unicellular

B. Have no vertebral column
C. Are multicellular
D. Are having aquatic habitat

b. …………..means organism with holes.
A. Cnidaria
B. Annelida
C. Platyhelminthes
D. Porifera

c. Which Phylum of animals refer to hollow body cavity?
A. Coelenterata
B. Porifera
C. Mollusca
D. Platyhelminthes

d. Tapeworm belongs to which Phylum?
A. Annelida
B. Nematoda
C. Platyhelminthes
D. Arthropoda

II. Answer in a word or sentence.
(i) Which organism among the invertebrates has tube feet?
(ii) Organisms of which phylum have shells as body cover?
(iii) The organisms of which Phylum have notochord?
(iv) Earthworm belongs to which Phylum?
(v) Mosquito belong to which Phylum?

III. Match the words of Column 'A' with that of Column 'B'.

Column 'A'	Column 'B'
a. Ascaris	i. Platyhelminthes
b. Sycon	ii. Arthropoda
c. Tapeworm	iii. Porifera
d. Scorpion	iv. Annelida
	v. Nematoda

IV. Explain the following in brief
(i) Triploblastic
(ii) Bilaterally symmetrical
(iii) Coelomic cavity
(iv) Water vascular system

Activity C

Activity-7.6a

Observe the specimens of Porifera, Coelenterata, Platyhelminthes and Nematoda in study centre and draw one sketch of animal from each category.

Activity-7.6 b

Compare the body structures of the animals from the four phyla. Draw a list of similarities and dissimilarities.

Activity-7.6.6

Make contrasts of body structures of Annelida and Arthropoda

Activity- 7.6.8

Make a contrast between Mollusca and Echinodermata with regard to their body structure. Draw sketch of at least one animal from each Phylum.

7.7 ANIMALIA- VERTEBRATA

So far we have learnt about Plantae Kingdom and its classification and from Animalia, we have completed Invertebrates. Besides them there is another group of animals that exist in this world who have distinctive features quite different from Invertebrata. These characteristics are:

i. These animals have true vertebral column and internal skeleton.
ii. Have a dorsal nerve cord.
iii. Have bilateral symmetry and are triploblastic and coelomate.
iv. Have a distinct head with a differentiated tubular brain.
v. Presence of closed circulatory system.

The vertebrates are grouped into five classes:

Pisces, Amphibia, Reptilia, Aves and Mammalia.

7.7.1 Pisces

These are true fishes. They have following characteristics:

i. They are having acquatic habitat.
ii. Their skin covered with scales or plates.
iii. They have jaws supported by skeleton.
iv. They have a pair of gills through which they absorb oxygen dissolved in water.
v. Body is streamlined and two sets of paired fins, pectoral and pelvic in addition to dorsal, caudal and anal fins.
vi. Body is distributed into head, trunk and tail.
vii. Two chambered heart and cold blooded.

Example- Bony fishes Rohu, catfish, scoliodon etc.

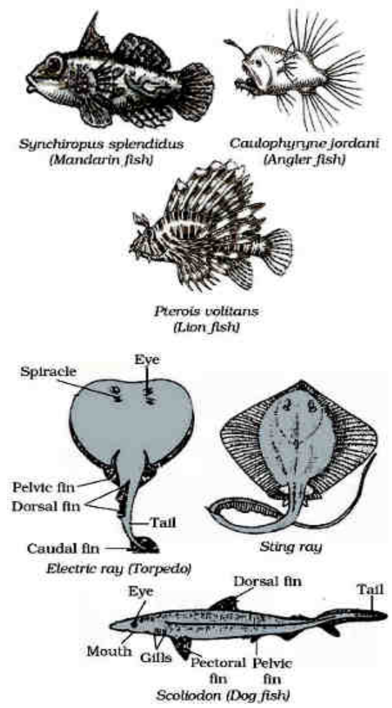


Fig. 7.19 Figures of Fishes

7.7.2 Amphibia

The following characetristucs are of amphibians:

i. Live in both acquatic and terrestrial habitat.
ii. Skin is slippery or has mucous glands without any scales.
iii. Body is divided into head and trunk.
iv. Unshelled eggs and external fertilization.
v. Breathe through skin and gills/lungs (Primitive).
vi. Three chambered heart and cold blooded.

Examples- Frogs, Toads, Salamanders, Hell benders

Fig. 7.20 Figures of Amphibians

7.7.3 Reptilia

Reptilia have the following characeristics:

i. Air breathing with specified lungs.
ii. Have three chamber heart (crocodile- four chambered) and are cold blooded.
iii. They creep with their legs, burrow, are terrestrial and have scales on their rough skin.
iv. The body is divided into head, neck, trunk and tail.
v. Most of them lay eggs or bear live youngs fertilised internally.

Examples- Crocodile, Snakes, Lizards, Turtle, Chameleon.

Fig. 7.21 Figures of Reptilians

7.7.4 Aves

Majority of aves can fly in the sky. They have feathers and live in terrestrial habitat. Aves have following characteristics:

i. Aves are warm blooded and have four chambered heart.
ii. Their forelimbs are modified to wings.
iii. Have well developed flight muscles that help during flying.

iv. Their hind limbs are adapted for walking and associated activities and have epidermal scales.
v. They lay eggs.
vi. They breathe through lungs.
vii. They have beak with no teeth.

Examples- Stork, Duck, Pigeon, Crow, Sparrow, Ostrich.

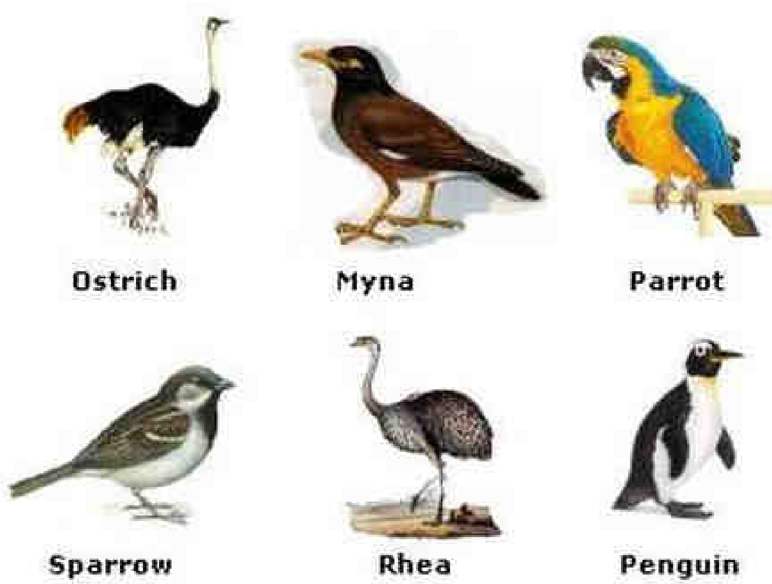


Fig. 7.22 Figures of Aves

7.7.5 Mammalia

The class of animals in which the young ones are nourished with milk from special mammary glands of the mother are known as Mammalia. They have distinguished features such as:

i. They are warm blooded animals with four chambered hearts and well developed organ system.
ii. They have hair or fur on their skin and skin has sweat and other glands.
iii. They produce live young ones but few of them like platypus and the echidna lay eggs.
iv. They have more complex brain than all other animals.
v. They have specialised teeth.
vi. They produce sexually with internal fertilisation.

Examples: Cat, Lion, Human, Bat

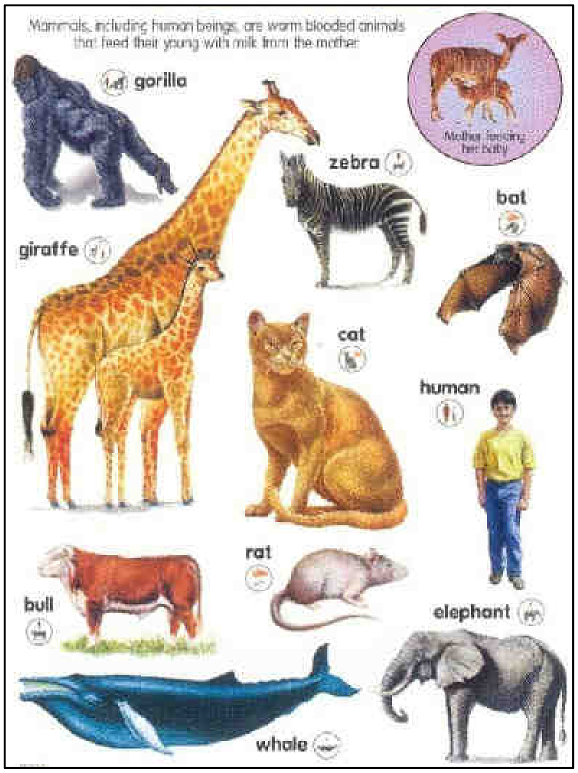


Fig. 7.23 Figures of Mammals

CHECK YOUR PROGRESS 7.4

1. Choose the correct answer
   i. Which class of vertebrates have streamlined body with fins:
      A. Crocodile
      B. Amphibia
      C. Pisces
      D. Aves
   ii. Which of the following indicates a distinctive difference of vertebrates from invertebrates:
      A. Triploblastic body feature
      B. Bilateral symmetry
      C. Aquatic habitat
      D. Capable of movement (locomotion)

   iii. Which distinctive character indicates similarity between Pisces and Amphibians
      A. Internal fertilization
      B. Aquatic lifestyle
      C. Body is divided into head, trunk and tail
      D. External fertilization in water

iv. What is the similarity in characteristic feature between Amphibians and Reptilia ?
   A. Life cycle passes through aquatic and terrestrial habitat
   B. Air breathing styles are same
   C. Are cold-blooded
   D. Shelled eggs with external fertilisation

II. Answer in one word or sentence

(i) Platypus which lay eggs belong to which Class?
(ii) How many chambers are there in hearts of Aves?
(iii) What type of fertilisation takes place with the Aves?
(iv) Which class of animals have hair on the skin?

III. Match the words given in Column 'A' with that of Column 'B'

Column 'A'	Column 'B'
a. Snake	i. Pisces
b. Mammal but lay eggs	ii. Internal fertilization
c. External fertilization	iii. Mammals
d. Tubular brain	iv. Cold blooded
	v. Echidna

IV. Correct the following by changing the underlined word.
i. <u>Balanoglassus</u> has true vertebral column.
ii. <u>Reptilia</u> complete life cycle through aquatic and terrestrial habitat.
iii. Vertebrates reproduce <u>vegetatively</u>.
iv. <u>Forelimbs</u> of aves are adapted for walking on the ground.

Activity-7.7

Compare the nature of blood circulatory systems and blood temperature (cold or warm) and number of chambers of heart of vertebrates.

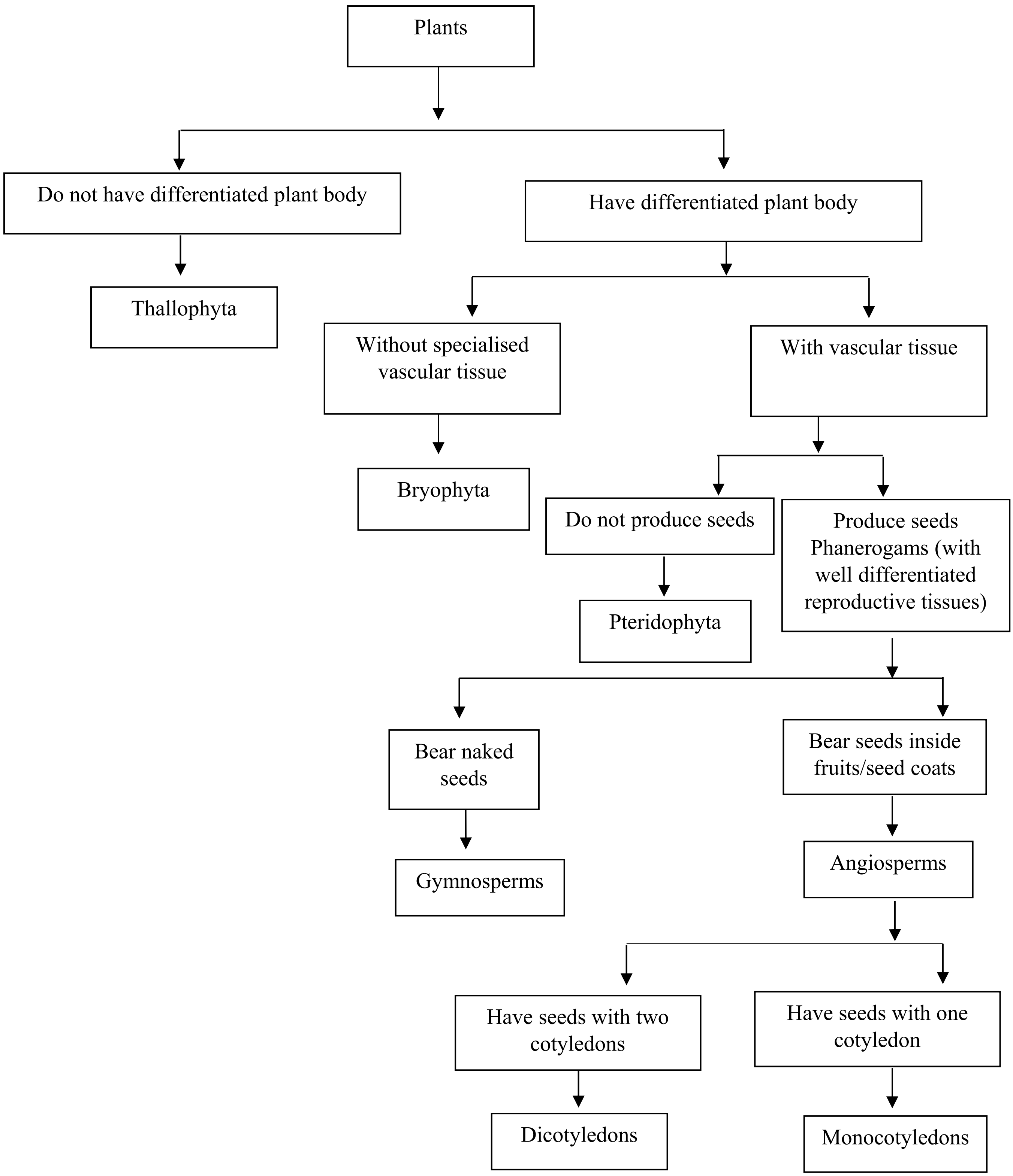
RECAPITULATION POINTS

- Classification is essential in exploring and explaining the diversity in organisms.
- The organisms are classified into 6 major kingdoms based on the characteristics:
  (i) Whether the organisms are prokaryotes or eukaryotes.
  (ii) Whether the cells are capable of living singly or multicellular in their organisation.

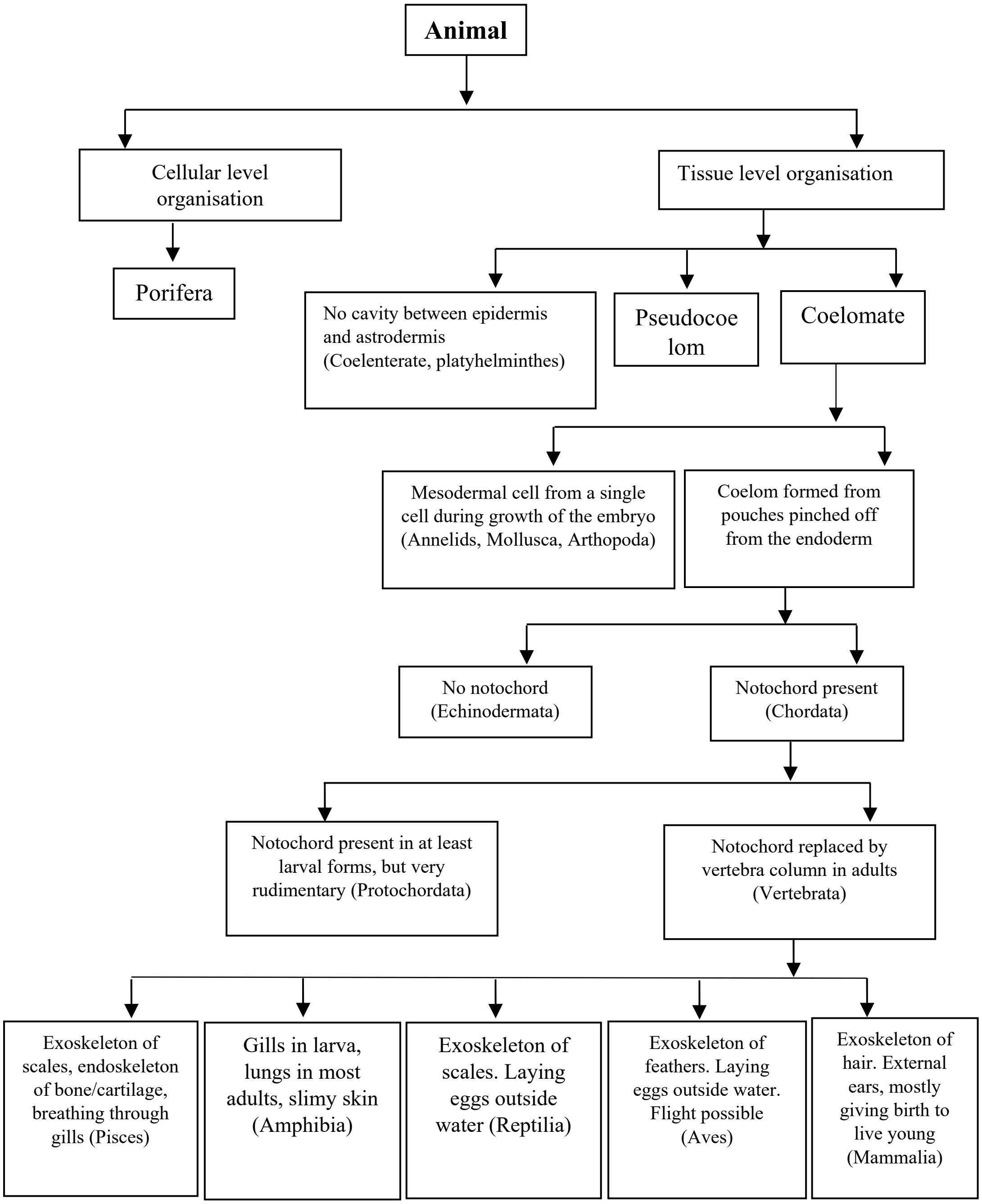
(iii) Whether they are having cell wall and autotrophs.

- All living organisms are classified into six kingdoms such as Eubacteria, Archaebacteria, Protista, Fungi, Plantae and Animalia.
- The classification of life forms is related to the process of evolution.
- Plantae and Animalia are further subdivided based on the increasing complexity of their body organisation.
- Plants are subdivided into five groups namely Thallophyta, Bryophyta, Pteridophyta, Gymnosperms and Angiosperms.
- Animals are subdivided into two groups like Invertebrates and vertebrates.
- The invertebrates are further subdivided into Phyla like Porifera, Coelenterata, Platyhelminthes, Nematoda, Annelida, Arthropoda, Mollusca, Echinodermata, Protochordata.
- The vertebrates are subdivided into Phyla like Pisces, Amphibia, Reptilia, Aves and Mammalia.
- The binomial nomenclature is made by taking into consideration of generic name and specific name.

The flow chart of Plantae and Animalia are placed as indicated.



Classification of Plants- At a glance



Classification of Animals - At a glance

TERMINAL EXERCISE

1. Why are the organisms classified?
2. Explain the basis of classifying the organisms into six kingdoms.
3. How are classification and evolution based.
4. What is the difference between the hierarchy of classification between plantae and Animalia?
   Write the hierarchy of plantae and Animalia in complete forms.
5. What are the differences between Eubacteria and Archaebacterial?
6. How do Protista vary from Fungi?
7. Differentiate between Angiosperms and Gymnosperms.
8. Explain how animals in vertebrates are classified into subgroups.
9. What are the major divisions in Plantae? What is the basis of these Divisions?
10. What is the basis of the difference between invertebrates and vertebrates? How animals in vertebrates are classified into different subgroups?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 7.1

1. i. – C
   ii. – A
   iii. – D
   iv. – C

2. a. Eukaryote
   b. Unicellular-multicellular
   c. Photosynthesis- presence of chlorophyll
   d. Division

3.

Column A	Column B
a	III
b	I
c	V
d	IV

4. Domain- Eukaryote, Kingdom- Animalia, Phylum- Chordata, Sub-phylum- Vertebrata, Class- Mammalia, Order- Primate, Family- Hominidae, Genus- Homo, Species- Sapiens

CHECK YOUR PROGRESS 7.2

1. i. – A
   ii. – C

iii. – D
iv. – B

2.

Column A	Column B
a	V
b	I
c	IV
d	II

3. a. Storage of food and protection of embryo
   b. Reproduction
   c. Cryptogams- Seedless plants Phanerogams- Seed bearing plants
   d. Pistil- Female sex organs help in reproduction
   e. Ovary

CHECK YOUR PROGRESS 7.3

1. i. – B
   ii. – D
   iii. – A
   iv. – C

2. i. Starfish
   ii. Mollusca
   iii. Protochordata
   iv. Arthropoda

3.

Column A	Column B
a	V
b	III
c	IV
d	II

4. i. Three embryonic layer – ectoderm, mesoderm, endoderm
   ii. Making the body with two similar halves
   iii. Body cavity
   iv. Movement of water inside the body in a particular manner (to help in nourishment and excretion)

CHECK YOUR PROGRESS 7.4

1. i. – C
   ii. – A
   iii. – D
   iv. – C

2. i. Mammalia

ii. Four
iii. Internal
iv. Mammals

3. Column A — Column B

Column A	Column B
a	IV
b	V
c	I
d	III

4. i. Pisces or any other member of vertebral group
ii. Amphibia
iii. Sexually
iv. Hindlimbs

SUPPLEMENTARY STUDY MATERIAL

1. NCERT (2008). Science Text Book for Class VIII.
2. NCERT (2008). Science Text Book for Class IX.
3. Verma, P. S. (2021). ICSE Biology Science for Class 9. Part-3 Oswaal Books. New Delhi.
4. Vishnoi, H.S. (2021). ICSE Concise Biology, Part 1for Class 9..
5. Dutta, A. C. (1998). Botany only for Degree students. Oxford, Cuttack.
6. https://www.physiopedia.com
7. https://www.osmosis.org
8. https://www.britanica.com
9. https://training.seer.cancer.gov
10. https://quizlet.com

8 LIFE PROCESSESS

INTRODUCTION

How can we differentiate between living and non-living?

The activities by which living organisms take in food, derive energy, remove waste from their body and respond to changes in the environment are called life processes. In this lesson, you will learn about basic life processes, namely nutrition, respiration, transportation of nutrients and fluids in the body, and excretion.

8.1 LEARNING OBJECTIVE

After reading this lesson, you will be able to

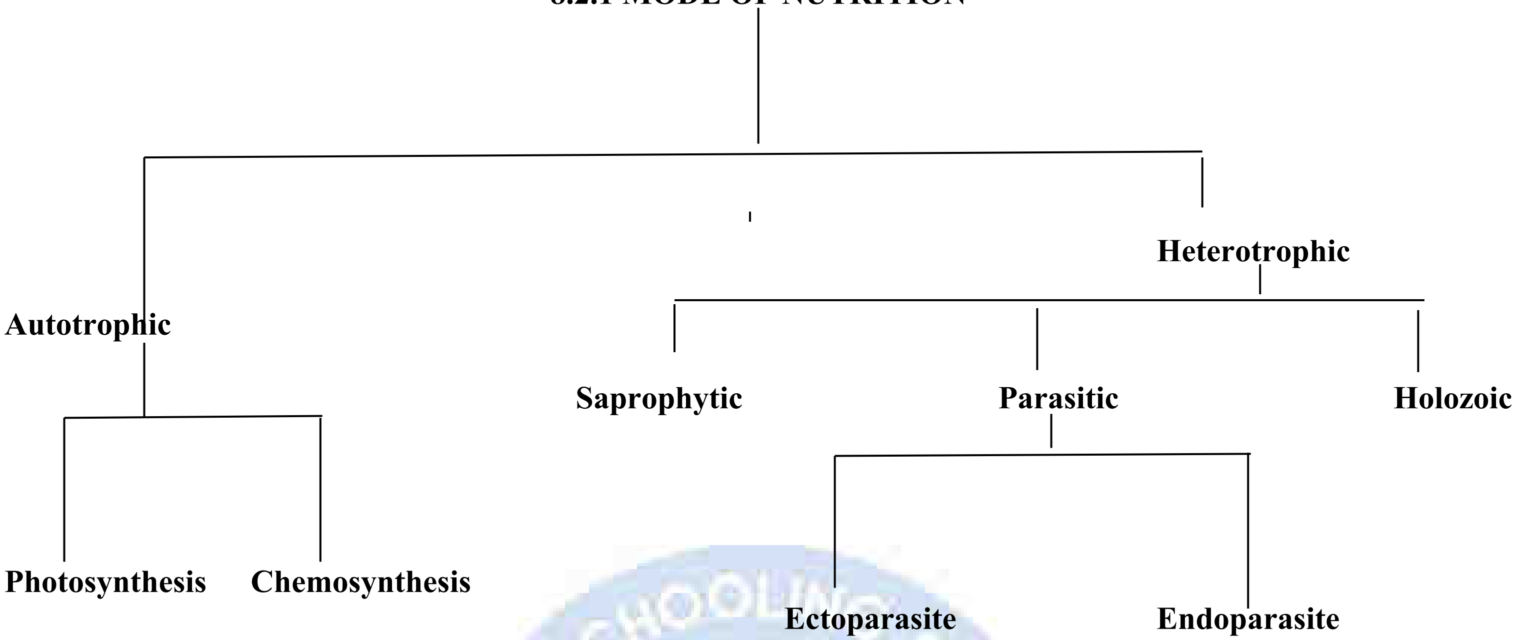
- Emphasize the need for energy requirement for life processes
- Explain the steps in the process of photosynthesis
- Appreciate the autotrophic and heterotrophic nutrition in living organisms.
- Realize the importance of the process of nutrition in humans,
- Identify nutritional disorder
- Explain the concept of balanced diet.
- Gain knowledge about the fundamental aspects of transport of material (food, waste etc.) in plants and animals (e.g. humans)
- Understand the process of excretion in humans.

8.2 NUTRITION

What Is Nutrition?

Nutrition – Nutrition is a process by which living being obtains food or synthesizes it for growth, repair, maintenance ,reproduction and for the energy need.

8.2.1 MODE OF NUTRITION



Autotrophic nutrition- In autotrophic nutrition organisms manufacture their food from simple inorganic compound. These are of two kinds:

Photosynthesis – In Photosynthesis green plants and some bacteria synthesize glucose from carbon dioxide and water.

Chemosynthesis- Some non- green autotrophs like iron and sulphur bacteria make use of chemical energy released during oxidation of simple inorganic compounds to prepare organic food.

Heterotrophic nutrition- Some organisms cannot manufacture their food like autotrophs. They obtain readymade food from plants or animals dead or alive.

For example – All animals, mostly protists and bacteria.

Type of heterotrophic nutrition

Saprophytic nutrition: Saprophytic organisms feed on dead and decomposed organisms and decaying organic matter such as wood, leather, rotten leaves and stored food. They are called saprophytes.

For example- Mostly Fungi such as mushrooms, molds, yeast etc., and many bacteria.

Parasitic nutrition – In parasitic nutrition an organism derives food from the other living organisms. These are of two kinds:

Ectoparasite – They attach on the host body form outside

For example –Leech, mosquitoes etc.

Endo parasite – They live inside the host body and derives their food from them. For example-roundworm, hookworm. Cuscuta (Amarbel) is a plant parasite.

Holozoic nutrition – Holozoic means feeding on solid food. The food is taken through mouth (ingestion) and the food is hydrolyzed into simple and soluble form (Digestion). The undigested matter is removed from the body (Egestion).

CHECK YOUR PROGRESS 8.1

1. Give two examples of autotrophs. Why do you call them so?
2. Why are autotrophs termed 'producers' of food chain?
3. The parasitic and saprotrophic modes of nutrition do not need the three processes required by holozoic animals. Which processes are these?
4. Classify the following as saprotrophs or parasites: leech, yeast, head louse, mushroom.

8.2.2

What is Photosynthesis?

Photosynthesis-

The process by which green plants manufacture their food with the help of carbon dioxide and water in presence of sunlight and chlorophyll.

Reduction

$$6CO2 + 6H_2O \xrightarrow[\textit{Chlorophyll}]{\textit{Sunlight}} C_6H_{12}O_6 + 6O_2$$

(Carbon-di-oxide water) (Food)

Oxidation

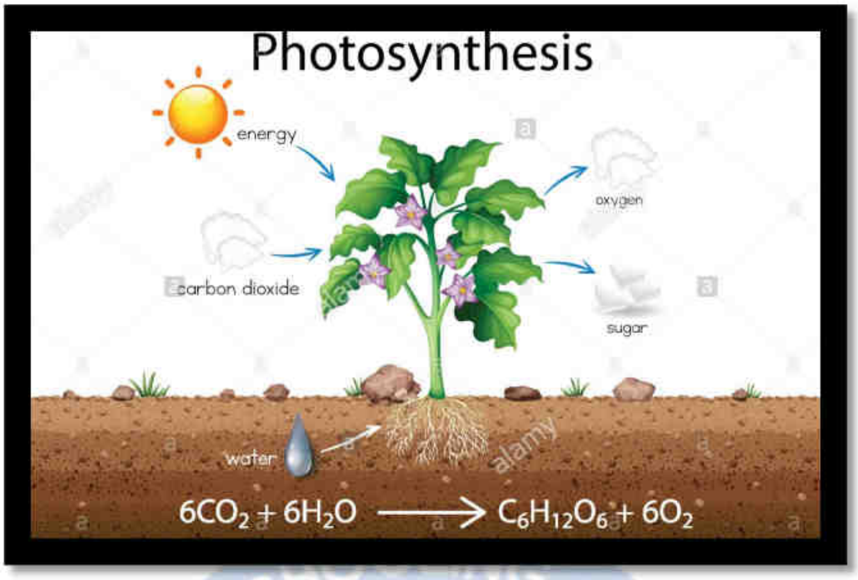


Fig. 8.1: Photosynthesis

- It is a redox reaction, i.e. where the oxidation and reduction take place simultaneously.
- It takes place in chloroplast.

- The process of photosynthesis completes in two steps:
  - Light reaction
  - Dark reaction

Light reaction

1. It takes place in granum of chloroplast.
2. This step takes place in presence of sunlight.
3. In this step of photosynthesis, photolysis of water takes place and O_2 is relased which is used for respiration by other animals.

Dark Reaction

It takes place in stroma region of chloroplast.

1. Light is not necessary for dark reaction.

2. In this step, fixation of CO_2 takes places and glucose (food) is formed.

Chlorophyll – It is a green colour pigment which is found in chloroplast of the cell. The green colour of leaves is due to the presence of chlorophyll in plants cells.

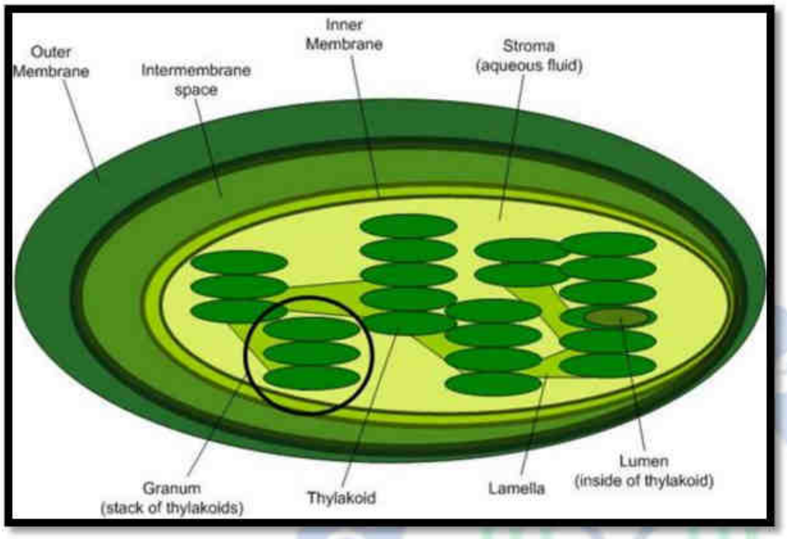


Fig. 8.2 Internal structure of a chloroplast

CHECK YOUR PROGRESS 8.2

1. In two sentences, justify the term photosynthesis (photo + synthesis).
2. What makes plants look green? What does the green pigment of plants do for them?
3. Glucose and starch are two food substances manufactured in the plants. Which one is formed during photosynthesis and in which form is it stored.
4. What role does stomata play in photosynthesis?

8.2.3 Nutrition in Amoeba

It involves the following steps-

Ingestion- Amoeba does not have any oral aperture. The food is captured by finger like extensions called pseudopodia. Process of ingestion of solid food particle in amoeba is called phagocytosis. The food gets enclosed in vesicle called food vacuole or phagosome.

Digestion- In unicellular organism digestion is intracellular that is within the cell. Tiny lysosomes release digestive enzymes and digest the food inside the food vacuole.

Absorption- The digested food diffuses into the cell cytoplasm.

Assimilation – The absorbed nutrients are used for growth, repair, energy and Storage.

Egestion – In Amoeba, the undigested food is thrown out of the cell by exocytosis.

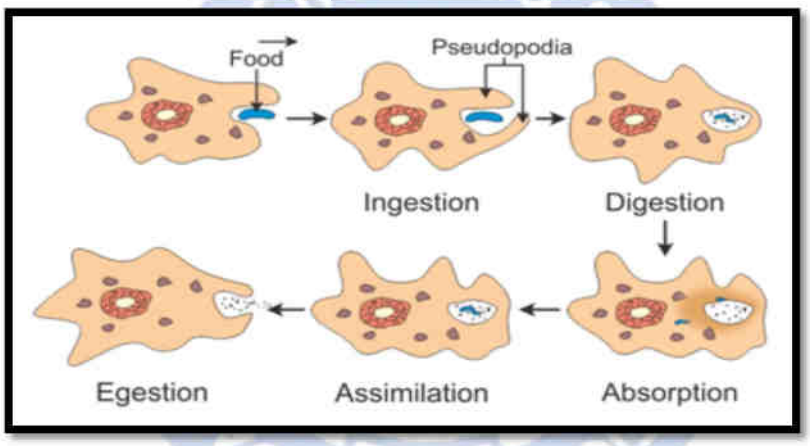


Fig. 8.3 Nutrition in amoeba

8.2.4 Nutrition in Human Being

The process of nutrition in human being completes in the following steps-

1. Injection
2. Digestion
3. Absorption

4. Assimilation
5. Egestion

Digestive system of human beings- The process of nutrition in human being completes in an organ system called digestive system.

It has the following parts-

Buccal cavity- Buccal cavity is the space where food is chewed. Its opening is called mouth.

1. Mouth- It is bordered by upper and a lower jaw. The jaws are covered by cheeks on the side and by lips in the front.

2. Teeth- Teeth are the hardest non-bony structure. Adult humans have 32 teeth, sixteen in each jaw. These are of four types-

A. Incisor 4
B. Canine 2
C. Premolar 4
D. Molar 6

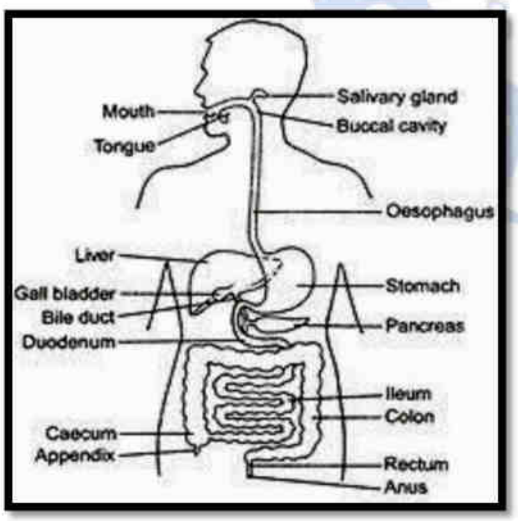


Fig. 8.4 Human Alimentary Canal

Palate-The roof of buccal cavity is formed of hard and soft palates. It separates buccal cavity from the two nasal chambers.

Tongue- Tongue is a flat muscular protrusible structure attached to the floor of the buccal cavity. It bears taste buds to taste the food tongue helps in manipulating the food during chewing and swallowing.

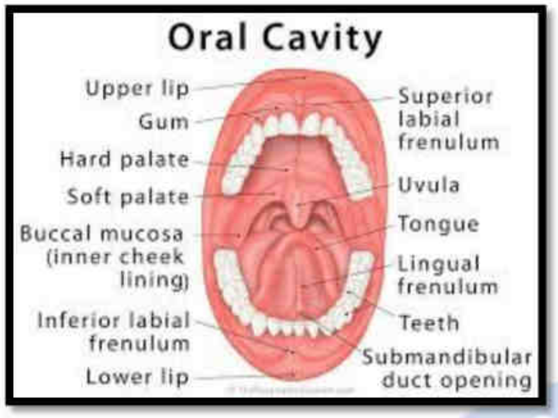


Fig. 8.5 Internal structure of mouth

Glands- Mucus gland in the cheek lining secretes mucus. It lubricates the food and makes it easier to chew and swallow. Three pairs of salivary gland spores their secretion

1. Parotid
2. Submaxillary
3. Sublingual

Pharynx- It is a funnel shaped passage behind soft palate where food and air channel cross each other. Food channel continues as oesophagus and air channel forms the trachea.

Oesophagus- It is a straight muscular tube about 25cm long. Food passes down the oesophagus by peristaltic movement of its muscular bone.

Stomach- Stomach is an elongated J-shaped muscular bag. It lies below the diaphragm. The lining of stomach wall contains gastric glands. These glands secrete gastric juice, HCl and mucus.

Functions of stomach

1. It stores food until it is partially digested.
2. It secretes gastric juice which helps in digestion.
3. It churns the food and mixes gastric juice.

4. HCl kills bacteria that enter stomach along with food.

Small Intestine- It is about 6m long tube of around 205cm diameter. It is differentiated into 3parts.

1. Duodenum,

2. Ileum,

3. Jejunum

1. Duodenum- Duodenum is c- shaped first part of intestine about 25cm long. It receives the opening of common bile duct and pancreatic duct.

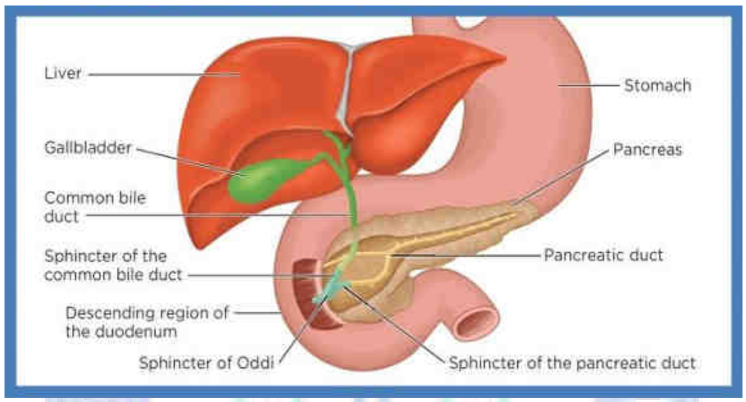


Fig. 8.6 Stomach. Liver, pancreas and duodenum

2. Jejunum- jejunum is about 2.5m long and narrower than duodenum.
3. Ileum- Ileum is about 3.5cm long. The inner lining of intestine is produced into finger like projection called villi. These greatly increase the area for absorption.

Large Intestine(colon)- Large intestine is wider than small intestine. It is about 1.5 to 1.8m long and 6m wide. It is divided into three parts-

1. Caecum 2. Colon 3. Rectum.

Caecum is small pouch, colon is an inverted U-shaped tube and rectum is a 15 cm long terminal tube.

Function of large intestine-

1. Absorption of water from the food.
2. Secretion of mucus.
3. Ejection of undigested waste material.

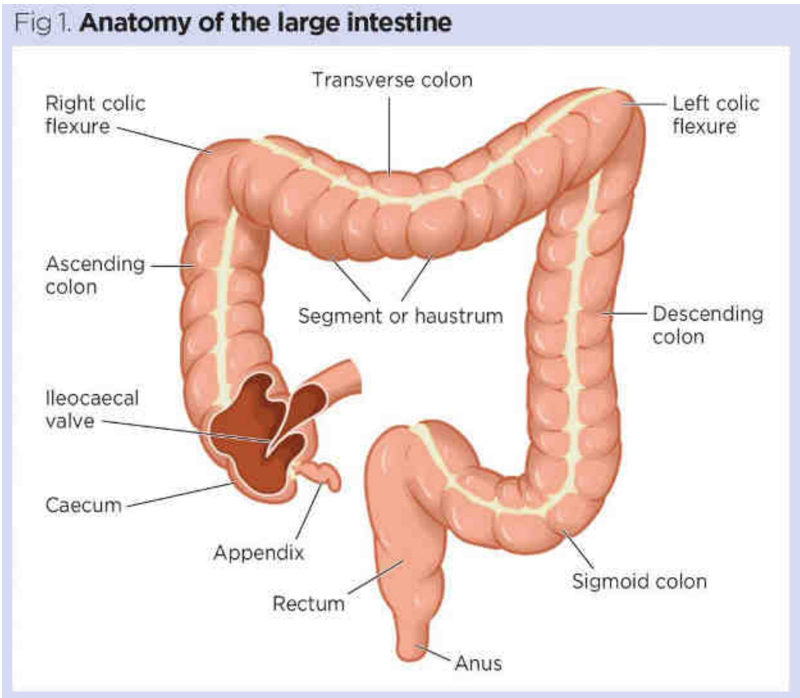


Fig. 8.7 Anatomy of the large intestine

CHECK YOUR PROGRESS 8.3

1. Why should raw vegetables and fruits be a regular item in lunch/dinner?
2. I ate one gram of starchy food and you ate one gram of fatty food - who shall get more energy you or me?
3. What is common between vitamins A and D and B and C to group them together?

What is Digestion of Food?

Digestion is a process of breakdown of food into simple and soluble molecules by the action of digestive enzymes. So that they can diffuse in the blood through the gut wall.

Digestion in Buccal Cavity-

1. The ingested food is chewed and masticated in buccal cavity.
2. Mucus in saliva moistens and lubricates the food, makes it soft. So, that it is easily swallowed.
3. *Salivary amylase*- Salivary amylase present in saliva hydrolyses starch into maltose.

Digestion in stomach- Protein digestion begins in stomach. The muscular wall of stomach undergoes alternate contraction & relaxation, churns the food into fine pulps mass called chyme.

Gastric juice contains HCl, digestive enzymes and mucus.
Hydrochloric acid- it makes pH of food from alkaline to acidic. It destroys bacteria present in the food and activates the inactive propepsin (pepsinogsin) into active pepsin. It also controls opening and closing of the pyloric aperture.

Rennin – In presence of HCl and $Ca+^{+}$ (Calcium ions), rennin helps in the digestion of milk, protein.

Digestion in the small intestine- The partially digested food is pushed into the duodenum and pancreatic juice from pancreas is mixed with the chyme.

Function of Bile Juice

1. It has no digestive enzyme yet it is important for digestion.
2. It neutralizes the acidity of the chyme.
3. It makes the medium alkaline for the action of enzymes of pancreatic and intestinal juice.
4. Bile emulsifies fats and prepares them for the action of enzymes.

Role of pancreatic juice- Pancreatic juice contains following enzymes-

1. **Trypsin& chymotrypsin-** it breaks proteins into polypeptides.

2. **Carboxypeptidase-** It hydrolyses polypeptides into dipeptides, tripeptides and amino acids.
3. **Pancreatic amylase-** It hydrolyses the remaining starch and glycogen into maltose.
4. **Pancreatic lipase-**It acts on emulsified fats and hydrolyse them into fatty acids and glycerol.
5. **Nuclease and nucleotidase-** It hydrolyses DNA and RNA into nucleotides and nucleosides.

Digestion in large intestine- Water is absorbed by the mucus lining of large intestine and undigested residue is changed to semisolid, faces. These are pushed into rectum from where they are passed out through Anus. This is called egestion.

Absorption of food- The end products of carbohydrates, fats and protein digestion are glucose, glycerol, fatty acids and amino acid. They are absorbed by intestinal wall. Glucose, fructose, galactose, amino acid and vitamins are diffused through intestinal wall into the blood while glycerol and fatty acids enter the lymph for efficient absorption. The intestine has following features-

1. It is extremely long and provide a large absorbing surface to the food.
2. Its absorbing surface is further increased by the presence of numerous minute finger like projection called villi.
3. Its epithelium lining is very thin and allow rapid diffusion
4. Lymph vessels are present in each villi for absorption of fat.

Assimilation- The absorbed food is distributed to various body cells by the blood.

- Glucose is used in respiration to release energy. Excess of glucose is converted into muscle cell and liver cell.
- Amino acids are used for the synthesis of protein.
- Fatty acid and glycerol convert into fat.

CHECK YOUR PROGRESS 8.4

1. Name the enzyme secreted by stomach that converts proteins into peptones.

2. What is the movement of muscles of oesophagus that pushes down food called?
3. In which part of the alimentary canal do the pancreas and liver pour their secretions?
4. Name the enzymes present in the pancreatic juice that digests proteins, carbohydrates and fats.
5. Name the acid that takes part in in digestion process.

8.3 RESPIRATION

What is Respiration?

Respiration- Respiration is the process of oxidation or breakdown of food particularly glucose with the release of energy.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + 38ATP (energy)

8.3.1 Types of respiration-

Depending upon the use of oxygen, respiration is of 2 types. -

1. Aerobic
2. Anaerobic

Aerobic respiration- It occurs in the presence of oxygen. During this process glucose is completely oxidized into Co_2 and H_2O and release the energy.
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + 38ATP (energy)

Anaerobic respiration- It occurs in the absence of oxygen. In this process, glucose is incompletely broken down into alcohol and CO_2 or lactic acid. Due to incomplete oxidation the energy released is much lesser than in aerobic respiration.

$C_6H_{12}O_6 \rightarrow C_2H_5OH + 2CO_2$ + (energy)
(Ethanol)

$C_6H_{12}O_6 \rightarrow 2C_2H_6O$ + 2ATP (energy)
(Lactic acid)

8.3.2 Respiration in plants-

Plants also exchange gases with their environment but they do not have special respiratory organs for exchange of gases. Different parts of the plants such as root, stem & leaves transport gases.
Energy requirement of plants is much lesser than animals therefore, respiration in plants is slow.

Exchange of gases-
Oxygen enters in the plants through the following parts:

- Stomata in leaves
- Lenticels in old stem and in old roots.
- General surface of the roots.

1. **Exchange of gases in leaves-** The air enters through stomata from where oxygen and CO_2diffuse through the intercellular space between the mesophyll cells in the leaf. During day time stomata are open and photosynthesis is in progress. So, CO_2 is taken in through stomata & oxygen is released. During night, there is no photosynthesis. So, there is intake of oxygen and release of CO_2.
2. In older portions of stems and roots, exchange of gases takes place through the lenticels present in the bark of old plants.
3. The root hairs are in contact with oxygen present between the soil particles. This O_2 enters the root hair by diffusion & from there passes into other cells of the root.

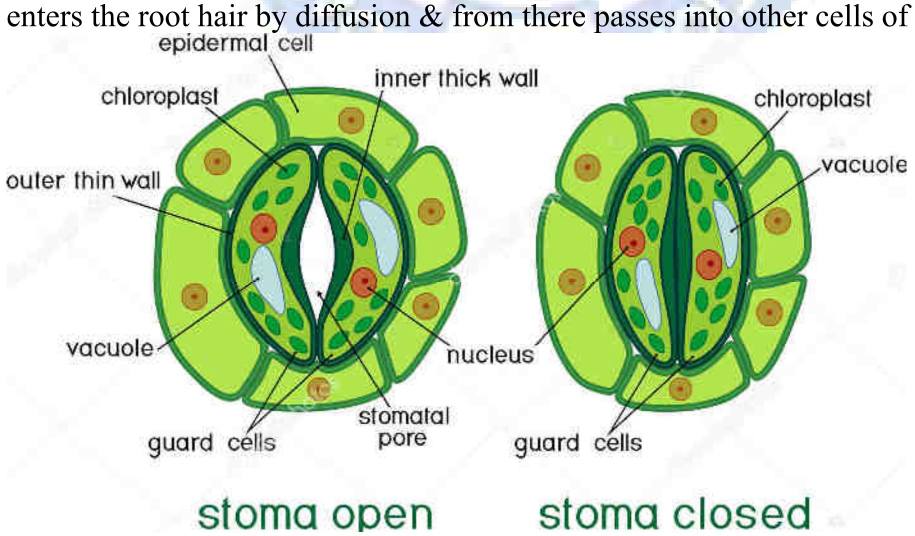


Fig. 8.8 Stomata (open and closed)

Exchange of gases in unicellular and simple multicellular organisms. Unicellular animals like Paramecium and Amoeba and simple multicellular animals like sponges coelenterates etc show direct respiration. The oxygen dissolved in water diffuses directly into their body cells and carbon dioxide diffuses out of the cell into water.

Exchange of gases in complex multicellular animals-

a) Through skin- In earthworm, nereis, leech and frog etc. skin helps in exchange of gases. Respiration through the skin is called Cutaneous respiration.
b) Through gills- Aquatic arthropods (Prawn, crabs etc), molluscs (Pila, Unio etc.) and fishes have gills for respiration it is called branchial respiration.
c) Terrestrial animals make use of oxygen present in the air they have following organs for respiration.

1. Trachea or air tubes- Insects
2. Book lungs- Scorpions and spider
3. Pulmonary sac-Pila
4. Lungs- all vertebrates.

8.3.3 Respiration

The human respiration system consists of following organisms.

1. **Nostrils and Nasal Passage-**Nasal passage are paired tube in the roof of buccal cavity. They are lined with moist, ciliated mucus membrane. Nasal passages open into the pharynx.

Functions of Nasal passage-

1. The hairs present in the nostrils trap bacteria and dust particle present in the air.
2. The moist mucus lining makes the air moist.
3. Nasal passages warm or cool the air to body temperature before it enters the lungs.
4. Olfactory receptors present in the mucus lining detect the smell.

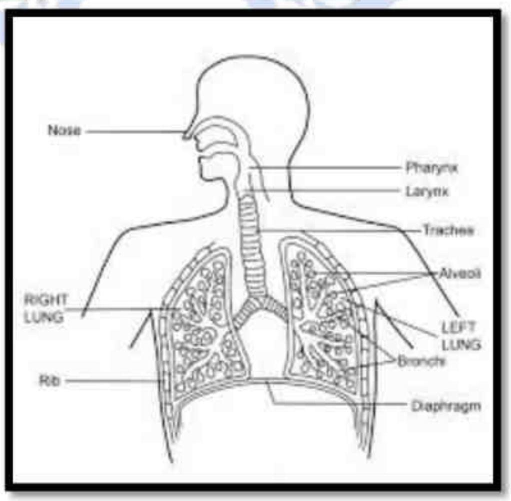


Fig.8.9 Human Respiratory System

Pharynx-The food and air tube cross each other in the pharynx. The opening of air tube in the pharynx is called glottis. It is guarded by a cartilaginous flap called epiglottis. During swallowing epiglottis closes the glottis and keeps the food out of the respiratory tube.

Larynx (Voice box)-The interior of the trachea dilated and is called Larynx. It has two pair of vocal cords. The vibration of vocal cords produces voice.

Trachea-It is a tube that arises from the base of the larynx, passes through the neck and reaches up to the middle of thorax which is covered by dilated and mucus

secreting epithelium for trapping finger dust particles and microbes & pushing them toward the interior and through leading of cells.

Bronchi-Trachea divides into two branches called bronchi which enter the lungs of their respective side and divide into branches**.**

Lungs-There is a pair of lungs located in the thorax cavity. Each lung is enclosed in the double walled called pleura.

Finer branches give rise to alveoli or alveolar sac. Alveoli are polyhedral to round sacs having extremely thin single layered wall invested closely with blood capillaries. The two lungs with estimates to have about 300 million alveoli. Alveoli provide a larger surface area for gaseous exchange.

How breathing takes place- Breathing is the taking in fresh air& releasing foul air. It is an involuntary process, breathing consists of 2 steps- inspiration and expiration.

Inspiration-When we breathe in, air from outside is drawn into the alveoli of the lungs. This is called inhalation (or inspiration). During inhalation, the diaphragm & the muscles attach to the ribs contract. As a result, thoracic cavity expands. This makes the thorax move upward the volume of air inside the thoracic cavity. Due to increase in volume, the air pressure decreases inside and air from outside rushes into lungs through the nostrils, trachea and bronchi. In this manner the alveoli get filled with oxygen rich air.

From the thin walls of alveoli, oxygen diffuses into the blood capillaries & exchange by blood from the tissues & is carried to the alveoli breathing out.

Expiration: When we breathe out, the diaphragm and the muscles attached to the ribs relax due to which the thoracic cavity contracts and becomes smaller. This causes CO_2 to be pushed out of the lungs through the trachea and nostrils. Breathing of air is called exhalation or expiration.

Gas exchange in tissue-Breathing is followed by gaseous exchange between the blood and the body tissue where CO_2 is produced in various metabolic activity and oxygen is used up. The blood brings oxygen and higher concentration of CO_2. Due to the difference in concentration, exchange of gases takes place between blood and tissue. This is called tissue respiration and is followed by the last step in which food is oxidized and energy is released. This is called cellular respiration.

CHECK YOUR PROGRESS 8.5

1. Why does the trachea not deflate (collapse) during exhalation?
2. The sequence of parts of human respiratory are jumbled. Place them in the right order. Nasal cavity, trachea, pharynx, internal nostrils, bronchi, lungs.
3. You have learnt in Physics that when volume increases, pressure decreases. How does this principle find a place in the process of breathing?
4. Once oxygen reaches cells, which of its organelles takes over respiration?
5. Why are the alveoli supplied with capillaries?

8.4 TRANSPORTATION

What is Transportation?

Transportation occurs in all organisms. It includes transport of food , metabolic gases, waste products, water and hormones.

8.4.1 Modes of Transport: In lower organisms which are mostly aquatic or semi-aquatic, transportation occurs through diffusion.

8.4.2 Transportation in Human Beings-The human body consists of several organ system. Each system requires the involvement of circulating body fluid. There are two main circulatory fluid in a body-

1. Blood
2. Lymph

Blood: Blood is a mobile connective tissue. Reddish in colour and circulates in the human body, supplying nutrients and oxygen to all the living cells and taking away waste products as well as CO2 from them.

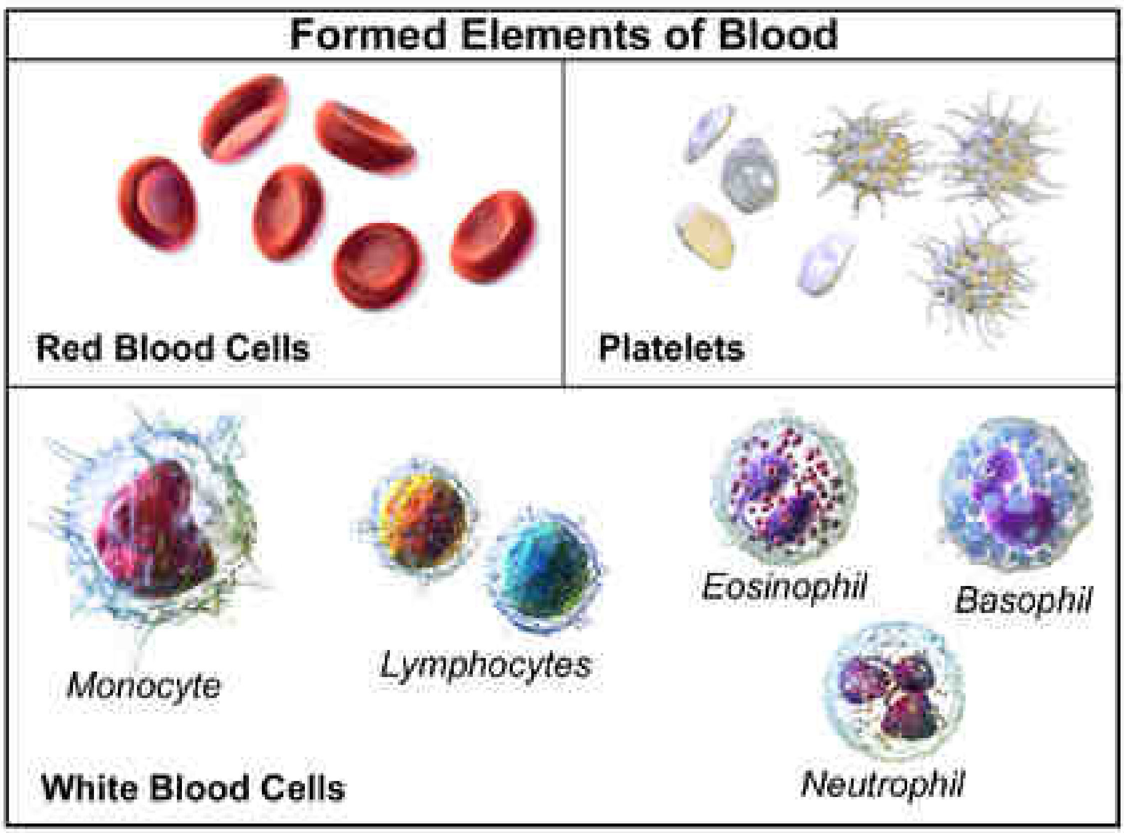


Fig. 8.10 Formed Elements of blood

Plasma-It is a pale yellow coloured transparent liquid. It contains 90 to 92 percent water. It is slightly alkaline in nature. Plasma contains 8% of solute such as proteins, nutrients, excretory products, inorganic salts and other substances.

Blood cells(corpuscles): -

1. Red Blood corpuscles (RBC's) are small circular biconcave disc.
2. In RBC's nucleus, mitochondria, Endoplasmic reticulum and ribosomes are absent.
3. Hemoglobin is a red pigment which is present in their cytoplasm.
4. Hemoglobin is specialized to transport O2 and CO2 to a small extent.
5. Life span of RBCs is 120 days. Two to three million RBCs destroy and replaced every second in our body.
6. New RBCs are formed in bone marrow and older RBCs are destroyed in liver and spleen. Spleen also stores a large number of fresh RBCs for emergency. Therefore, it is also called as a blood bank of the body.

White Blood Corpuscles (WBCs): -

1. WBCs are colorless and nucleated blood corpuscles of different shapes and sizes.
2. They are much fewer in number than RBCs (about 5 to 8 ml per litre of blood). Their life span is 12 hours to several days.
3. **WBCs are of two types: -**
   i) Granulocytes
   ii) Agranulocytes
4. **Granulocytes possess large size granules in their cytoplasm. Their nucleus is lobulated.**
5. **Granulocytes are of three types:**
   i) Basophils
   ii) Eosinophils
   iii) Neutrophil: The main function of WBCs is to defend the body against disease causing germs. WBCs produced anti-body and provide immunity by ingesting and destroying bacteria.

CHECK YOUR PROGRESS 8.6

1. Which blood cells would you categorise as (i) transporters of oxygen and carbon-dioxide (ii) enemies of germs that enter the body.
2. Sheena has blood group O+ and Veena has AB+. Whose blood would be useful if it has to be transfuser into an accident victim of unknown blood group and why?

3. What makes RBCs look red? What is the role of this pigment?
4. In which function is lymph similar to blood?

Platelets

They are colourless non-nucleated irregular shaped self-fragments with a very short life span of three to five days. They help in the clotting of blood.

8.4.3 Function of bloods

1. It transports nutrients like sugar and amino acid etc.
2. It transports oxygen & CO_2gases used in respiration.
3. It carries nitrogenous waste from various parts of the body.
4. It transports hormones.
5. It regulates the body temperature.
6. It maintains the pH of tissue fluid.
7. It contains the defence system of germs.
8. In the region of injury, the blood coagulates and seals the region to prevent from loss of body fluid & entry of germs.

8.4.4 BLOOD VESSELS

Arteries-These are the blood vessels which carry blood coming from heart to various organs of the body.

Veins- They are blood vessels which carrying blood from various parted of the body towards the heart.

Capillaries- They are very narrow blood vessels having a single: Layered wall and they are meant for exchange of materials.

8.4.5 HUMAN HEART

1. Heart is a muscular pumping organ which brings about circulation of blood by its pumping activity.
2. It is located in the chest cavity slightly towards the left and is enclosed in a double walled sac called pericardium.
3. A pericardial fluid is present in between the heart wall and pericardium. The heart is made up of muscle cell called cardiac muscle fiber.
4. The heart consists of 4 chambers-
    a. **Upper chambers-** They constitute the right &left atria
    b. **Lower chambers –** They from right and left Ventricles.
5. The right and left sides are separated and do not communicate. Due to this separation of the oxygen rich blood does not mix with the blood containing CO2
6. The left atrium open into left ventricle by atrio-ventricular aperture. A valve called by bicuspid is present at this aperture. The right atrium opens into right ventricle through right atrio-ventricular aperture which is guarded by a tricuspid value.
7. The valves permit the flow of blood from atrium to ventricle and not in reverse.

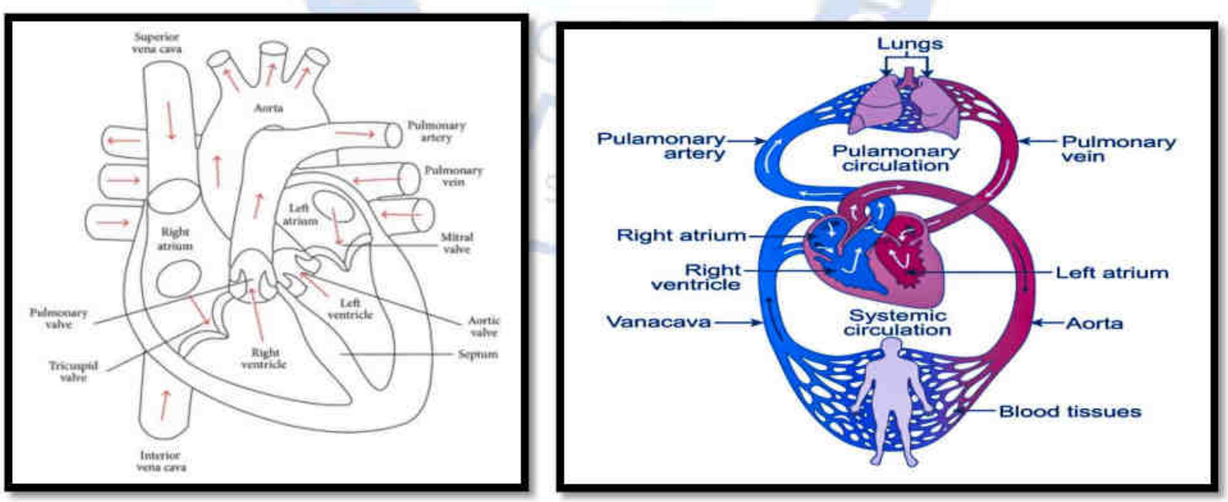


Fig. 8.11 Schematic representation of Transport and Exchange of Oxygen and Carbon-dioxide in Heart

Working Of Heart

1. Oxygen rich blood from the lungs comes to thin walled upper chamber of the heart on the left side called left atrium.
2. The left atrium relaxes when it collects the blood.
3. When the sufficient blood pumps, it contracts and the left ventricle expand so that blood is transferred to it.
4. When muscular left ventricle contracts the blood is pumped out of the body through aorta.
5. Deoxygenated blood comes from the body to the upper chamber on the right, the right atrium.
6. When sufficient blood comes, the right atrium contracts and valves open so, that blood will flow into right ventricle.
7. Valves get closed and right ventricle contracts to pump the blood to the lungs for oxygenation.
8. Thus, there are two circulations in human body as the blood flows twice through the heart it is called double circulation.

Transport of oxygen- The oxygenated and deoxygenated blood are not allowed to mix and this is achieved by the separation of the heart into right side and left side. Such a separation of heart provides a sufficient method of supplying O_2 to the body. This is useful in animals that have high energy needs such as birds and mammals.

Animals need, more energy to maintain their body temperature. Fishes have only 2 chambered heart and blood is pumped to gills (respiratory organ) where it is oxygenated then the blood passes directly to the rest of the body. Thus, in fishes blood goes through the heart only once. This is called single circulation.

Hearts Beat- Rhythmic expansion and contraction of heart is called heartbeat. The expansion is called diastole while contraction is known as systole. The rate of heart beat is 70-72 per minute in adult human male and 80 per minute an adult female. Heart beat is listened with the help of stethoscope. The low pitched sound of longer duration is called lub and a high pitched sound of a shorter duration is called dub.

Blood Pressure- It is the pressure asserted by force full flow of blood on the elastic wall of the arteries. It is measured in millimeter by an instrument called sphygmomanometer.

Normal systolic pressure is 120 mm Hg. While diastolic pressure is 80 mm Hg.

Lymph

1. Lymph is a light-yellow viscous fluid. It is formed from tissue fluid by special lymph capillaries.
2. Lymph does not contain RBCs and blood platelets.
3. Lymph is specialized to collect tissue secretion which cannot pass directly into blood. For example- Hormones.
4. Lymph flows only in one direction from tissue to heart.
5. Lymph is present outside the cells.
6. Lymph is formed inside blind tubes called lymph capillaries.
7. Lymph capillaries joint to from Lymph vessels.
8. At places where lymph vessels are swelling called Lymph nodes. They filter germs and foreign particles.

8.5 TRANSPORTATION IN PLANTS-

Unlike animals some materials pass in and out of plants through diffusion. In case of higher plants there is a vascular system of independent channels or conduction tube called Xylem and Phloem.

There are three aspects of transportation in plants.

1. Movement of gases- CO_2 present in atmosphere by diffusion to internal plant organs and their release back into the atmosphere through stomata present on leaf surface.
2. Movement of water and minerals from soil solution by roots and their upward transportation to other aerial portions of the plant.
3. Movement of food materials synthesis by green leaves to other parts of the plant body.

XYLEM & PHLOEM

8.5.1

XYLEM

1. Xylem is the complex tissue which is used to transport water and minerals.
2. Xylem has four types of cells.
    a. Tracheids
    b. Xylem vessels
    c. Xylem parenchyma
    d. Xylem fibre
3. Tracheids and vessels are called tracheary elements because it takes part in transport of sap (water and minerals).
4. Vessels are long, multi-cellular tubes which are formed by end-to-end union of several cells.
5. Tracheids are elongated cells with pointed ends.
6. Tracheary elements have lignified walls. Xylem parenchyma takes part in flow of water.
7. Vessels are main conducting elements of flowering plants.
8. Tracheids are main conduction elements of gymnosperms and non- flowering plants.

PHLOEM

1. Phloem is a complex tissue which takes part in transport of food.
2. Phloem has four type of cells.
   a. Sieve tube
   b. Companion cells
   c. Phloem parenchyma
   d. Phloem fibre
3. Sieve tubs are elongated multicellular tubular elements formed by end-to-end union of numerous sieve tubes elements.
4. The end walls or septa between adjacent sieve tube elements tube they are called sieve plates. Sieve tube elements do not have any nudes.
5. Their functioning is controlled by adjacent nucleated companion cells.

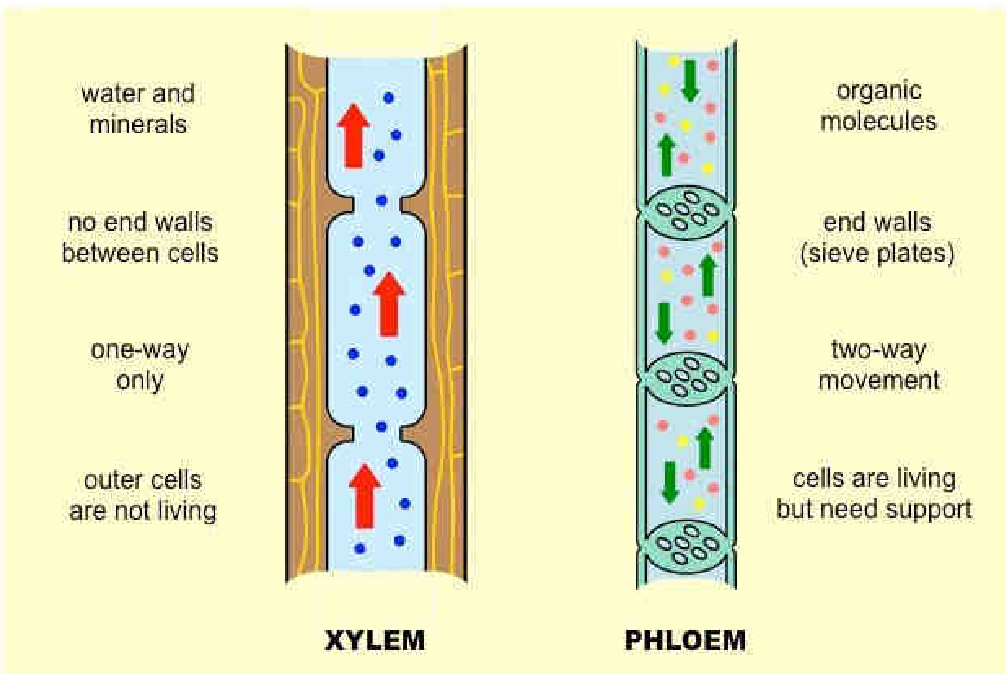


Fig. 8.12 Xylem and Phloem tissues

Absorption of water-Water is absorbed by the hairs in the apical parts of the root. Root hairs increase the surface area of roots many times. Water enters the root hairs through the simple process of diffusion. This water travels through the root tissues called cortex and endodermis and reaches the xylem.

Absorption of minerals-Minerals are absorbed from the soil in the form of ions. These minerals are absorbed by the apical portion of the roots by active absorption. Thus, minerals further diffused through the root tissues and reach the xylem. This solution of water and minerals is called sap. The upward movement of sap occurs through a specialized tissue called tracheids and vessels of Xylem. It is called ascent of sap.

Transportation of water and minerals- The ascent of sap can be explained by transpiration pull theory. According to this theory water continues to transpire through stomata of the leaves drop water from the deeper layers which in turn draw water from the xylem of the leaves. It creates a kind of pull in the leaf's cells called transpiration pull.

The xylem of the leaves is connected to the xylem of the stem and further to the xylem of the root. Since there is continuous column of water in plants, water is lifted up due to transpiration pull.

Transport of food- Food is prepared by the green levees of plants by the process of photosynthesis. This food is distributed to all parts of the plants by a process called translocation of organic food. Translocation takes place through phloem by an active process it takes place by the expenditure of the energy.

Significance of translocation-

1. Translocation of food is necessary because every part of the plant needs food.
2. Food is stored in fruit seed or other parts.
3. Plants hormones & amino acid are also supplied by translocation to the plant parts where they are required.

8.6 EXCRETION

What is Excretion?

Removal of metabolic waste products from the body is called excretion.

Waste products are unwanted and toxic byproducts of metabolism. A number of biochemical reactions take place during the various metabolic activities going on within the body. During these biochemical reactions many useful substances & energies are produced. At the same time some toxic wastes are also produced. It is very much essential that the waste product is removed from the body and proper ionic balance within the body is maintained. This process of removing waste products is excretion. The process of maintaining the right amount of water & proper ionic balance in the body is called osmoregulation.

Excretion in unicellular organism such as amoeba take place by simple diffusion. The specific excretory organs are absent in these organisms. Fresh unicellular forms also possess and osmoregulatory organ called contractile vacuole. Contractile vacuole collects water & waste product from the cell, it swells up, reach the surface and burst to release its contents to the outside.

8.7 EXCRETION IN HUMAN BEINGS-

Human excretory system consists of the following organs.

a. A pair of kidneys
b. Ureter
c. Urinary bladder
d. Urethra

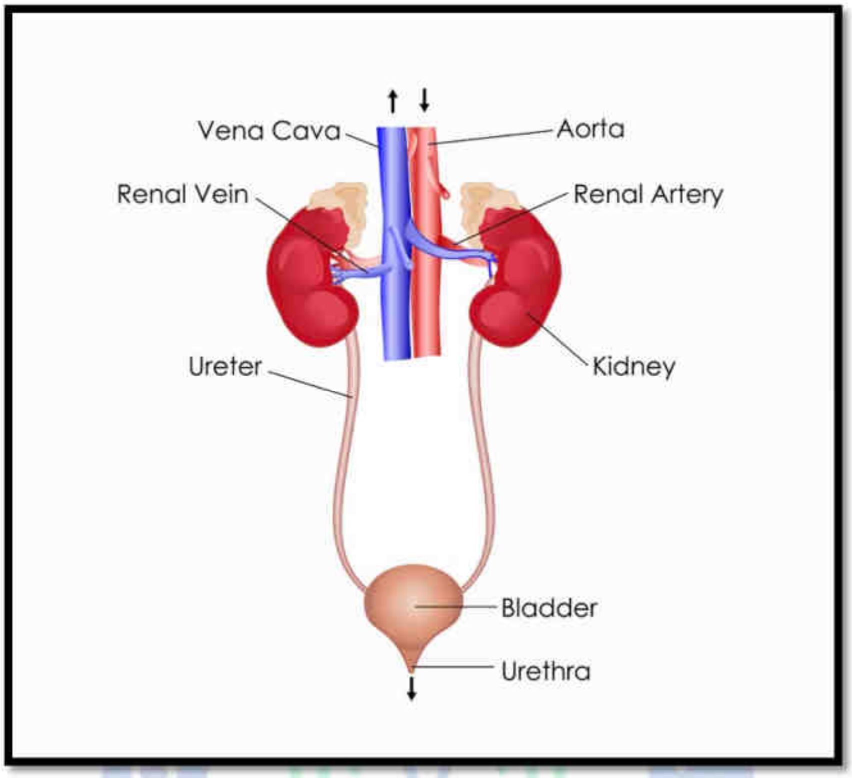


Fig. 8.13 Excretory System in Human Beings

Kidney

Kidneys are bean shaped structure they are located just above the waste on either side of the back bone. The right kidney is placed just above the left kidney.

Structure of kidney-A kidney shows a dark colour outer zone called cortex and a pale yellow coloured inner zone, the medulla. Each kidney is made up of large number of excretory units called nephrons.

Each nephron consists of two parts-

a. Abounded cup shaped body called bowman’s capsule.

b. The tubule called collecting tubule.

Bowman's capsule is present in the cortex whereas the medulla consists of the tubular part. The Bowman's capsule contains a bunch of finely divided and intertwined blood capillaries which are formed by the repeated branching of the renal artery. These structures are called glomeruli. The blood capillaries bring waste and excess water from the body to the kindly. The tubular part is highly coiled. The collecting tubules of many nephrons joint and collects urine from the nephrons & transport it in the medulla of the kidney.

Ureters-It is a narrow tube which runs from the inner side of the kidney. it carries urine from kidney to the urinary bladder**.**

Urinary bladder-The ureters are connected to a large sac called urinary bladder. Urine is collected and stored in the urinary bladder**.**

Urethra-it is a tube which, takes urine from urinary bladder. It is 4 cm long in female and about 20 cm long in male. Its opening is separates in females but is common with reproductive tract in male.

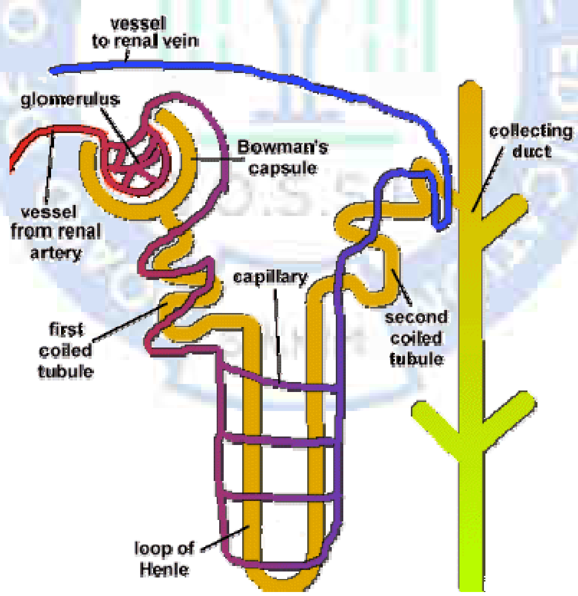


Fig. 8.14 Structure of a Nephron

8.7.1 Formation of urine-The blood carrying the waste material like urea is brought by renal artery to the glomerulus where the blood is filtered. From the glomerulus the filtrate enters into the bowman's capsule. As the filtrate passes through the tubular part of nephrons, useful products such as glucose, amino acids, salts are reabsorbed through the blood capillaries surrounding the tubules. The liquid left behind in the tubules is urine. Urine contains water and nitrogenous substances that is urea. The collecting duct of the kidney passes urine to the ureter and ureter passes it into the urinary bladder where it is stored for some time ultimately it is passed out of the body through urethra when the pressure of the expanded bladder urges us to urinate.

8.7.2 Excretion in plants-Plants use completely different strategies for excretion than those of animals. Oxygen itself can be thought of as a waste product generated due to photosynthesis. Plants get rid of excess water by transpiration for other waste plants use the dead cells of tissue from some plant parts such as leaves which have to be fallen off. Many waste products are stored in the cell vacuoles or as gums and resins. Plants also excrete some waste substances into the soil around them.

CHECK YOUR PROGRESS 8.7

1. Name the organ of the excretory system, which stores urine before its removal from the body.
2. Draw a rough diagram of the nephron and label only the part where filtration occurs?
3. What happens to be useful substances that move into the glomerulus along with nitrogenous waste?

ACTIVITY 1

Food Adulteration

Take any five food items present in your house e.g. pulses, rice, channa, black pepper, wheat, coriander seed etc. look for the various adulterants (if any) present in each of the five food items. Now state whether these adulterants are edible or inedible. Record your observations in a tabular form.

ACTIVITY 2

Locate and hold the radial artery present in your wrist. Try and count the number of beats in a specified time. It is called ‘pulse’ and will give you an idea of the number of times your heart beats in a minute.

ACTIVITY 3

Visit the local medical centre and get your pulse rate and blood pressure checked and also that of your family members. Do you find any difference in blood pressure and pulse rate of your family members?

ACTIVITY 4

Check your breathing rate at rest. Now run for 5 minutes or climb 15 stairs and then check breathing rate. Do you find any difference? You will observe that you start panting and your rate of breathing increases as you run or climb the stairs.

RECAPITULATION POINTS

- Nutrition is a process by which living beings procure food or synthesize it and change it into simple absorbable form by series of biochemical processes in the body.
- The photosynthesis provides food for all. It is the ultimate source of energy for all living organisms. It is essential for sustaining life.
- A balanced diet contains adequate amount of essential nutrients such as carbohydrates, fats, proteins, vitamins, minerals and water. The amount of these nutrients in diet depends upon a number of factors, such as age, sex and nature of work an individual performs.
- Conversion of complex food material into smaller substances so that it can be absorbed by the cells is called digestion. The digestive system enables conversion of ingested food into its simpler form. The process of digestion. requires a number of enzymes.
- The absorption of food occurs mainly in the small intestine. The simple soluble food molecules are absorbed from the small intestine into the blood which takes them to all the cells of the body.
- A disease that occurs due to lack of adequate and balanced diet is called deficiency disease. Deficiency diseases caused due to malnutrition are of three types: protein energy malnutrition (marasmus and kwashiorkor); mineral deficiency diseases (goitre and anaemia); and vitamin deficiency diseases (xerophthalmia, rickets, beri-beri, pellagra).

- The distribution of food and oxygen to all parts of the body as well as the removal of body wastes is performed by a transport system within the body of all living organisms.

- Heart in humans is four-chambered, two upper chambers are called atria and lower chambers are ventricles. Heart is made of cardiac muscle fibres.

- Every human being belongs to one of four blood groups: A, B, AB and O. Blood transfusion can be between matching blood groups. The persons with blood group O can donate blood to all and 'O' group is called universal donor and AB group can receive blood from all and is called universal recipient.

- Breathing is the physical process of respiratory gaseous exchange between the organism and the environment by diffusion. On the other hand, respiration involves oxidation of food and release of energy along with respiratory gaseous exchange.

- In human beings, excretion is carried out by an organ system known as the urinary system or the excretory system.

- A nephron is the structural and functional unit of the kidney.

TERMINAL EXERCISE

1. Choose the correct answers:

i. Rickets is caused due to deficiency of:

a) Iron

b) Vitamin D

c) Proteins

d) starch

(ii) One gram of a substance was oxidized. The energy released amounted to 9.0Kcal. what was the type of substance?

a) Carbohydrates

b) Fats

c) Vitamins.

d) Proteins

iii. A person living in the hilly regions of Shimla developed swelling in his neck region. The doctor said his thyroid gland got swelled up. Name the nutrient deficient in his diet.

a) Calcium

b) Iron

c) Phosphorus

d) Iodine

iv. The vitamin that helps in the clotting of blood is:

a) Vitamin A

b) Vitamin D

c) Vitamin E

d) Vitamin K

(v) In human beings, gas exchange between the environment and the body takes place in the:

a) larynx

b) bronchi

c) alveoli

d) trachea

(vi) RBCs of human beings who live in high altitude regions:

a) increase in number

b) decrease in number

c) decrease in size

d) increase in size.

vii. Lungs have a large number of alveoli for

a) maintaining a spongy texture and proper shape.

b) more surface area for diffusion of gases.

c) more nerve supplies.

d) more space to increase volume of inspired air.

viii. The main function of lymph is to:

a) transport O, to the brain.

b) transport CO, to lungs.

(c) return interstitial fluid to blood.

(d) return RBCs and WBCs to lymph vessels.

2. Name the following.

(i) A fluid that transports fatty acid and glycerol.

(ii) The valve present in between the chambers on the right side of the human heart.

iii. The respiratory pigment present in RBCs.

iv. The iron containing pigment in RBCs.

v. The phase of cardiac cycle in which the auricles contract.

3. Give one point of difference between the following.

(a) Autotrophic and heterotrophic nutrition

(b) Breathing and respiration

(c) Arteries and veins.

(d) Blood and lymph

(e) Auricular systole and ventricular systole

4. Match the columns A and B.

COLUMN A	COLUMN B
1. Sponge-like organs located in the chest cavity	a. trachea
2. Chamber acting as a common passage for food and air	b. bronchioles
3. Elastic tissue that forms a flap over the top of the larynx	c. epiglottis
4. Main passageway to the lungs	d. pharynx
5. Small tubes that branch from the bronchi	e. bronchi
6. Small air sacs in the lungs	f. lungs
	g. alveoli
	h. larynx

5. Given below is an example of a certain structure and its function.

"Kidney and excretion'

Fill in the blanks on a similar pattern.

(a) Alveoli and……………………………………

(b) Diaphragm and…………………………………………..

(c) C-shaped cartilage rings and…………………………….

(d) Erythrocyte and…………………………………….

(e) Left ventricle and…………………………………..

(f) Pacemaker and………………………………………….

6. Answer the following questions:

a) What is a balanced diet? Name three items of a diet that provide three different nutrients?

b) What are the main steps of photosynthesis? Is sunlight essential for photosynthesis and why?

c) A patient complains of lack of appetite, exhaustion and is losing weight. Diagnose the deficiency. What kind of diet would you suggest for the patient?

d) Deficiency of which vitamin causes night blindness. What should be taken to prevent this deficiency?

e) Where does the digestion of starch, proteins and fats take place and what is the role played in digestion by liver and pancreas?

f) Which component in our diet will not be digested if the enzyme lipase is not secreted?

g) Explain how oxygen leaves the blood from the tissue capillaries and carbon dioxide enters the blood in the tissue capillaries.

h) Explain the usefulness of large surface area provided by alveoli for respiration in human beings.

i) Why do arteries have a thick or elastic wall?

j) What are the types of blood groups present in humans? Prepare a table having two columns to show the different human blood groups and names of compatible blood groups in the other column.

ANSWER TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 8.1

1.Algae and green plants. We call them autotroph because they can produce its food by using light, water, carbon dioxide or other chemicals. they are also called producers.

2.We call them producers because they can produce its food by using light, water, carbon dioxide or other chemicals.

3.Digestion, absorption and assimilation of food.

` 4. Parasites - Leech and Head louse

Saprophytes - Yeast and mushroom

CHECK YOUR PROGRESS 8.2

1. **Photosynthesis:** the process by which green plants turn carbon dioxide and water into food using energy from sunlight.
2. Chlorophyll gives plants their green color because it does not absorb the green wavelengths of white light. That particular light wavelength is reflected from the plant, so it appears green. Plants that was photosynthesis to make their own food are called autotrophs.
3. Glucose is formed as a result of photosynthesis and starch Is the form in which food is stored.
4. Stomata allow a plant to take in carbon dioxide, which is needed for photosynthesis. By closing when conditions are hot or dry. Stomata look like tiny mouths which open and close as they assist in transpiration.

CHECK YOUR PROGRESS 8.3

1. Raw vegetables and fruits or Roughage, or fiber, has long been recommended to help with digestive issues like constipation, but it also plays many other important roles in your body. For example, the roughage in plant foods can promote optimal gut health, help you manage your weight, and even reduce your risk of heart disease.
2. I will get more energy.
3. Vitamin A and D are fat soluble while B and C are water soluble.

CHECK YOUR PROGRESS 8.4

1. Pepsin
2. Peristalsis
3. Duodenum.
4. Trypsin, lipase and amylase.
5. Hydrochloric acid

CHECK YOUR PROGRESS 8.5

1. Because of the presence of c-shaped cartilage rings on trachea.
2. Nostril------nasal cavities - pharynx

   $\downarrow$

   Lungs ------bronchi-------- trachea
3. When the pressure in lungs is higher than the pressure around us we are able to breathe in and uf the pressure around us exceeds, than we can easily breathe out the air.
4. Mitochondria
5. For gaseous exchange.

CHECK YOUR PROGRESS 8.6

1. A. Red Blood Cells
   B. White blood cells
2. Blood group O positive which can be given to anyone.
3. Hemoglobin. Its role is transport of oxygen.
4. Both of them circulate within vessel.

CHECK YOUR PROGRESS 8.7

1. Urinary bladder
2. Figure from the text.

3.When blood moves through glomerulus, almost the whole blood is filtered except blood plasma

SUPPLEMENTARY STUDY MATERIAL

i. NCERT- Class X Science
ii. ICSE- Concise Biology Part-II H.S. Vishnoi, Selina Publishers, N. Delhi
iii. https://ncert.nic.in
iv. https://www.learncbse.in
v. https://www.nios.ac.in

9 CONTROL AND COORDINATION

INTRODUCTION

Observe our body regularly, but few of us are able to appreciate what a well harmonized machine it is! When we eat food, digestive juices are secreted, but these are secreted only when there is some food in the food canal and so long as the food has to be digested. Our muscles move only when stimulated. Our body temperature remains constant even when outside temperature fluctuates. These actions need to be properly timed and coordinated. Can you tell how various organs perform their functions together accurately at the right time? How does the right physiological activity occur at the exact moment? Do you know which organs are responsible for our thoughts, feelings, emotions and behaviour? We shall try to get answers to some such questions in this lesson.

9.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Explain the role of nervous system and hormonal system in control and coordination of various activities of the body;
- Recognize major components of the nervous system and enlist their functions, emphasizing their role in informed decision making;
- Explain the role of nerve cells (neuron) in the transmission of nerve impulses;
- Identify the location and explain the functions of spinal cord in evoking a reflex action;
- Analyze the role of some of the endocrine glands in regulating our growth and behavior; and
- Appreciate the role and relevance of reflex, voluntary and involuntary actions as well as hormones in efficient functioning of the human body.

9.2 ANIMALS-NERVOUS SYSTEM

We know that our body performs various life processes for its survival. To control and coordinates all the movements of the body related to the life processes, there is a separate system working in the body called **Nervous system**. It also controls the function of stimuli.

Stimulus is defined as any change in the environment (external or internal) of an organism which brings about a response from it. For example, when we touch a hot plate, we quickly pull our hand away.

Response: It arises due to stimuli. Reactions to the environmental changes (stimuli) are called in response.

The control and coordination in the body of an animal can be categorized in to two categories, i.e. **chemical** and **nervous**. Plants do not have a nervous system. They consist only chemical type of control and coordination.

Nervous system in an animal involves nervous organs, nerves and neurons. They form a network throughout the body for conducting information via electric impulses to control and coordinate all the activities of various body parts.

Divisions of nervous systems-

a. Central Nervous System: Brain and Spinal Cord
b. Peripheral Nervous System:
    i. Somatic Nervous System: Cranial and spinal nerves.
    ii. Automatic Nervous System: Sympathetic and Para-sympathetic.

CHECK YOUR PROGRESS 9.1

1. Can you think of real-life example, when team work helped you to achieve something that you could not have done by yourself? Please write about this incidence in 3-5 sentences.

2. Give one example of coordination of a process taking place in our body which is brought about by both the nervous system and hormonal system.

9.2.1 Nerve Cell (Neuron)

Structurally and functionally, neurons are the most complicated cells in vertebrates. It ranges in measurement according to body size, from 0.1 mm to several meters in length. In human nervous system, about 100 billion neurons are found. Majority of the neurons occur in the brain. Neuron consists of

(i) a nerve cell body or soma and
(ii) two types of processes-axons and dendrite.

Structures of cell body

It is also called as **neurocyton**. The following structures are found in the cell body:

1. Nucleus: It is commonly large, spherical or slightly ovoid and centrally placed. It varies in size of the cell. The neuroplasm or cytoplasmic matrix of the neuron cell contains filamentous, membranous and granular organelles which are arranged more or less concentrically around the nucleus. With a light microscope these organelles are neurofibrils, Nissl bodies or chromophilic substance, Golgi complex, mitochondria and a centrosome.

2. **Cell processes:** These are axons and dendrons. Axon is the process of a nerve cell body that carries impulse away from it. While dendrite or Dendron carry impulses towards the cell body.

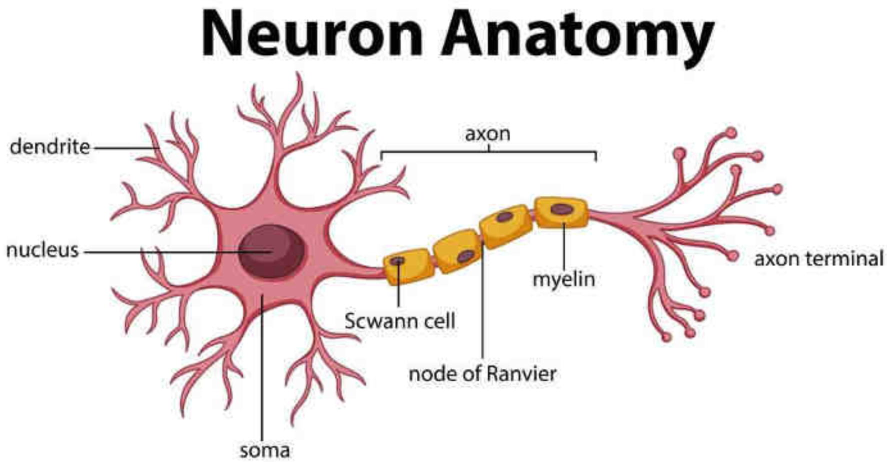


Fig. 9.1 Neuron Anatomy

CHECK YOUR PROGRESS 9.2

I. Choose the correct answer:

1. The structural and functional unit of nervous system is (encircle the correct alternative of the following)

(a) Nephron

(b) Neuron

(c) Synapse

(d) Axon

2. Consider that you are passing by a garbage disposal area and you immediately cover your nose. Arrange the events below in a logical order by a marking them from 1 to 5 to trace the events that happen in the nervous system from detection of foul smell (stimulus generation) to covering your nose (response).

(a) At the end of the axon, electrical impulse releases chemicals

(b) Stimulus received on the dendritic cells of a neuron sets off chemical reaction

that creates an electrical impulse.

(c) Electrical impulse transmitted through cell body and axon

(d) The chemicals cross the synapse and reach the next neuron. Similarly, the electrical impulse crosses several neurons.

(e) Finally, the impulse is delivered from neuron to the gland that helps in

recognition of the foul smell and muscle cells that help in covering the nose

B. Spinal cord

The spinal cord lies in neural canal of vertebrae and encloses a cavity know as central canal (neurocoel). The spinal cord is divided in two distinct halves by dorsal septum and ventral fissure. The outer region is called as white matter and the inner as grey matter. The gray matter is dorsally produced into dorsal horns and ventrally into two ventral horns. The dorsal horn extends to form dorsal roots ganglia which consist of monopolar neurons. The ventral horn extends in the form of ventral roots.

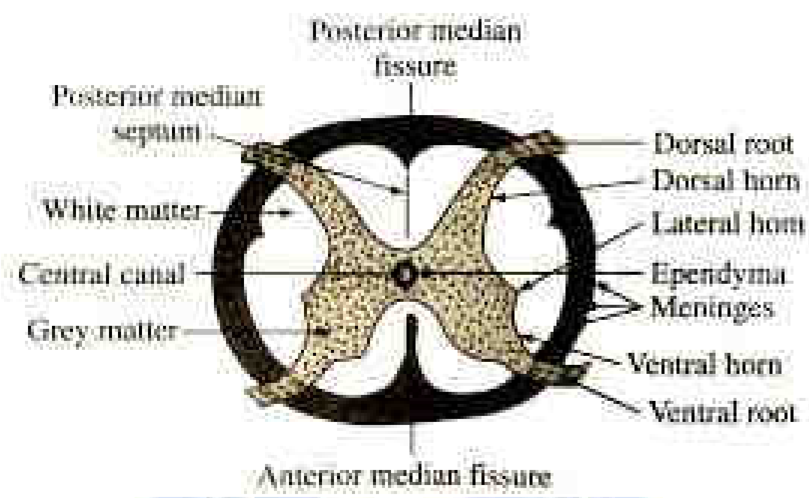


Fig.9.2 Spinal Cord

Function: it provides pathway to sensory impulses towards the brain and away from it. It coordinates and controls those reflex responses that occur without the brain. The reflex responses that occur through the reflex arc formed by the five members namely receptors, sensory roots, grey matter, ventral roots and the effectors. The reflex actions include eyelid closure, knee jerks, elbow jerks, sneezing, coughing, yawing, swallowing of the food and so on, the conditioned reflex action are those which occur due to habitual repetition of certain acts.

Nerves: These are of two kinds, i.e. **cranial and spinal**.

(a) The cranial nerves originate from the brain. There are 12 pairs of a cranial begins. Some nerves are purely sensory, a few are purely motor (action performing) and rest are mixed.

(b) The spinal nerves originate from the spinal cord. There are 10 pairs of spinal nerves in frog; 31 pairs in man and 37 pairs in rabbit. All the spinal nerves are of mixed type, i.e. partly sensory and partly motors.

CHECK YOUR PROGRESS 9.3

I. Fill in the blanks

(i) The central nervous system consists of ……………. and …………

(ii) The two functions of the cerebrum are …………… and ………………….

(iii) The major function of cerebellum is to maintain ……………. of the body.

(iv) The ………………… part of brain controls the activity of all internal organs of the body.

(v) The outer and inner region of the cerebrum are composed of ……………… and ……………… matter respectively.

9.2.3 REFLEX ACTION

The quick responses given immediately in response to some stimuli are called as reflex actions. For ex: flushing of tear, shivering, dilation of eye pupil, non-stop beating of heart. In these acts brain is not consulted. The reflex actions are quick, fast and show up immediately. They follow the route called reflex arc for quick response in the following manner:

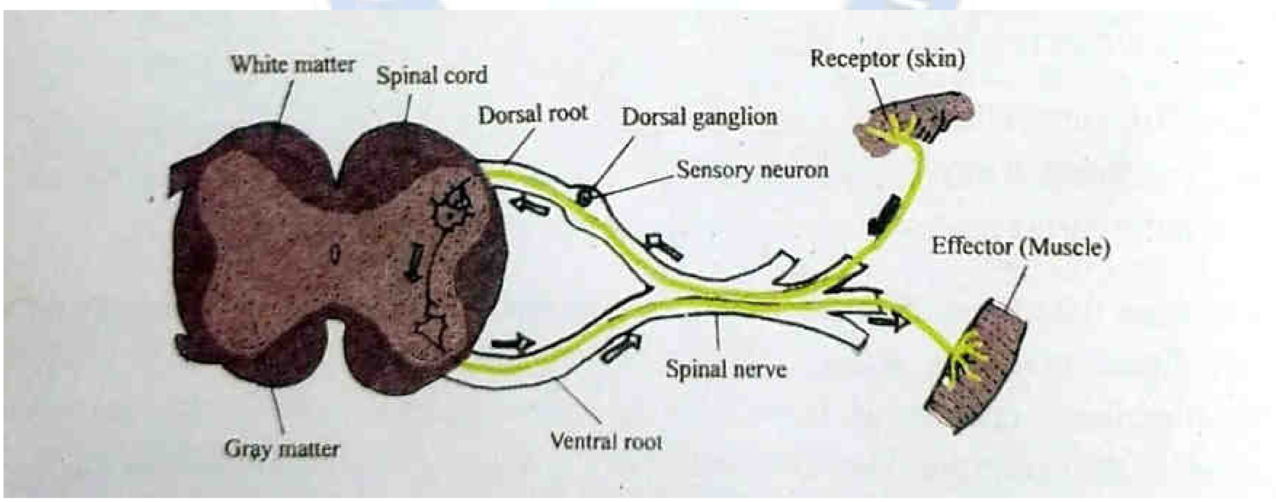


Fig. 9.3 Reflex Action

9.2.4 Human Brain

It is soft whitish large sized and slightly flattened structure present inside cavity of the cranium. In human beings it is about 1200-1400 gm in weight and forms about 98%of weight of Central Nervous System. It is the busiest organ in the body.

Brain is distinguishable into three parts:

1. Fore brain (Pros encephalon)
2. Mid brain (Mesencephalon)
3. Hind brain (Rhomb encephalon)

1. Fore brain

It is divided into following parts:

(a) **Olfactory lobe (Rhinencephalon):** They are well developed in animals with strong seat of smell. The first pair of cranial nerves originates from this part of the brain.

(b) **Cerebrum:** Cerebrum is divided into two cerebral hemispheres. It is undivided in fishes but amphibians there appears a longitudinal fissure in between, dividing into two hemispheres. These two hemispheres are joined by some special neurons called as corpus callosum. These hemispheres are not a flattened structure. Some convolutions (gyrus) and depressions (sulcus) are found on these hemispheres. They increase the surface area of cerebrum. The cerebrum is the seat of intelligence, memory, speech and voluntary muscular movement.

(c) **Diencephalon:** This part of forebrain is completely covered by cerebral hemispheres. It forms less than 1% of the brain volume. It is made up two parts i.e., thalami and hypothalamus. The root is epithalamus which modified into an endocrine gland known as the master gland, the pituitary.

2. Mid brain

The brain comprises two optics lobe which vary in structure and function in lower vertebrates and mammals.

3. Hind brain

The hind brain (rhomb encephalon) is distinguishable into the following parts:

(a) **Cerebellum**: It is formed of two cerebellar hemispheres with outer grey matter and inner white matter. The grey matter and white matter are highly branched forming a structure called as tree of life or arborvitae. Gyri and sulci are present on the root of cerebellar hemispheres.

(b) **Medulla oblongata**: It is a vital part of the brain. All the reflex centers are located in the medulla oblongata such as sneezing, coughing, yawning, etc. The chemical and respiratory centers are also located in this part.

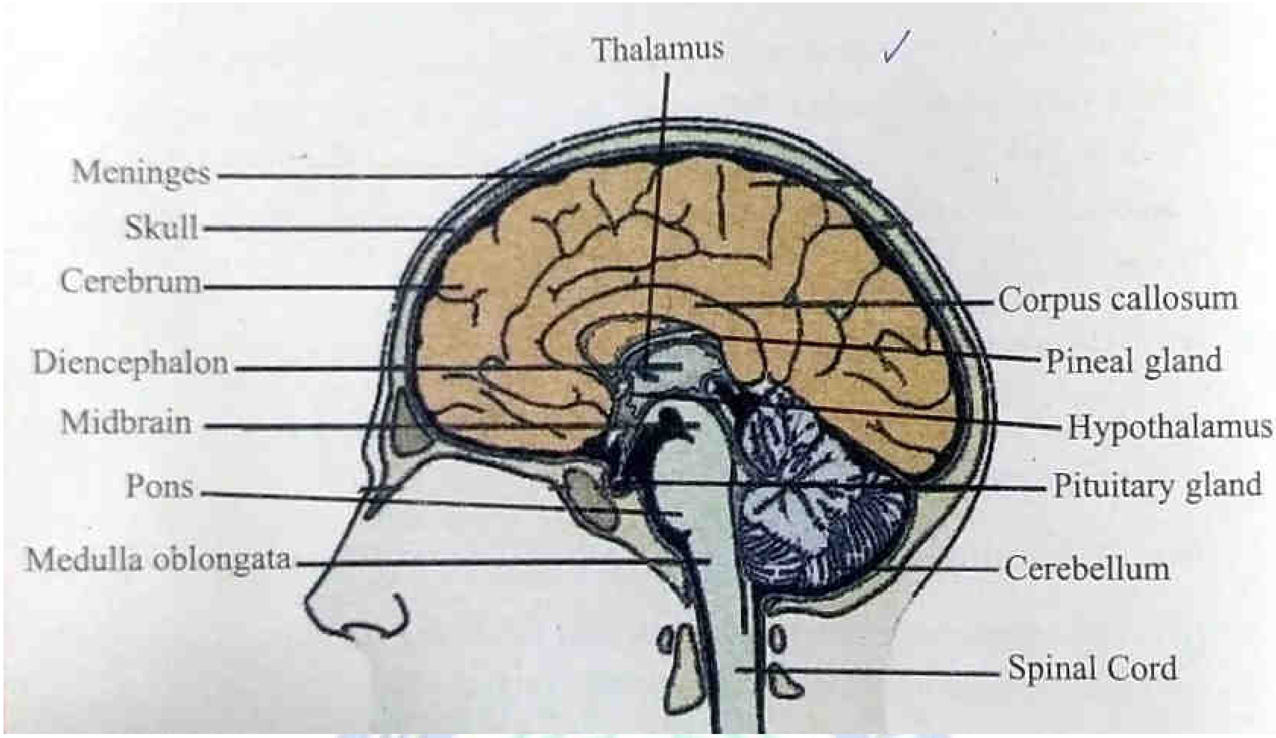


Fig. 9.4 Structure of Brain

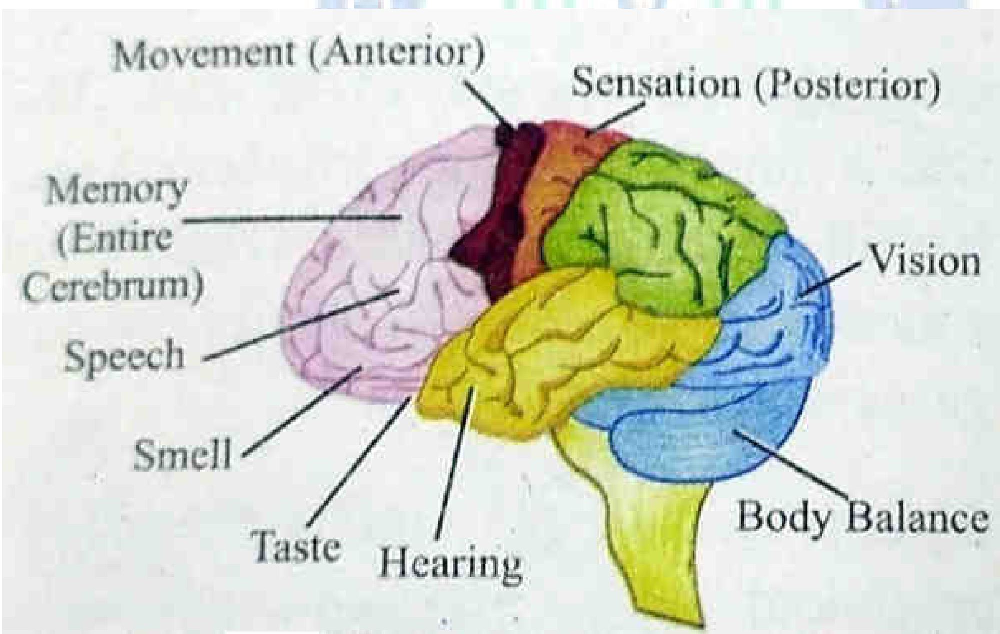


Fig. 9.5 Functions of different parts of brain

CHECK YOUR PROGRESS 9.4

1. Name the two types of reflexes.

2. Given below are the different components of the reflex are in a haphazard manner. Arrange them in the correct order in the space provided below.

Sensory neuron, Effector, Stimulus, CNS, Receptor, Response, Motor neuron.

3. Now that you are aware of the well thought out voluntary actions that are coordinated by the cerebrum of immediate response actions or reflex actions, coordinated by the spinal cord, try to identify whether the following situations may be best managed by well-thought out voluntary actions or quick response reflex actions. Please provide at least one reason for your choice.

Situation	**Appropriate action voluntary action or reflex**	**Reason for your choice**
You need to immediately stop your bicycle as a speeding motorbike comes in front of your bicycle.		
You have scored good marks in all the subjects in class X and now need to choose between science and commerce stream.		
Your family feels you should study science while you like numbers and would like to study commerce.		
You are cleaning your cupboard, a sharp needle pokes you and you remove your hand immediately.		
You have moved to a new neighborhood and are trying to make new friends.		

9.3 COORDINATION IN PLANTS

Animals have nervous system for controlling activities in the body but plants do not have nerves and muscles. Still, they show movements which are well coordinated and controlled .in plants, movement or changes in position are of two types:

1. Movement of locomotion
2. Movement of curvature

Curvature movements are changes in orientation of plant part in relation to others like bending, twisting and elongation. It is common in plants because they are fixed.

Movement of locomotion are changes in position of whole organism or cellular components.

The agent or factor which causes movement is called stimulus. The reaction of plant to stimulus is called response. The part of plant which shows response is called responsive region.

Movement of locomotion:

These are of two types- *autonomic and paratonic*

1. **Autonomic or spontaneous movements of locomotion**: they occur automatically due to intrinsic regions. Such as flagellar movements in unicellular algae like Chlamydomonas.

2. **Paratonic or tactic movements of locomotion**: they are locomotory movement in response to external stimuli.

I. **Chemotaxis**: it is locomotory movement in response to chemicals. For example, spermatozoids (motile male gametes) towards archegonia (female sex organs in mosses, ferns and most conifers).

II. **Phototaxis:** it is locomotory movement in response to light, for example, chloroplasts in different intensities of light inside palisade cells.

Movement of curvature: they are movement of plant parts in relation to others-

1. Turgor movements
2. Growth movements

The stimulus of touch or shock received by any part of the leaf is converted into electrochemical potential or a chemical called turgor in. The chemical travels at the rate of 20cm/ sec and reaches at the bases of pinnules, pinnae and petiole where thin-walled cells occur. As the impulse or chemical reaches here, the thin-walled cells eject K+ ions and then water. They shrink in size resulting in folding and drooping movements. The leaf recovers after 10 min.

CHECK YOUR PROGRESS 9.5

1. How many pairs of cranial nerves are present in our body?

2. Name the two parts of autonomic nervous system.

9.3.1 Plant Movements Due to Growth:

These are of two types- autonomic and paratonic

a. **Autonomic movement of growth**:

They are shown by apical regions of stems and tendrils. The movements are called mutations.

While growing the apices of these organs bend in different directions resulting in their rotation. It helps the climbing stem and tendrils to find support for climbing.

b. **Paratonic movement of growth**:

They are growth movement s in response to an external stimulus. Paratonic movements of growth are of two types-

Nastic movements: movements which depends on growth of plant is called nastic movement.

Tropic movements: Movement which is independent of growth is called tropic movement.

Nastic movements of growth: they are nondirectional movements of growth that are determined by the structure of the responding organ irrespective of the direction of stimulus which is generally diffuse. Greater growth on one side causes the organ to bend to the opposite side.

Tropic movements of growth: they are paratonic growth movements of curvature in which direction of movement is determined by the direction of stimulus. Tropic movements generally occur in cylindrical organs like stem and roots. The important tropic movements are phototropism geotropism, hydrotropism, thigmotropism and chemotropism.

i. **Phototropism**: movement of a plant of its part in response to light is called phototropism. Shoots generally grow towards light and are said to be positively, phototropic while roots grow away from light and are said to be negatively phototropic.

ii. **Geotropism:** it is the directional growth movement of curvature in response to force of gravity. The upward growth of shoot against gravity represents negative geotropism while the downward growth of roots towards gravitational force shows positive geotropism.

iii. **Hydrotropism:** it is directional growth of curvature in response to water. Roots are positively hydrotropic and shoot is negatively hydrotropic.

iv. **Chemotropism**: movement of plant in response to chemical stimulus is called chemotropism. For example, growth of pollen tube towards ovules.

v. **Thigmotropism**: it is directional growth movement of curvature in response to contact stimulus. Twiners and tendrils show thigmotropism.

9.3.2 PLANT HORMONAL SYSTEM (Growth Regulators)

The plant growth regulators are organic compounds other than nutrients which promote, inhibit or modify growth. Some important growth regulators are discussed here under:

a) Auxins

There are the growth hormones of plants influencing shoot elongation and other physiological activities such as leaf fall, development of fruits etc. IAA is the main natural auxin. The auxins are synthesized mainly in the shoot apex. Besides IAA, a large number of synthetic auxins are presently being used in agriculture, e.g. Indol butyric acid (IBA), Naphthalene acetic acid (NAA), 2-4 dichlorophenoxy acetic acid (2-4 D) etc.

The auxins perform several roles in plants:

1. **Cell elongation**: They induce cell elongation.

2. **Apical dominance**: In higher plants the apical bud is far more active than the lateral buds. For certain period, the growth of the lateral buds is suppressed. This phenomenon is called as **apical dominance** or **bud inhibition**. This property of auxin is used in prolonging the dormancy period of potato tubers.

3. **Parthenocarpy**: When ovary is converted into fruit without the act of fertilization, the phenomenon is called as parthenocarpy. By applying auxins on the stigma, the ovary is converted into fruit without fertilization.

4. **Abscission**: An abscission layer is formed at the base of the leaf or fruit at maturity. This layer is delimited by a separation layer on the organ side and a protection layer on the stem side. External spray of auxins prevents premature abscission.

5. **Root initiation:** The auxins induce rooting in stem cutting. Application of IAA in low concentration at the cut end of stem induces formation of adventitious roots. By this process we can produce numerous plantlets of the mother plant. Thus, this property of auxins is of great economic value.

6. **Respiration:** The auxins stimulate respiration most probably by increasing availability of respiratory substance.

7. **Metabolism:** Application of auxins has been found to enhance metabolism due to mobilization of plants metabolites, thus increasing storage of solutes inside the cells.

8. **Cambial activity**: The degree of cambial activity is directly proportional to auxin concentration. The auxins promote cell division activity there.

9. **Tissue Culture**: In tissue culture, the development of callus, i.e. mass of undifferentiated cells is promoted by auxins. Differentiation of callus occurs in the presence of both auxins and cytokinins.

10. **Weedicides:** There are chemicals which kills weeds growing in the fields. 2, 4D is a well-known weedicide. However, only dicot weeds can be killed form a monocot crop field.

b) GIBBEERELLINS

The gibberellins are acidic growth hormones first isolated form a fungus *Gibberella*. They induce the following growth activities:

(1) **Stem elongation**: They cause stem elongation and leaf expansion, but have no effect on root. When the genetically dwarf cabbage plant was treated with gibberellin, it became vine like.

(2) **Seed Germination**: The gibberellins promote seed germination.

(3) **Leaf expansion**: The leaves of plants like pea, bean, tomato, cabbage etc., on treatment with gibberellins become broader.

(4) **Breaking of dormancy**: The gibberellins break the dormancy of buds and tubers but in sweet potato their application inhibits the development of root tubers.

(5) **Parthenocarpy**: When applied on stigma, they induce parthenocarpy in apple and pear.

(6) **Increasing fruit size**: In specific cases their application increases the fruit size.

(7) **Flowering:** The application of gibberellins in long day plants under unfavourable short-day condition induces flowering.

(8) **Sex expression**: The gibberellins promote maleness in flowers.

c) CYTOKININS

These are the compounds that cause call division activity in plants. This activity of cytokinins increases in presence of auxins. Miller and others (1954) isolated the first cytokinin form a fish sperm. The hormones were identified as 6 – furfuryl amino purine. It is a degradation of DNA. A naturally occurring cytokinin in plants named Zeatin was isolated from maize. The cytokinins are found in all types of plants including fungi and bacteria. They influence the following growth activities:

1. They promote cell division and cell elongation.

2. They also promote the growth of lateral buds by neutralizing the effect of auxins which causes apical dominance.

3. The cytokinins cause differentiation of tissues.

4. The dormancy of seeds can by broken by the action of cytokinins.

5. They delay the degradation of proteins and chlorophyll thereby delaying senescence (death).

d) ETHYLENE

It is synthesized in the plants from amino acid methionine. Ethylene produces effect on the growth of vegetative and reproductive parts of the plants. It is associated with fruit ripening; leaf drop and senescence. It is the only gaseous plant growth regulator. High concentration of auxin induces ethylene formation. Some of the actions of ethylene are as follows:

1. **Growth Inhibition:** It modifies growth by inhibiting stem elongation and causes swelling of nodes. But is causes leaf expansion.
2. **Flowering:** It induces flowering in pineapples, but it causes discolourations of petals after fertilization.
3. **Germination:** It stimulates seed germination in some plants.
4. **Fruit Ripening:** It induces the ripening of fruits. Unripe fruit can be made to ripe if they are placed in ethylene atmosphere.
5. **Abscission:** It accelerates abscission of leaves, by promoting enzyme activity.

e) ABSCISIC ACID (ABA)

It is a growth inhibitor which retards or suppresses growth. It has been isolated from several parts of higher plants including dormant buds and seeds.

Many of the activities of ABS are reverse of gibberellic acid and hence it is also called as anti-gibberellin. It may inhibit the synthesis of other growth hormones, RNA and protein synthesis.

1. It causes ageing and abscission of leaves.
2. ABA is a growth inhibitor. It prolongs dormancy in seeds. But dormancy is regulated by balance of ABA and cytokinin.
3. It helps the plants of cope up with adverse environmental conditions (**stress hormone**)
4. It causes temporary closure of stomata i.e., it functions as anti-transpirant.
5. It inhibits seed germination and accelerates senescence of leaves.

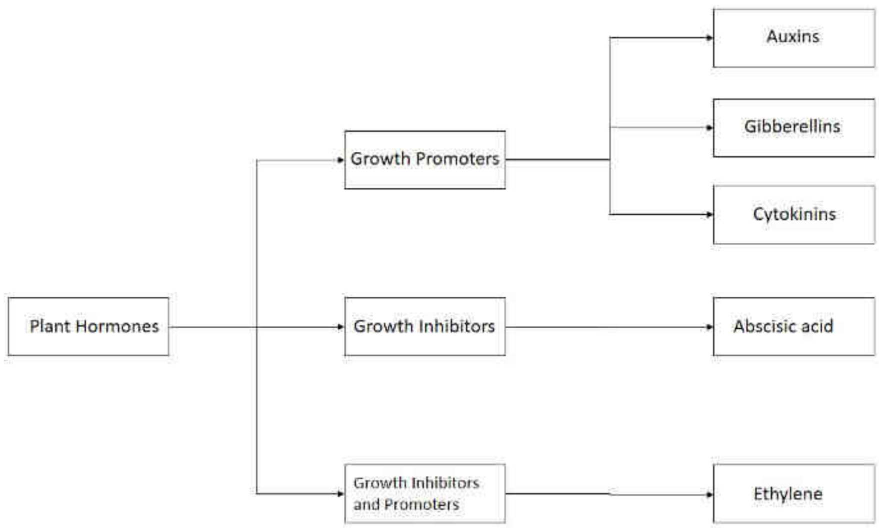


Fig. 9.6 Plant Hormones

9.4 HUMAN HORMONAL SYSTEM (ENDOCRINE GLANDS)

We already know about some glands, like salivary glands of the mouth and the gastric glands of the stomach. They all pour secretions into the digestive tract through ducts. We call these glands as **exocrine glands**. Here, we shall study the ductless glands. They are quite different from the digestive glands. The term ductless indicates that they have no ducts. Instead, their secretions go directly into the blood stream. The blood transports these secretions to all parts of the body and they influence all the organs. **Ductless glands are called endocrine glands**.

The secretions of ductless glands are called as **hormone**. These secretions are formed from substances the glands take from the blood**. Hormones regulate the activities of all the body processes**. The circulatory system is vital to the endocrine system. It supplies the raw materials and transports the finished product. Most endocrine glands are small, but their effect on the body is great.

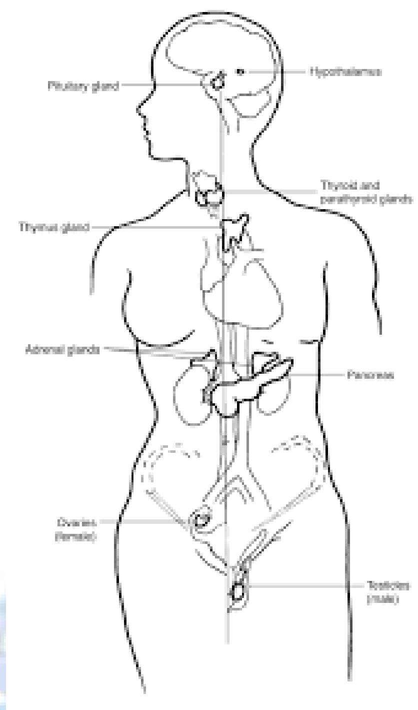


Fig. 9.7 Human Endocrine System

9.4.1 The Thyroid Gland

This gland is relatively larger and it lies close to body surface. The thyroid gland lies in the neck, the lower part of the larynx where it meets the trachea. It consists of the lobes connected by a narrow bridge, or isthmus. Lobes lie on each side of the trachea, extending along the sides of the larynx. The hormone produced by the thyroid gland is called thyroxine.

Sometimes the thyroid gland enlarges. The major causes of this are Iodine deficiency. This enlargement is called as simple goiter. This condition occurs more often in residents of the mountains. In these areas, there is not much iodine in the water. Since lower iodine levels cause goiter, hence it should be added in the diet.

9.4.2 The parathyroid glands

There are four parathyroid glands that lie embedded in the back of the thyroid, two in each lobe. The parathyroids secrete **parathyroid hormone**. This hormone controls the body's use of calcium. A constant, stable balance of calcium is vital to the body. Bone growth, muscle tone and normal nervous activity depend on calcium balance.

9.4.3 Pituitary Gland (Hypophysis)

The pituitary is a small, red-grey pea-shaped gland attached to the hypothalamus of the brain by a stalk of infundibulum in front of pons. The pituitary gland consists of three lobes:

anterior lobe or pars anterior, intermediate lobe or pars intermedia and posterior lobe. All the three lobes of the pituitary secrete separate hormones.

A. Anterior lobe

(i) Growth hormone or somatotropin (GH or STH): it stimulates the body growth, by stimulating retention of proteins and calcium in the body, synthesis and deposition of proteins in tissues, growth and elongation of long bones and proportionate growth of muscles and visceral organs. The less secretion of growth hormone cause dwarfism while excess secretion causes gigantism. Over secretion of GH in adolescence cause elongation of long bones of arms, hands, legs, lower jaw, gorilla like appearance (Acromegaly)

(ii) Thyrotropin or thyroid stimulating hormone (TSH): It stimulates the growth of the thyroid and secretion of thyroid hormone.

(iii) Corticotropin or adrenocorticotrophic hormone (ACTH): It stimulates the growth of adrenal cortex (outer layer of adrenal gland) and secretion of glucocorticoid hormones from it.

(iv) Luteinising hormone (LH): It stimulates testes to secrete the male sex hormone testosterone. It also stimulates ovaries to secrete the female sex hormone called progesterone.

(v) Follicle stimulating hormone (FSH): It stimulates sperm formation in the male and growth of ovarian follicle in the female.

(vi) Prolactin hormone or luteotrophic hormone (LTH): It stimulates growth of milk glands during pregnancy and the secretion of milk after delivery.

B. **Intermediate lobe**:

It secretes a hormone named melanocyte-stimulating hormone (MSH). It stimulates the synthesis of black pigment melanin in the skin.

C. **Posterior lobe:**

It secretes two hormones:

(i) **Oxytocin**: It induces the contraction of smooth muscles of the uterus during the birth of the young one, as well as induces the myoepithelial cells to release milk during sucking by the infant. Because of its role, oxytocin is also called as birth hormone and milk ejecting hormone.

(ii) **Vasopressin**: it is also called anti diuretic hormone (ADH). This hormone decreases the loss of water in the urine by increasing the reabsorption of water in the distal convoluted tubules, collecting tubule and collecting ducts in the kidneys.

9.4.4 Adrenal Gland:

The adrenals, are paired glands placed on the top of the kidney. The adrenals are conical, yellowish bodies. Each has two distinct regions having different embryonic origin, structure and function. The two regions are called adrenal cortex and adrenal medulla.

a. **Adrenal cortex**: the adrenal cortex is an external, firm, pale yellowish- pink tissue. It further shows three concentric regions outer, middle and inner. The adrenal cortex is essential for life. its destruction or removal causes death of the animal, it secretes three groups of steroid hormones:

(i) **Mineralocorticoids**: These hormones are secreted by the outer region of the adrenal cortex. They regulate mineral metabolism ratio in the extracellular and intracellular fluids.

(ii) **Glucocorticoids:** These hormones are secreted by the middle region of the adrenal cortex, proteins and fats. They increase the blood-glucose carbohydrates which are in turn converted to glucose.

(iii) **Sex corticoids**: They include steroids which may stimulate the development of external sex characters of the male type such as male pattern of distribution of body hairs.

B. Adrenal Medulla

The adrenal medulla is an internal soft, dark reddish-brown tissue. It secretes two similar hormones, i.e. adrenaline and noradrenaline.

9.4.5 Pancreas

It comprises both exocrine and endocrine parts. The endocrine part consists of small masses of hormone secreting cells called Islets of Langerhans. Insulin and glucagon hormones are secreted from pancreatic islets. A rise in blood glucose level stimulates both, the synthesis and secretion of insulin. Insulin increases the utilization of glucose in tissues, increases in synthesis of fats in adipose tissues, reduces the breakdown and oxidation of fat, promotes proteins synthesis in tissues and reduces catabolism of proteins in the body. Failure of insulin secretion causes diabetes mellitus.

9.4.6 Testis

It is an organ whose main function is to produce sperms. In the testis, seminiferous tubules are surrounded by the interstitial tissue. In this tissue, there are a type of cells known after a scientist, Leydig. These cells of Leydig become activated by the lutenizing testosterone hormone. Testosterone hormone is produced at the onset of puberty (age of sexual maturity). It helps in the development of secondary sexual characters in the male, for example beard etc.

9.4.7 Ovary

Progesterone helps in the development of uterus, particularly the inner part of the uterus, called endometrium. It stimulates mucus secretion in the vagina, and the growth of mammary gland of the mother during pregnancy. It also helps in the development of placenta. In brief, progesterone is essential for the maintenance of pregnancy and is therefore, called pregnancy hormone. Relax in hormones is secreted particularly at a later stage of pregnancy. It causes relaxation of muscles and ligaments in the pelvic region so that there may not be pressure on the fetus.

9.4.8 **Pineal Gland**

It is a cone-shaped gland, 8 mm in length, 4 mm in breadth, attached by a hollow stalk to the root of the dorsal surface of the diencephalon. Pineal gland secretes melatonin hormone. Environmental lighting affects melatonin production. It leads to reduction in the weight of the gonad (testis and ovary). Melatonin has been found to inhibit the growth of testis and ovaries

CHECK YOUR PROGRESS 9.6

1. Fill in the blanks

(i) A hormone is transported by the ……………… to the target organ.

(ii) Hypoactivity of thyroid gland causes …………….. leading to cretinism in your children.

(iii) Pancreas secretes two hormones, which help in the …………….. of glucose in our body.

2. Each of the following statements has one correct response please choose the correct option and encircle it.

(i) If a pathologist were to collect a hormone, where would it be collected from?

(a) Blood (b) Brain

(c) Specific endocrine gland (d) Any part of the body

(ii) Hyperactivity of the pituitary gland causes:

(a) Dwarfism (b) Gigantism

(c) Cushing's disease (d) Cretinism.

(iii) The neurons that carry impulses from sense organs to the brain or spinal cord are:

(a) Sensory neuron (b) Motor neuron

(c) Association neuron (d) Connecting neuron

(iv) The parts of a reflex are connected to:

(a) Brain (b) Spinal cord

(c) Both brain and spinal cord (d) A synapse

(v) Two neurons are connected to each other through:

(a) Their axons (b) Their dendrons

(c) The dendrites of the first neuron and the dendrites of the second one

(d) Synapse

(vi) An axon is:

(a) A nerve fibre (c) A bundle of nerve fibres

(b) A bundle of dendrites (d) The sheath of a nerve fibre.

(vii) An individual reported to the neuro-physician diagnosed that a tumor in a specific area of the brain was causing this symptom. Where do you thing the tumor may have been located?

(a) Cerebrum (b) Cerebellum

(c) Hypothalamus (d) Diencephalon

(viii) Where is the subconscious mind located?

(a) Thalamus (b) Hypothalamus

(c) Cerebellum (d) Cerebrum

(ix) Hyposecretion of insulin causes:

(a) Diabetes (b) Goiter

(c) Cretinism (d) Gigantism

(x) Which part of our brain helps in maintaining the balance of our body?

(a) Cerebrum (b) Cerebellum

(c) Medulla (d) Hypothalamus

(xi) Sudha likes to sleep in and someone always has to wake her up in the morning. However, during exams she is able to get up without an alarm or any other help. Which part of the nervous system helps her to deal with this situation?

Sleep in-sleeping beyond waking hours

(a) Parasympathetic nervous system (b)Medulla

(c) Sympathetic nervous system (d) Cerebrum

9.4.9 Ductless Glands and their Secretions

Gland	Location	Hormone	Function of hormone
Thyroid	Neck, below larynx	Thyroid hormone	Accelerates the rate of metabolism.
		Growth hormone	Regulates growth of the skeleton.
		Gonadotropic hormone	Influences development of sex organs and hormone secretion of the ovaries and testis.
		ACTH	Stimulates secretion of milk by mammary glands.
		Lactogenic hormone	Stimulates secretion of milk by mammary glands.
		Thyrotrophic hormone	Stimulates activity of the thyroid.
Posterior lobe		Oxytocin	Regulates blood pressure and stimulates smooth muscles.
		Vasopressin	Controls water resorption in the kidneys.
Adrenal-cortex	Above kidneys	Cortin (a hormone complex)	Regulates metabolism, salt and water balance and structure of connective tissue.
Adrenal medulla		Epinephrine or adrenalin	Causes constriction of blood vessels. Increases in heart action and output; stimulates liver and nervous system.
Islets of Langerhans	Inside the pancreas	Insulin	Enables liver to store sugar.
Ovary-Follicular	Pelvis	Estrogen	Produces female secondary sex characteristic; influences

cells			adult female body functions.
		Progesterone	Maintains growth of the mucus lining of the uterus.
Testis-interstitial cells	Below pelvis	Testosterone	Products male secondary sex characteristics.

RECAPITULATION POINTS

Nervous system and endocrine system are the two systems that control and coordinate various functions in the body.

- ❖ The human nervous system is studied under two divisions: The central nervous system and the peripheral nervous system.
- ❖ The central nervous system consists of brain and the spinal cord while the peripheral nervous system is further divided into somatic nervous system and autonomic nervous system.
- ❖ The autonomic nervous system has two parts sympathetic and - parasympathetic, which cause physical reactions opposite to each other.
- ❖ The neuron is the basic unit of nervous system. There are three types of neurons-sensory, motor and association or connecting neurons.
- ❖ A synapse is the function of the branches of the axon of one neuron with the dendrites of another neuron. It is here that the transfer of nerve impulse from one neuron to another neuron takes place.
- ❖ The reflex action is defined as a spontaneous, automatic and the mechanical response to a stimulus controlled by the spinal cord without involvement of the brain.
- ❖ The pathway followed by sensory and motor neurons in a reflex action is called reflex arc.
- ❖ Our body has a number of endocrine glands which produce chemical secretions called hormones.
- ❖ These hormones are carried by blood to the target organ situated elsewhere in the body to stimulate a specific activity.
- ❖ Pituitary gland plays an important role in the growth of the child from puberty to the reproductive maturity, i.e. upto the age of adolescence.

- ❖ Pituitary glands secrete many hormones which influence the development of secondary sexual characters among boys and girls. These hormones stimulate the production of eggs and sperms from ovaries and testes respectively. These hormones have profound influence on the behaviour as well as body shape, turning the child into an adult.
- ❖ Under secretion of thyroid gland cause cretinism and goiter.
- ❖ Pancreas secrete two hormones – the insulin and glucagon, which help in the metabolism of glucose in the body.

TERMINAL EXERCISES

A. Tick the correct answer of the followings

1. The three protective coverings over the brain also called:

   (A) Membranes (B) Layers

   (C) Meninges (D) Sheaths

2. Which part of the brain controls the body temperature?

   (A) Cerebrum (B) Cerebellum

   (C) Hypothalamus (D) Medulla oblongata

3. The spinal cord is extended from the medulla upto the whole length of the vertebral column and lies within the:

   (A) Neural canal (B) Vertebral canal

   (C) Spinal canal (D) Eustachian canal

4. Which one of the following hormones is secreted by the pancreas?

   (A) Prolactin (B) Thyroxin

   (C) Adrenalin (D) Insulin/

5. Name to specialized tissues that provide control and coordination in multicellular organisms
6. Which part of the nervous system controls reflex arcs.
7. Why endocrine glands release their secretions into the blood?
8. Which glands secretes growth hormone in the human beings?
9. What are hormones?
10. What is synapse?
11. Define ‘reflex action’

12. Define neuron. Name the parts of the neuron where:

    (i) information is acquired?

    (ii) impulse must be converted into a chemical signal for onward transmission?

13. Write two differences between the response of the plants and response of the animals to stimuli?

14. How does feedback mechanism regulate the hormone secretion?

15. Differentiate between nervous system and hormonal system.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 9.1

1. Winning a football match (Learner can write any other real-life experience)
2. Immediately leaving road on seeing a speedy truck approaching. Under the stressed 'flight or fight' conditions, the nervous system and hormonal system work together.

CHECK YOUR PROGRESS 9.2

(1)- b

(2)- ii, iii, i, iv, v

CHECK YOUR PROGRESS 9.3

i- brain, spinal cord

ii- speech, thinking, learning, vision

iii- balance

iv- medulla oblongata

v- gray, white

CHECK YOUR PROGRESS 9.4

1. There are two types
   Autonomic reflex arc and somatic reflex arc.
2. Stimulus-------Receptor---- sensory neuron----- CNS------- Motor------- Receptor-------Response
3. Involuntary, voluntary, involuntary, voluntary

CHECK YOUR PROGRESS 9.5

(1)- 12 Cranial Nerve pairs

(2)- sympathetic and para sympathetic.

CHECK YOUR PROGRESS 9.6

1. (I) blood stream
   (II) hypothyroidism.
   (III) digestion.
2. (I) a
   (II) a
   (III) a
   (IV) b
   (V) d
   (VI) a
   (VII) a
   (VIII) a
   (IX) b
   (X) d
   (XI) a

SUPPLEMENTARY STUDY MATERIAL

1. NCERT- Class X Science
2. ICSE- Concise Biology Part-II H.S. Vishnoi, Selina Publishers, N. Delhi
3. https://ncert.nic.in
4. www.livescience.com
5. https://www.britannica.com,

10 REPRODUCTION IN PLANTS AND ANIMALS

INTRODUCTION

You are well aware that a family continues generation after generation and also that organisms produce their own kind. This process of reproducing one's own kind ensures the continuance of the variety of organisms that inhabit the earth. Reproduction is a characteristic feature of every living being and has its own role to play in the body just like the other biological processes such as respiration, circulation, nutrition and others.

In this lesson, you shall learn how new organisms gain life, grow and become ready to give rise to another generation of similar individuals. You shall also learn the importance of reproductive health and hygiene so as to prevent the spread of sexually transmitted diseases. This will enable you to make correct choices the appropriate time.

10.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Know that reproduction is a characteristic feature of organisms for the continuance of their species and that asexual and sexual reproduction are the two different modes of reproduction;
- Recognise the different types of asexual reproduction in organisms;
- Recognise the sex organs and describe in brief the process of reproduction in flowering plants;
- Known facts about reproduction in animals with special emphasis on human reproduction;
- Recognise the changes in the human body upon reaching puberty and emphasize importance of reproductive health and hygiene;
- Recognise the major organs of reproduction in humans (both male and female), state their location in the body and relate each organ with its function;
- Recognise the reproductive events leading to pregnancy and parturition. and express concern regarding negative consequences of adolescent pregnancy,
- Demonstrate awareness regarding the prevention and transmission of Sexually Transmitted Diseases (STDs) and Reproductive Tract Infections (RTIS) caused by microbes;

- Express awareness of increase in population growth and suggest methods of population control.
- Understand modes of transmission and prevention of Human Immuno Deficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS) and utilize this information in making safe informed choices.

10.2 REPRODUCTION

Living organisms reproduce by two methods which are as follows:

a) Asexual Reproduction
b) Sexual Reproduction

10.2.1 Asexual Reproduction: In asexual reproduction a single parent gives rise to two or more young ones that have hereditary traits identical to their parent.

a) **Fission:** In unicellular organisms cell division (fission) leads to the creation of new individuals. For ex: amoeba, Malarial parasite.

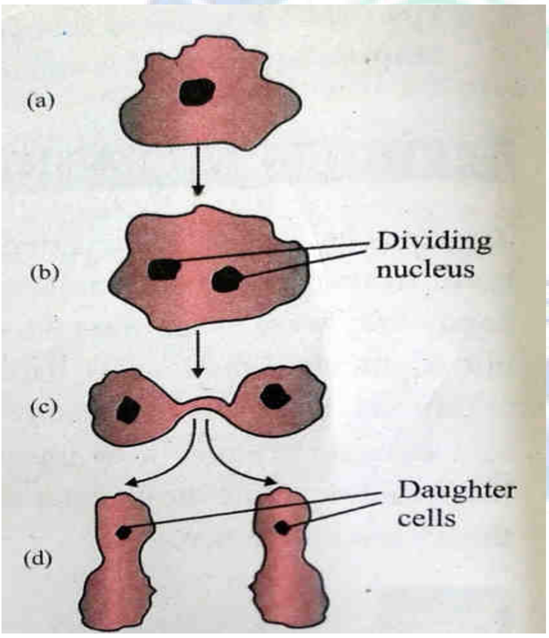


Fig.10.1 Binary Fission in Amoeba

b) **Regeneration:** The ability to regenerate in differentiated organisms is due to presence of special reserve or stem cells. The reserve cells first proliferate and form a large number of cells. Cells then undergo differentiation giving rise to various cell types and tissues.

For ex: Planaria

c) **BUDDING:** In this process, a daughter organism is formed from a small projection the bud, arising from the parent body. Bud is an outgrowth, which grows externally (exogenous) on the surface of the body.

The bud may split away from the parent and take up an independent existence as in ***Hydra*** or it may remain attached and become a more or less independent member of the colony. For example, in ***Sycon.***

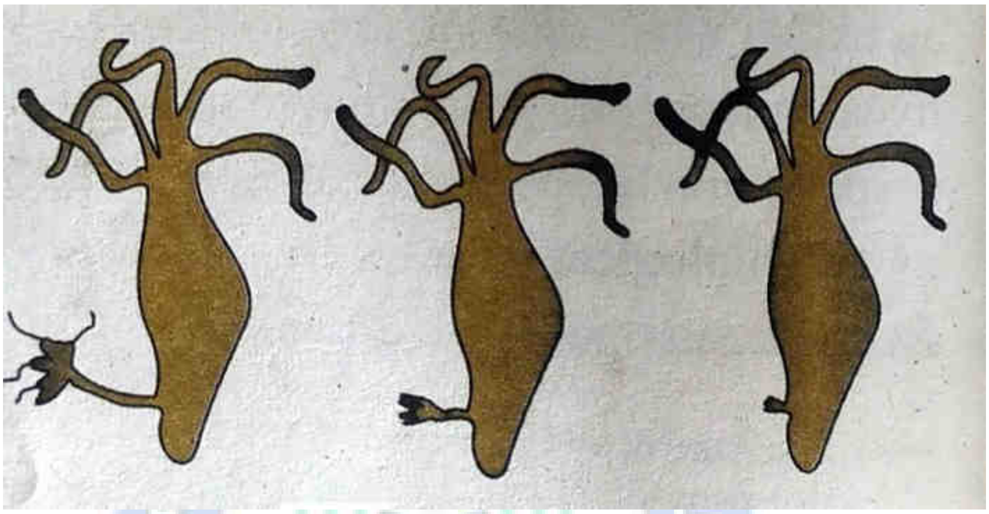
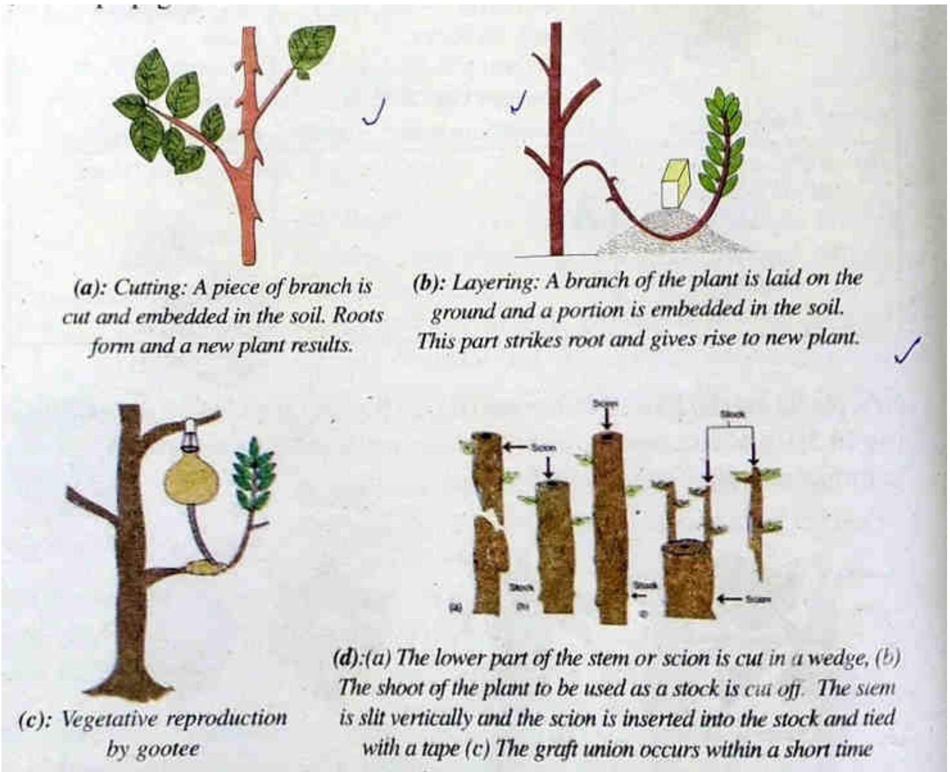


Fig.10.2 Budding in Hydra

d) **Vegetative Propagation:** Vegetative Propagation or Vegetative reproduction is the process of multiplication in which a portion or fragment of plant body functions as a propagule and develops into a new individual. In higher plants, every part of the body can take part in the vegetative propagation. Besides the natural methods of vegetative propagation human beings have developed a number of techniques for artificial vegetative propagation of economically and aesthetically important plants.



(a): Cutting: A piece of branch is cut and embedded in the soil. Roots form and a new plant results.

(b): Layering: A branch of the plant is laid on the ground and a portion is embedded in the soil. This part strikes root and gives rise to new plant.

(c): Vegetative reproduction by gootee

(d):(a) The lower part of the stem or scion is cut in a wedge, (b) The shoot of the plant to be used as a stock is cut off. The stem is slit vertically and the scion is inserted into the stock and tied with a tape (c) The graft union occurs within a short time

Fig.10.3 (a to d): Artificial vegetative propagation in plants

e) **Fragmentation:** In multicellular organisms like spirogyra, simple breaking up into smaller pieces takes place. These fragments grow into new individuals.

10.2.2 Natural Vegetative Propagation: Vegetative propagation also occurs naturally by following parts:

1) Roots:

Ordinary roots of plants can develop adventitious buds which grow to form new plants. *e.g., Guava, Dalbergiasissoo and Populus*

2) Underground Stem:

Underground stem like **rhizomes, corns, bulb** which store food for perennation, posses buds for forming new shoots during favourable periods e.g. **banana, turmeric, onion (bulb),** etc.

3) Leaves:

Leaves of a numbers of plants develop or possess adventitious buds for vegetative propagation. *e.g. Bryophyllum*

4) Bulbils:

They are fleshy buds which develop into new plants after falling on soil e.g.,

Pineapple

Artificial or horticultural Methods of Vegetative;

These are the techniques developed by human beings (horticulturists) to propagate desired varieties.

10.2.3 Specialized Vegetative Organs

a) Banana, ginger (rhizome) and potato (tuber) are propagated by cutting their underground parts into small pieces. A piece of potato tuber should have at least one eye (a node having three buds can produce a new plants).

Vegetative reproduction in potato, the whole tuber has been planted in soil.

b) Cutting

They are small pieces of stems, roots or leaves which when placed in the soil can sprout to form new plants for example, **Sugarcane**.

1) Stem cutting with one node having buds.

2) Formation of a young plant forms the bud.

c) Layering

A soft one year old basal branch is defoliated for a few centimeters roughly in the middle. In the defoliated region an injury is made. The injured and defoliated part is pegged down and covered with soil. The apical leafy part of the shoot is supported to remain nearly erect. The branch with pegged down middle part is called **layer.**

After few days, the injured part develops roots. The layer can now be cut off from the parent and planted separately *e.g.* **jasmine and grape vine.**

If branches do not occur near the ground, then air layering can be performed at the base of an aerial branch *e.g.* **litchi and pomegranate.**

A ring of bark is removed for 2-5cm. The bare area is covered by moistened clay mixed with hay and cow dung. It is then wrapped in polythene. Within 1 to 3 months, roots develop in the area of ring. The branch is now cut at the base and planted.

d) Grafting

This technique includes joining parts of two plants so as to form a composite plant. It is carried out between two related plants having vascular cambium. For example, **mango**.

One Plant has a strong root *e.g.,* Desi Mango while the other plant possesses better flower or fruit yield *e.g.* Dussheri Mango. The former is called **stock** while the latter is known as **scion or graft. Scio**n is defined as the upper part of the composite plant that is grafted. It has a I shoot system with desired traits and generally belongs to high yielding exotic variety. It also provides better and high quality yield of flowers and fruits.

Stock is defined as a basal portion on which grafting is carried out. It has a strong and extensive root system. Stock generally belongs to local variety which is fully acclimatized to local condition and provides good anchorage, proper water and minerals. The scion is fixed over the stock. The union is covered with grafting wax to avoid infection. The area is then bandaged properly.

e) Micro - grafting

It is performed in those cases where virus-free shoot apices do not grow quickly into full plants in tissue culture. A young seedling is taken and the virus-free shoot apex is grafted over it in a culture medium. The shoots of the stock are removed from time to time. Micro grafting is performed in case of citrus, **potato and sugarcane.**

f) **Micro -Propagation**

It is the method of raising new plants from a small plant tissue over a culture medium under aseptic conditions. Micro propagation is therefore, also called as **tissue culture**.

g) Spore Formation

In this process, spores, take part in a sexual reproduction. The tiny blob-on-a stick structures are involved in the reproduction are formed inside special cell sacs. e.g., **Sporangia** in **Rhizopus** or outside them e.g., **conidia** of **Penicillium**

CHECK YOUR PROGRESS 10.1

1. Define reproduction

2. State one point of difference between asexual and sexual reproduction.

3. Why is binary fission considered to be an asexual form of reproduction?

4. Define vegetative propagation with the help of an example.

5. Define the following (i) clone

10.2.4 Asexual Reproduction

1) A single parent is involved.
2) Gametes are not formed.
3) No fertilization.
4) There is only mitotic cell division.
5) Daughter organisms are genetically identical to the parent.
6) Multiplication occurs rapidly.

10.2.5 Significance of Asexual Reproduction

Asexual Reproduction has no variation so, it does not contribute to the evolution of species.

10.3 Sexual Reproduction in plants

Sexual Reproduction is the most common method of reproduction in flowering plants. It involves formation and fusion of gametes. New individual develops from zygote or fusion product of two gametes. We all know that normally a plant produces numerous seeds and each seed in germination gives rise to a new plant. But a seed is produced when a plant undergoes sexual reproduction. Let us know the various parts of flower participating in reproduction:

Flower: The reproductive parts of angiosperms are located in the flower. Flowers have different parts.

1) Sepals: Green coloured protect flower in bud condition.

2) Petals: Coloured other than green and showy. In addition protect the reproductive parts. They also attract the insects for pollination.

3) Stamen and Carpel: Reproductive parts of a flower which contain germ cells

10.3.1 Type of Flower

There are two types of flowers, Unisexual and Bisexual.

Unisexual: When flower contains either stamens or carples is called as Unisexual. E.g Papaya, Watermelon, etc.

Bisexual: When flower contains booth stamens and carpel is called as bisexual e.g. Hibiscus, Mustard, etc.

10.3.2 Reproductive Parts of a Flower

a) Male Reproductive Part:

Stamen is the Male Reproductive Organ of a flower. It is made up of two parts.

- A stalk like filament.
- A knob like terminal anther.

Anther contains pollen-grains which are yellowish in colour. They often stick to our hands, if we touch the anther of a flower.

b) Female Reproductive Part:

Carpel is the female reproductive organ of a flower. It develops from the central region of a flower.

It is made up of three parts.

- The swollen bottom part ovary.
- Middle elongated part style.
- The terminal sticky part stigma.

The **ovary** contains the **ovules** and each ovule is having **egg-cell** (female gamete for sexual reproduction). The male gamete produced by pollen fuses with the female gamete present in the ovule. For this, pollen grains form anther is carried to the stigma by **pollination**.

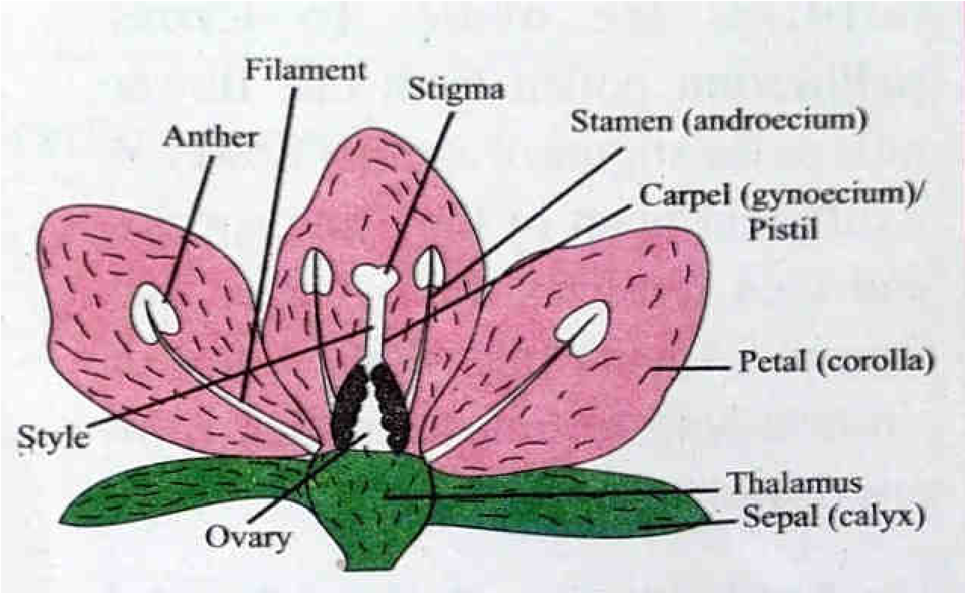


Fig.10.4 TS of a Typical Flower

10.3.3 Fertilization

The fusion of male and female gametes is called **fertilization**. The male gametes are brought to the egg containing female gametophyte by a **pollen tube**. i.e., when pollen grains are deposited on the stigma, they absorb moisture and give out pollen tube which travels through style and reach the ovary and then fusion of male gamete with an egg takes places and results into fertilization. After fertilization, **zygote** forms, which divides several times to form an embryo within the ovule?

10.3.4 Formation of a seed

The ovule develops a tough coat and is gradually converted into a seed. The seed contains an embryo having tiny root called as **radicle**, future shoot as **plumule** and **cotyledons** that contain food reserve. With time the seed dries up and hardens, enabling it to survive in adverse conditions.

The ovary grows rapidly and ripens to form a fruit. Meanwhile, the petals, sepals, stamens, style and stigma shrivel and fall off.

The fruit after dehiscence (break open) releases the seeds. Each seed contains a future plant and on germination produces a new individual.

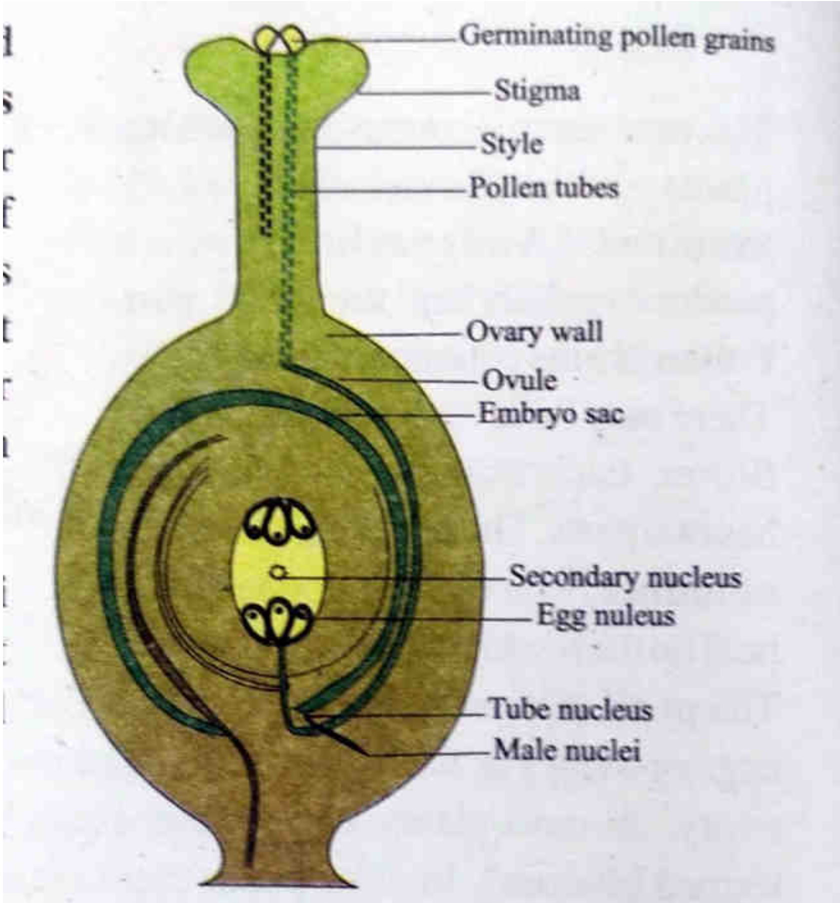


Fig.10.5 Fertilization in Plants

CHECKYOUR PROGRESS 10.2

1) What purpose does the flower serve in a plant?
2) Give one point of difference between self-pollination and cross pollination.
3) What will happen if the pistil of the flower is removed?
4) Trace the path of the pollen after it lands on the stigma.
5) What is germination of seed?

10.4 Reproductive System in Humans

In Human beings only **sexual reproduction** takes place. It is a complex system and functions under the influence of hormones. The reproductive organs become functional after a certain age i.e.**13-14 yr**s. and this age is called as **puberty**.

Generally, **in males** puberty is attained at the age of **13-14 yrs**, while in **females,** it is **10-12 yrs**.

10.4.1 Reproductive Organs

In females the main reproductive organ is **ovaries** which produce female gametes called as **ova**.

In males main reproductive organ is **testis**, which produces male gametes called as **sperms**.

Testes (male reproductive organ) secrete **testosterone** and **ovary** (female reproductive) secretes estrogen.

Role of Hormones:

Hormones bring significant changes in the process of reproduction in human beings. In males and females, it brings out certain changes which help in the process of reproduction.

- Hormones regulate the process of gametogenesis i.e., formation of ova and sperms in female and males respectively.
- They maintain the structure and function of accessory sex organs.
- They lead to the development of secondary sexual character.

Secondary sexual characters are those which take place in males and females at the time of puberty. The secondary sexual characters which occur in males and females are as follows:

Males:

- Deepening of voice
- Growth of beard laratril
- Growth of moustaches.
- Growth of public hair.
- Growth of larynx.
- Increase in musculature.

Female:

- Appearance of mammary glands.
- Appearance of public hair.
- High pitch voice.
- Menarche or beginning of menstruation.
- Broadening of pelvis.

Male Reproductive System:
Male reproductive organs consist of organs that produce.

- The male germ cells or sperms.
- Organs, that delivers the sperms near the site of fertilization.

The male Reproductive System consists the following organs:

- Testes (2) in the scrotal sac (Scrotum)
- Epididymis (2)
- Vas deferens (2)
- Urethra
- 5)Penis
- Accessory glands (seminal vesicles & prostate glands)

1) Testes:

They are **male gonads or primary sex organs** which produce sperms and secrete hormone testosterone.

Testes are two in number and are present in a pouch of loose skin or fibrous covering called as **scrotal sac or scrotum** that lies outside the abdominal cavity. Each testis is oval in shape.

The scrotum helps in maintaining a 1-3° C lower temperature than the body temperature. This is necessary for the development of sperms. Sperms are produced throughout the reproductive life of a man (puberty stage onwards).

2) Epididymis:

This is a coiled tube -like structure which is firmly attached to the testis and serves as the store house for sperms, where sperms become mature and develop motility.

3) Vas deferens

Epididymis opens into a thick muscular tube known as vas deferens. It connects the epididymis to the seminal vesicle and opens into a common duct called as **urethra**.

4) Urethra

Urethra, in addition to a duct from testis also gets a duct from urinary bladder. Thus, it serves two functions, It acts as a passage of urine as well as for sperms.

5) Penis:

The urethra runs through a muscular organ called as penis. It is male copulatory organ. It is cylindrical in shape with richly supplied blood vessels. Penis is used for passing out urine and for ejecting and depositing sperms in the female genital tract. Thus, there is only one opening for urine and sperms.

6) Accessory Glands:

a) Seminal vesicles:

These are a pair of thin-walled, muscular and elongated sacs. They secrete a viscous fluid for nourishment of sperms.

b) Prostrate Gland:

They too produce a fluid which is released into the urethra along with the secretion of seminal vesicles. The secretion of these glands together with sperms is called semen. Semen is milky, viscous, alkaline fluid ejaculated by males during organ. The quantity of 2.5 -4.0 ml of semen has 300-400 million sperms.

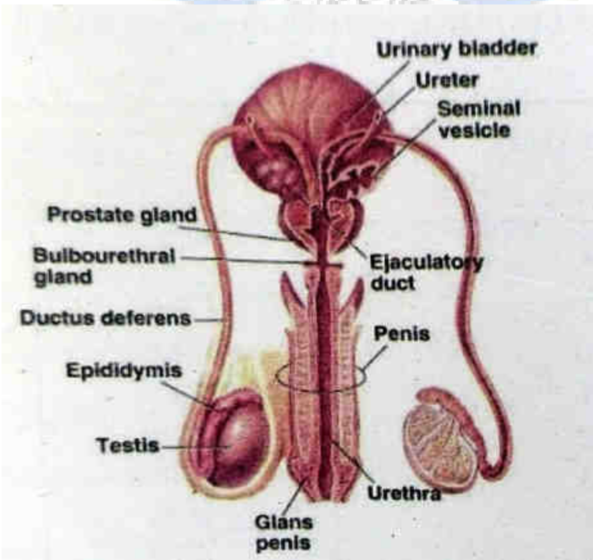


Fig.10.6 Male Reproductive Organs

10.4.2 Female Reproductive System

It consists of organs that produce ova and organs that help in fertillzation of an ovum and its later growth into a foetus. The female reproductive system consists of the following organs:

1) Ovaries (2)
2) Fallopian tubes or oviducts
3) Uterus or womb
4) Vagina

1) Ovaries:

- Ovaries are almond shape paired structure present in the abdominal cavity.
- Its main function is to produce ova.
- **Follicle** is the layer which surrounds the ovum. As the egg grows larger, the follicle also enlarges and gets filled with a fluid.
- The fully grown mature follicle is called as **Graffian follicle**.
- After Maturity the ovary releases one ovum after 28 days.
- Only about 400 ova mature during the reproductive span of a female.
- Ovaries also secrete two sex hormones

  a) Estrogen **b) Progesterone.**

2) Fallopian Tubes:

- They are a pair of curved tubes, about 10-12 cm in length.
- They carry the ova (eggs) from the ovary to the uterus.
- They are not attached to ovaries but are present near the ovaries.
- They have funnel shaped fimbriated opening to receive the eggs as they mature.
- The fallopian tubes of the two sides unite to form a structure called as uterus.

3) Uterus

- Uterus is a hollow muscular organ, which is specialised to retain and nourish the foetus during pregnancy.
- The cavity of the uterus is lined by a layer of cells called as **endometrium**.
- The embryo gets implanted and develops for nine month during the pregnancy in uterus.

➢ The lower tip of the uterus called the **cervix**

4) Vagina

➢ It is also called as birth canal.

➢ It is large muscular tube that runs from the uterus to the outside.

➢ Vagina receives sperms from the male and also serves as a birth canal during the birth of the child.

➢ In females, urinary opening and vaginal openings are separate.

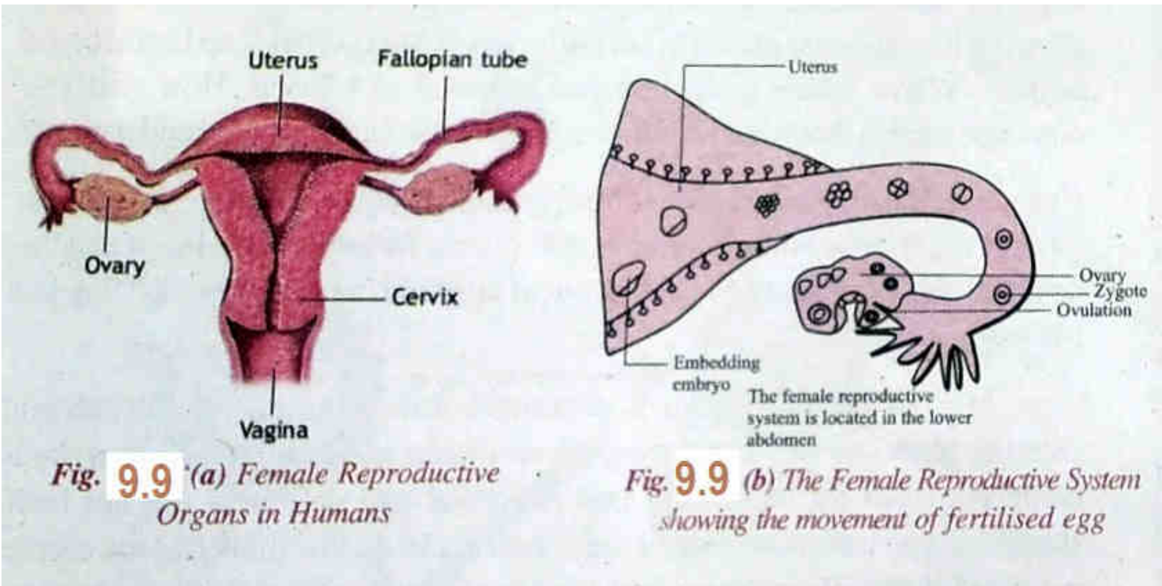


Fig.10.7 (a) Female Reproductive Organs in Humans

(b) The Female Reproductive System showing the movement of fertilised egg

10.4.3 MENSTRUAL CYCLE

The Human female usually produces one mature egg each month. If the egg is not fertilized, it lives for one day and then it is expelled. Menstrual cycle is a series of cyclic changes that occur in the reproductive system of human females with a periodicity of about 28 days. The cycle begins with puberty and is called as menarche and stops between age of 45-50 yrs. Stoppage of menstruation permanently is called menopause.

During this cycle, a series of changes occur in the ovary and uterus. These changes are termed as menstrual changes.

CHECK YOUR PROGRESS 10.3

1. Define the terms (1) adolescence (1) puberty (iii) hermaphrodite (iv) oviparous (v) viviparous (VD) foetus

2 Name the hormones secreted by the testes and ovary.

3 Name the part of the female reproductive system where the egg. gets fertilised by the sperm.

4 State the function of (i) uterus (ii) vas deferens

5. Consider the three case studies given below. Please provide your suggestions for managing these situations in 2-4 sentences each.

   Case1: Your friend, Suresh is extremely shy and withdrawn because he is growing hair at many places in his body. His voice is croaky and sometimes he gets dreams which make him feel ashamed of himself. How will you convince Suresh that what he is undergoing is absolutely normal and natural?

   Case2: Amrit, your friend, is disappointed because he is the same age as most of the friends but in comparison to others, he looks baby-faced and has no facial hair. How will you get him out of this 'odd man out feeling? Suggest two ways.

   Case 3: Your cousin Madhu is prevented from entering the kitchen and entering places of worship during menstruation and Madhu feels that she is being punished for something that is normal and definitely not her fault. Based on your understanding of menstrual cycle, do you think this is a correct practice? If not, please provide at least two reasons to convince your aunt to stop this practice.

6. Your friend Kiran would not look at boys during her periods as she had heard from someone that if she did so she would become pregnant. Write a letter to Kiran that helps her realize that she is holding on to a false belief.

10.5 Fertilization

In fertilization, the sperms are released in the vagina during sexual intercourse. The sperms actively swim with the help of their tails and enter into the uterus. From uterus, they reach the Oviduct. If there is an egg in the oviduct, it gets fertilized by one of the sperm.

10.5.1 Pregnancy:

After fertilization, the zygote fixes itself on the wall of the uterus, this fixation is also called as **implantation** and after implantation it starts its development. This is the beginning of the developing embryo is attached to the mother's uterus through an attachment, called **placenta**. Placenta provides passage for glucose, amino acids, oxygen and other useful materials from mother to the embryo.

Once fertilization has taken place and zygote gets fixed to the uterine wall, ovulation and menstruation do not take place. The development of foetus inside the uterus is called **gestation**. The birth of the fully developed foetus is called **parturition**. Delivery of baby is followed by expulsion of placenta.

CHECK YOUR PROGRESS 10.4

1. List in a sequence the events that lead to the birth of a new individual.
2. Name the hormones responsible, for attaining reproductive maturity, and for formation and maturing of sperms and eggs in humans.
3. Given below is a list of hormones related to reproduction. List influence on functions in the space given below:

   FSH, LH, Estrogen, Testosterone, Oxytocin

Hormones	Function

10.5.2 Reproductive Health

Reproductive health is a term which deals with the issue of maintaining health after having attained sexual maturity.

The males and females, may be mature in terms of reproductive organs at the ages of 13 and 15 yrs. respectively, yet their general body growth still goes on and the individuals are still not ready mentally, socially or even financially to bear children.

In older days, children were married off with the attainment of puberty. However, this is highly harmful for the wife, husband and the society because.

1) The teenage wife and husband cannot bring up their children as they are themselves kids.

2) They cannot pursue studies, nor can they have career.

3) The young lady is not physically mature to bear a foetus.

4) Deformity of children will occur.

Sexual act in teenage is extremely harmful due to

- Incomplete development of body
- Danger of catching sexually transmitted diseases (STD)

STD are infections that are passed from one person to another through sexual contact. There are more than 20 types of STD's including Chlamydia, Genital herpes, Gonorrhea, HIV/AIDS, etc.

STD's can be caused by bacteria, viruses and parasites.

There are several such diseases. Two common bacterial STDs are gonorrhea and **syphilis**. Viral diseases which are sexually transmitted are warts and HIV - AIDS.

There is therefore a need to be aware of reproductive health. Another topic which comes under Reproductive health is **population control**.

CHECK YOUR PROGRESS 10.5

1) Name any four sexually transmitted diseases.
2) Name four devices which prevent fertilization in humans.
3) Expand the abbreviations (i) HIV and (ii) AIDS

10.6 Population Control

The increase in population has put tremendous strain on the available resources. The only long-term solution to the problem is population control. Population control means birth control method or **Family Planning.**

Methods:

There are several methods available for family planning. They are broadly classified into three types.

1) **Barrier Methods:**

In this method physical devices such as condoms, diaphragms and cervical caps are used to control birth. These devices prevent the entry of sperm in the female genital tract and thus fertilization of ovum is prevented.

In India **intra uterine contraceptive devices (IUCDS)** like copper -T or loop are very popular. In case of copper - I as IUCD, it is inserted inside the uterus of the female. As a result, implantation of embryo in the uterus is prevented.

2) **Chemical Methods:**

Chemical Methods include drugs or pills used by females. Pills are of two kinds - Oral or Vaginal. Oral pills used by women (like Mala-D) contain hormones which alter ovulatory cycle. The use of oral pills (commonly called oral contraceptives, OCs) is a safe method of avoiding pregnancy. OCS inhibit the production of gametes, by the action on hypothalamus, pituitary and the ovaries.

3) Surgical Methods:

a) Tubectomy in Females: It involves cutting and being of fallopian tubes of each side. A portion of 60th the fallopian tubes is excised obligated to block the passage of ovum.

b) Vasectomy in Males: It involves cutting and dieing of vas deferens of each side. The two vasa differentia of the male are blocked by cutting a small piece and trying the rest. This perverts passage of sperms from testes to semen.

Illegal Sex: Selective abortion of female foetus is becoming more and more common these days. Such illegal practice is prohibited by law and is a punishable offence. These illegal practices disturbing the female - male sex ratio in the human society and have dangerous implications.

ACTIVITY 1

- As you do so, make an album of your photographs from infancy to date. If there are no photographs, collect pictures of infants and growing children to get an idea of how changes take place in the body as one grows up.

ACTIVITY 2

- Take a branch from a champa tree or a money plant. Grow it. Observe how the branch produces a full fledged plant. You may even try to grow some grass picked up from the wild. What do you find? Under which conditions does the grass reproduce to form a carpet of grass?

ACTIVITY 3

- Procure a witted flower and look for the stamen and pistil. Identify the different parts and then check the terms for these parts in the pictures given in your book. Do you think we should pluck flowers from the plants? State 'Yes' or 'No' choosing points from the following
- look nice on plants

- are living
- where will butterflies go? Provide food for the butterflies
- are organs of reproduction?
- What do you think will happen if we pluck all the flowers that bloom on a plant?
- Write your answer in the space provided below:

ACTIVITY 4

- Have a frank and honest discussion with your friends about the kind of changes you are undergoing in your body and mind.
- You may find certain commonalities and some things that are unique to each of you.
- Is there a change during adolescence that makes you happy and a change that makes you nervous and anxious? Share it with your friend.
- Quote at least one incident when you experienced a mood swing.
- In your opinion, were you able to handle it well?
- If not, what could you do the next time to either prevent the mood swing or manage it better.

RECAPITULATION POINTS

- As you read this lesson, you shall begin to realize that a naturally occurring feature of all organisms is to grow up.
- Microbes, plants, animals all need to grow up to an extent when they are able to perpetuate their own species.
- Thus, the species lives on from one generation to the next.
- The biological process involved in the perpetuation of species is called reproduction. Reproduction may be defined as the biological process by which organisms give rise to their own kind.
- Reproduction may occur in two ways.
- Reproduction is a characteristic of all living beings.
- It is the biological process of producing offspring of one's own kind.
- Reproduction may be asexual or sexual
- In asexual reproduction offspring are produced by single individual.
- In sexual reproduction, a male individual and a female individual are needed.

- Hermaphrodites like tapeworm and earthworm have both male and female organs in same individual.
- Asexual reproduction in protozoa is by binary fission, in yeast and hydra by budding. In plants, parts like roots, stem and leaves may give rise to new plants. This is called vegetative propagation. Plants may be artificially propagated by layering, cutting, goottee etc. Recent laboratory methods are micro propagation and cloning.
- Sexual reproduction requires the fusion of male and female reproductive cells/gametes. In plants, flower is the reproductive part. Its stamens are the male part and pistil, the female part.
- The male gametes is the pollen of one plant may reach the female gamete of the same flower or same kind of flower by being transferred on the stigma of the pistil by agencies like wind, water or insects.
- Fusion of male and female gametes is called fertilisation.
- After fertilisation, ovules form seeds. Seeds can germinate into new plants.
- Reproductive maturity in humans begins during puberty in the adolescents. During adolescence, boys and girls undergo physical, physiological and psychological changes.
- Sexual reproduction in animals begins with fusion of sperm and egg (ova). Sperms develop testes, the male organ and ova in ovary, the female organ. Animals may lay eggs (oviparous) or the embryo may develop completely inside the uterus (viviparous).
- Male and female reproductive parts in humans are: Male- a pair of 2 testes, 2 vas diferentia, one ejaculatory duct passing through penis. Female: - a pair of ovaries, 2oviducts or fallopian tubes, one uterus, one vagina opening to the outside.
- Reproductive events are under the control of hormones.
- After fertilisation, the embryo which implants in the mother's uterus becomes the foetus. Foetus completely develops in the mother's womb.
- India has the largest human population after China. Population is one of the greatest resources for the country. Planning the size of the family and the timing of child birth helps to achieve better quality of life as there are likely to be sufficient resources to spend

on food, education, health and well being of all the members of the family. There are several methods of contraception that can be used based on the needs of the couple.

- Certain diseases are transmitted through sexual acts. These are sexually transmitted infections due to virus and bacteria and HIV-AIDS caused by HIV virus.

TERMINAL EXERCISE

1. Name the biological process by virtue of which a species continues from generation to generation?
2. Mention two differences between asexual and sexual modes of reproduction?
3. Mention an example for each of the following methods of reproduction.

   (i) Budding (ii) Spore formation

   (iii) Binary fission (iv) Vegetative reproduction
4. Why is vegetative reproduction considered as a type of asexual reproduction?
5. Mention the specialized parts that are responsible for vegetative mode of reproduction in the following plants.

   (i) Ginger (ii) Grass

   (iii) Onion (iv) Potato.

6 How is artificial vegetative propagation different from natural vegetative propagation? How is the former beneficial to humans?

7. How is a callus developed in tissue culture? Give the steps.

8. Why is it said that all living cells are totipotent? Explain.

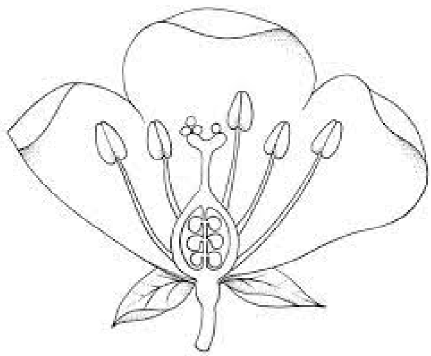
9 Label the following parts in the given diagram

(i) part that produces pollen.

(ii) part of the flower that receives the pollen.

(iii) part that contains ovules.

iv) the part of the flower that holds the anther.



10. Justify the following statements:

(i) Birds, reptiles and frogs are called 'Oviparous".

(ii) Human are 'Viviparous'.

(iii) Earth worm is a "hermaphrodite'.

(iv) The sheep 'Dolly' was a clone of her mother.

11. Trace the events after pollination that lead to seed formation

12. Identify (a) (b) (c) and (d) in the following table

Reproductive organ of Human	Function
1. Testes	1) Produces the hormone.........(a)......
2. S........ (b).	2) The womb in which the embryo develops
3. Cervix	3) ………………. c ……………………
4. ……………(d)…………..	4) Arise from the testis and later join together to form ejaculatory duct.

13. List the physiological changes that arise at puberty in

- human female
- human male

14. Mention the fate of the thickened uterine lining in human of in case fertilisation does not occur.

15. Do you agree with the statement "A strong force of one billion Indians can achieve all the developmental goals and lot more"? Why/Why not?

16. Mention the psychological changes that are experienced by the adolescents.

ANSWER TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 10.1

1. Reproduction is the production of offspring. There are two main forms: sexual and asexual reproduction. In sexual reproduction, an organism combines the genetic information from each of its parents and is genetically unique. In asexual reproduction, one parent copies itself to form a genetically identical offspring.
2. Asexual reproduction involves only a single individual. It does not require two sexes. Sexual reproduction involves two different individuals, male and female sexes. The offspring is produced due to fusion of male and female gametes.
3. Binary fission is asexual reproduction because during this process one bacterial cell splits into two.
4. Vegetative reproduction is any form of asexual reproduction occurring in plants in which a new plant grows from a fragment or cutting of the parent plant or specialized reproductive structures, which are sometimes called vegetative propagules. Examples: Banana, orange/roses/jasmine/sugarcane.
5. An exact copy of a plant or animal that is produced from one of its cells by scientific methods.

CHECK YOUR PROGRESS 10.2

1. The primary purpose of the flower is reproduction. Since the flowers are the reproductive organs of the plant, they mediate the joining of the sperm contained within pollen, to the ovules– contained in the ovary. Pollination is the movement of pollen from the anthers to the stigma.
2. The transfer of pollen grains from anther of stamen to stigma is called pollination. The transfer of pollen from the anther of one flower to the stigma of another flower of a different plant of the same species is called cross pollination. In this case, pollen grains of the same flower do not pollinate its stigma. In cross pollination, the transfer of pollen grains may take place through some agency like wind, insect, bird, water, mammals etc. Transfer of pollen from the anther of a flower to the stigma of the same flower or a flower on the same plant is called self-pollination.
3. If pistil of the flower is removed, then no fertilization occurs because pistil has the ability to recognize the pollen. So, in the absence of pistil, no pollination takes place.
4. The pollen tube enters the tissue of stigma and grows downward in the intercellular space or loose walls of the transmission tissue. Reaching the end of the style, pollen tubes enter into the ovary and continue their way on the inner surface of the ovary or on the central axis where fertilization process takes place:

5. Germination is the process by which an organism grows from a seed or spore.

CHECK YOUR PROGRESS 10.3

I. **Adolescence**: The period of a person's life between being a child and becoming an adult, between the ages of about 13 and 17 is called adolescence.

II. **Puberty:** the time when a child's body is changing and becoming physically like that of an adult is called puberty.

III. **Hermaphrodite:** a person, an animal or a flower that has both male and female sexual organs and characteristics is called hermaphrodite.

IV. **Oviparous:** animals producing eggs rather than live babies is called oviparous.

V. **Viviparous:** animals that produce live babies from their bodies rather than eggs is called viviparous.

VI. **Fetus:** a young human or animal or animal that is still developing in its mother, body is called fetus.

1. The testes secrete testosterone also known as male sex hormone. The ovaries secrete estrogenic and progesterone also known as female sex hormone.
2. Fertilization of an egg by a sperm normally occurs in the fallopian tubes. The fertilized egg then moves to the uterus, where it implants to the uterine lining.
3. **I.** The main function of vas deferens is to carry sperms to the seminal vesicles where they are stored temporarily in suitable alkaline medium.

   II. In females, uterus is an elastic bag like structure which acts a site for the placement and development of embryo till its birth.
4. **Case I:** Suresh can be convinced that he is absolutely normal and the reason of changed voice and body hairs that he has entered in adolescent stage and secretion of sex hormones has been started.

   Case II: Rehman is absolutely normal. He is different from his friends that still the sex hormones secretion is not started although he is entered in adolescence stage.

   Case III: Madhu has been stopped to enter in the kitchen because she Is passing through menstrual phase and during these phase, there is secretion of blood as well so many other fluids from her genital opening which can produce unhygienic conditions in the kitchen because kitchen consists all eatable items.

CHECK YOUR PROGRESS 10.4

1. Gametogenesis ------- insemination----------- fertilization--------- implantation----------- gestation --------------Parturition
2. Follicle stimulating hormone (FSH) and Luteinizing hormone (LH)
3. FSH- it helps in the stimulation of follicular growth and ovulation.
   LH- luteinizing hormone is a hormone plays a key role in gonadal functions
   Oestrogen- causes eggs to mature in ovaries once a girl hits puberty.
   Testosterone – it stimulates sperms production in male.
   Oxytocin- it stimulates uterine contraction in labor and child birth and to stimulate contraction of breast tissue to aid in lactation.

CHECK YOUR PROGRESS 10.5

1. AIDS, GONORRHEA, SYPHILIS AND HIV
2. Condom, Mala D, Tubectomy, Copper T
3. Acquired Immunity Deficiency Syndrome

SUPPLEMENTARY STUDY MATERIAL

1. NCERT- Class X Science
2. ICSE- Concise Biology Part-II H.S. Vishnoi, Selina Publishers, N. Delhi
3. https://ncert.nic.in
4. https://www.britannica.com

11 HEREDITY

INTRODUCTION

It sometimes happens that if any of your relatives sees you after a long time they are surprised to see your height or looks. The immediate response is that – "Oh, you resemble your mother more than your father or you have taken height after your father. This resembles even find its traces in grandmother or grandfather. Have you ever wondered how it happens? Why do we have characteristics of both mother and father? The answer lies in the word Heredity and Genes; about which we are going to study in this chapter. Heredity can be defined as the transfer of genetic characters from parents to off springs by the process of fertilization, where the nuclei of male and female gamete fuses with each other and forms the genetic material of the zygote. For example, the chances are two blue eyed parents will always give birth to a blue eyed baby. It can also be hair colour, skin colour, bone structure, ear lobes etc

11.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Understand the basic concept of heredity
- Gain knowledge about Dominant and recessive traits
- Explain about variation and evolution seeds to new generation
- Develop understanding of monohybrid and dihybrid cross
- Explain variations, their cause and advantages
- Explain how traits get expressed.
- Acquire knowledge about sex determination in humans.
- Apply the knowledge of sex determination in social scenario where women are considered responsible for sex of the child.
- Have knowledge about sex related diseases.

11.2 IMPORTANT TERMS RELATED TO THE CHAPTER

1.**Traits:** These are characters or features of a living organism such as height, complexion, shape of body, nose, colour of eye etc are called traits.

2 **Heredity**: The transmission of characters from the parents to their offspring is called Heredity'

3 **Variation:** It is defined as difference between the individuals of some species or group of individuals of any different species.

- These difference are called as variations.
- Offspring are never a true copy of their parents even no two individuals are exactly alike ex- Earlobe (having earlobe or attached earlobe) but variation is produced even during sexual reproduction

Advantages: -Variation to a species it increases the chances of its survival in a changing environment

- Variation may be of genetic type passed on from parents to offspring during reproduction called genetic
- Variation occurs due to environmental factors called environmental variation
- Variation which are beneficial to organism for their better adaptation to their environment and passed on to its progeny, always leading to the evolution of species.

4 Chromosome: - These are thread like structure located inside the nucleus of animal and plant cells.

- These chromosomes are made up of histone protein and deoxyribonucleic acid (DNA)
- These chromosomes are responsible for transmission of parental character to offspring
- DNA is chromosome called as 'gene'

5 Gene: A gene is the basic physical and functional unit of heredity

- Genes are made up of DNA
- Each chromosome contains many gene
- Genes work in pairs

- Gene controlling the characteristics of an organisms.
- The entire structure and function of the body is governed by the types and amount of proteins the body synthesizes
- Protein synthesis is controlled by genes, which are contained on chromosomes.

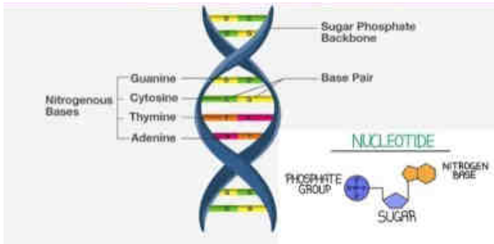


Fig 11.1 Structure of DNA

6 Allele: These are two alternative form of gene which are located at the some position, or genetic focus on a chromosome

- Human are diploid organism have to 2 alleles of gene at each genetic ………., with one allele is inherited from each parent
- If the two chromosomes contain the same allele are called Homozygous condition
- If the alleles are different are called Heterozygous condition

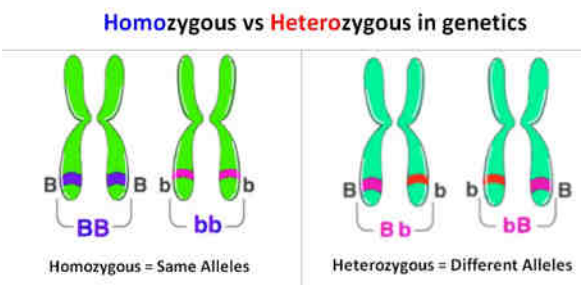


Fig 11.2 Homozygous and Heterozygous alleles

11.3 Genetics: It is the scientific study of

(i)The mechanism of inheritance by which characters pass from parents to offspring

ii) The cause of variation in living organism is known as genetics

John Gregor Mendel (1822-1884) was a Monk, teacher, scientist who observed and recorded information for 8 years over 32,000 plants. He was the first to formulate Law of heredity and is remembered as the father of genetics. His work laid the foundation of Modern genetics. Mendel worked on the garden pea plant (Piscum Sativum) and from his experiment he formulates clear cut principles or law of heredity. He postulated three basic law of inheritance

1 Law of Dominance

2 Law of Segregation

3 Law of Independent assortments

Gregor Mendel selected garden pea plant for his experiment because of certain special advantages as

1 Pea plant are easily available.

2 Pea plant has many contrasting character i.e. pairs of contrasting characters.

3 Short life span so that result could be bad within a year.

4 Flower is bisexual, self-pollination as well as cross pollination can be achieved.

5 It could be raised, maintained and handled conventionally.

6 It produced may seed in one generation.

7 Easily to cultivate and grow

Contrasting Characters: The traits which always appear in two offspring condition, one dominant and other is recessive is called contrasting traits

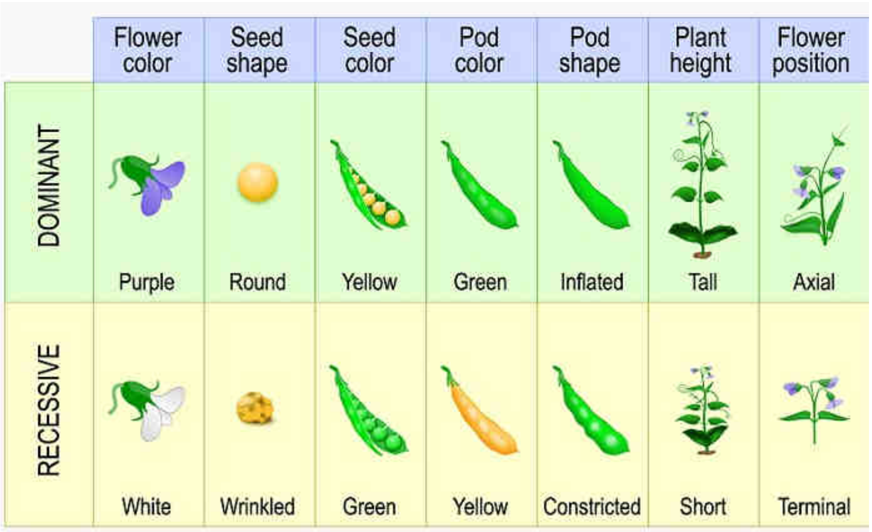


Fig 11.3 Contrasting character of pea plant

Contrasting character noted by Mendel in garden pea

S. No	Characters	Dominants	Recessive
1	Height	Tall	Dwarf
2	Position of flower	Axillary	Terminal
3	Colour of pod	Green	Yellow
4	Shape of pod	Inflated	Constricted
5	Colour of seed coat	Coloured	White
6	Colour of cotyledon	Yellow	Green
7	Form of seed	Round	Wrinkled

- He cross pollinate two three breed of contrast character is pure tall plant and pure dwarf plant.
- Found that only tall plant were produced in that first filial generation (F_1)
- No dwarf plants or intermediate size plant were produced.
- From this Mendel concluded that the first F_1 generation among themselves and found both tall plant as well as dwarf plants reappeared in F_2 generation.
- The ratio of tall and dwarf plant is secondF2 generation is 3:1 i.e therefore 3/4th plant were tall and1/4th were dwarf

- Mended said that the traits of dwarfness of the parent pea plant had not been lost but. Suppressed in the first generation and reappeared in second generation
- Mended called the 'dwarfness' as recessive trait and 'tallness' as dominant trait
- In this way he proposed first law of Dominance

Dominant Traits: - The trait that expressed and suppressed the expression of other when it is in hetero zygous condition is called Dominant trait.

Recessive Trait: - The trait that is expressed only when it is in homozy goes condition.

Phenotype: - Observable characteristics/traits of an organism. Ex- eye colour, height, blood type etc

Genotype: It is the genetic material passed through generation wise or a gene that are carried by an organism

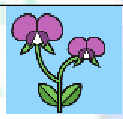
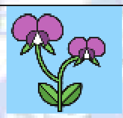
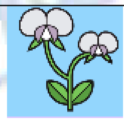
GENOTYPE	**PHENOTYPE**
The genotype is an organism's genetic information.	The phenotype is the set of observable physical traits.
BB Homozygous dominant	Purple 
Bb Heterozygous	Purple 
bb Homozygous recessive	White 

Fig 11.4 Genotype vs Phenotype traits

11.4 Mendel's Monohybrid cross: This cross is between only one pair of contrasting characters. Ex- cross between tallness or darkness of the plant Or it is the cross between two plants where they differ in only one character.

Explaining Mended's Monohybrid cross:

Let's 'T' represent the alleles of the pea plant with dwarf character

Parental phenotype → Tall (TT) X Drawf (tt)

Gametes → T T t t

F_1 generation → Tt

Self-pollination → Tt Tt

F2 generation →

	T	t
T	TT	Tt
T	Tt	tt

Punnett's square

Phenotypic Ratio

5 Tall:1 dwarf

75%: 25%

Genotype Ratio

pure tall: Hybrid tall: Pure dwarf

TT:2Tt:tt

11.5 Conclusion drawn from experiment:

Mendel drew the following conclusion: Gametes must contain 'something' which makes a character appear in the next generation. This 'something' was called by him a 'Factor'

- These factor are inherited character which help in transmission.
- There are a pair of unit factor for each character one inherited from each parent Ex- height of pea plant control by 2 factors (……) and (tt)
- That time Mendel didn't know about genes even chromosomes.

- Certain factors do not express their character in the individual but such factor expressed in later generation. He derived 2 laws from above experiment:

1) LAW OF DOMINANCE: This law state that in a hetero zygote condition. One trait expressed over another trait.

One factor in a pair may express itself and present the expression of other. The factor that expressed is a dominant and the unexpressed one is recessive

2) LAW OF SEGREGATION: This law state that "the factors of each character segregate (separate)during gamete formation so that each gamete receives only one factor for each character and is always pure"

- From the above case he noted that in F_1 generation No intermediate size is appear between two parents from this he concluded that blending of character doesn't occur. since the gamete passes one gene of each character, they are always pure

CHECK YOUR PROGRESS 11.1

I. Choose the correct answer

1. An organism with two unlike genes of a part is called

a) Homozygous b) Heterozygous c) Both of these d) None of these

2. A gamete contains which of the following

a) Both alleles of a gene b) Only one allele a gene c) All alleles of a gene d) No allele.

3. What is the maximum no of allele that monohybrid cross can contain

a)1 b) 2 c) 4 d) 8

II. Answer the following questions:

1. Who discovered law of heredity?

2. Who rediscovered Mendel's law of Heredity?

3. What is monohybrid cross? and its ratio?

4. What kind of plant will be produced in F_1 and F_2 generation in the following crosses?

a) Pure tall X pure Tall
b) Pure Tall X pure Dwarf
c) Tall X pure Tall

11.6 DIHYBRID CROSS: A cross between two pairs of contrasting character Ex- Colour of pea and shape of pea

Or the cross between two plant which differ in two species character is called dihybrid cross

Explaining Mendel' dihybrid cross:

Phenotype of parents → Yellow Round X Green Wrinkled

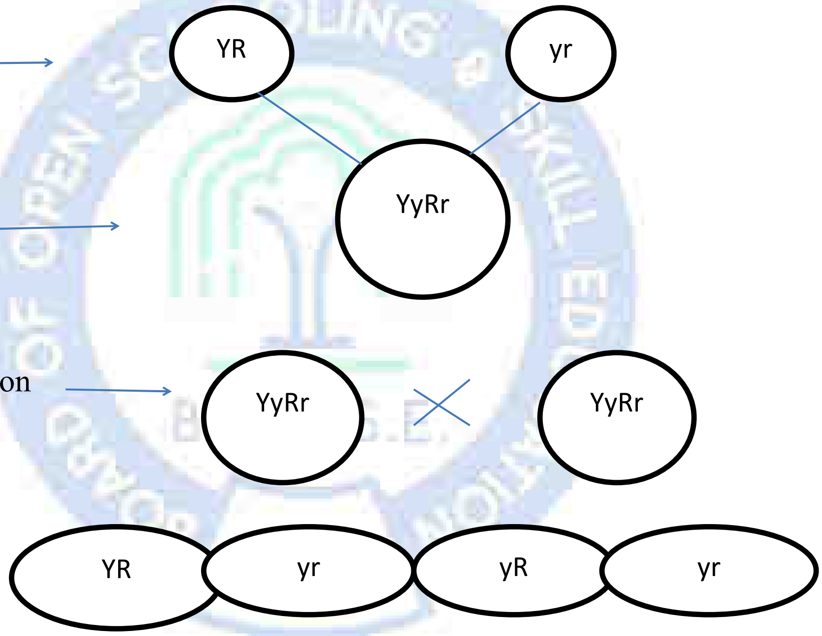
Genotype → (YYRR) (yyrr)

Gametes →

F1 generation →

………. of F1 generation →

Gametes →



F2 Generation

	YR	Yr	yR	yr
YR	YYRR Yellow Round	YYRr Yellow Round	YyRR Yellow Round	YyRr Yellow Round
Yr	YyRr Yellow wrinkled	YYrr Yellow Round	YyRr Yellow Round	Yyrr Yellow Wrinkled
Yr	YyRR Yellow Round	YyRr Yellow Round	YYRR Green round	YYRr Green Round
Yr	YyRr	Yyrr	yyRr	Yyrr

	Yellow Round	Yellow Wrinkle	Green Round	Green Wrinkle

Phenotypic Ratio- 9:3:3:1

9=Yellow round

3= Yellow Wrinkle

3= Green Round

1= Green wrinkle

3) LAW OF INDEPENDENT ASSORTMENT: This law that "gene of different character located in different pairs of homologous chromosome are independent of one another on their segregation during gamete formation"

CHECK YOUR PROGRESS 11.2

I) Choose the correct answers:

1. Mendel's second law is the law of

   a) Independent assortment b) Segregation c) Dominance d) Polygenic inheritance

2. Phenomenon of an allele of one gene suppressing the activity of allele of another gene called

   a) Dominance b) Suppression c) ……. d) Inactivation

3. Gene A and B are necessary for normal hearing. What is the possible genotype of animal child of deaf Father/Mother

   a) aabb b) aaBB c) AaBb d) Aebb

4. Gametes of AaBb individual can be

   a) AaBb b) AB,ab,AB c) AB,ab d) AB,Ab,aB,ab

II) Fill in the following blanks with suitable words

a) Genes always work in____________
b) In pea plant, gene for dwarfness is ________________ where as for tallness B

c) Human gametes contain _________ chromosome where as a normal body cell has _______________ chromosome

d) The _____________ chromosomes for a ____________ a XX and that for a _____________ are XY

11.7 SUMMARY OF MENDEL'S HYPOTHESIS

The summary of Mendel's hypothesis given below uses terms prevalent in genetics these days.

1) Each trials of an organism is controlled by a pair of alleles (principle of unit characters)
2) In an organism having too unlike alleles for a given traits, one (the dominant allele) may remain unexpressed (principle of dominant)
3) During gamete formation, the allele pairs of different traits segregate independently of each other (principle of independent assortment)
4) Each allele is transmitted from generation to generation as a discrete unchanging unit
5) Each organism inherits one allele for each trait from each parent.

11.8 EXPRESSION OF GENES

As per Mendel hypothesis traits are expressed by a pair of factors.

- Now a days these factors known as 'gene'
- Gene is a second of nucleic acid called DNA which codes for the formation of a protein, protein act as enzyme
- This protein controlling a specific character of the organisms.

DNA $\xrightarrow{\text{Transcription}}$ M-RNA $\xrightarrow{\text{Translation}}$ Protein $\rightarrow$ Character/Traits

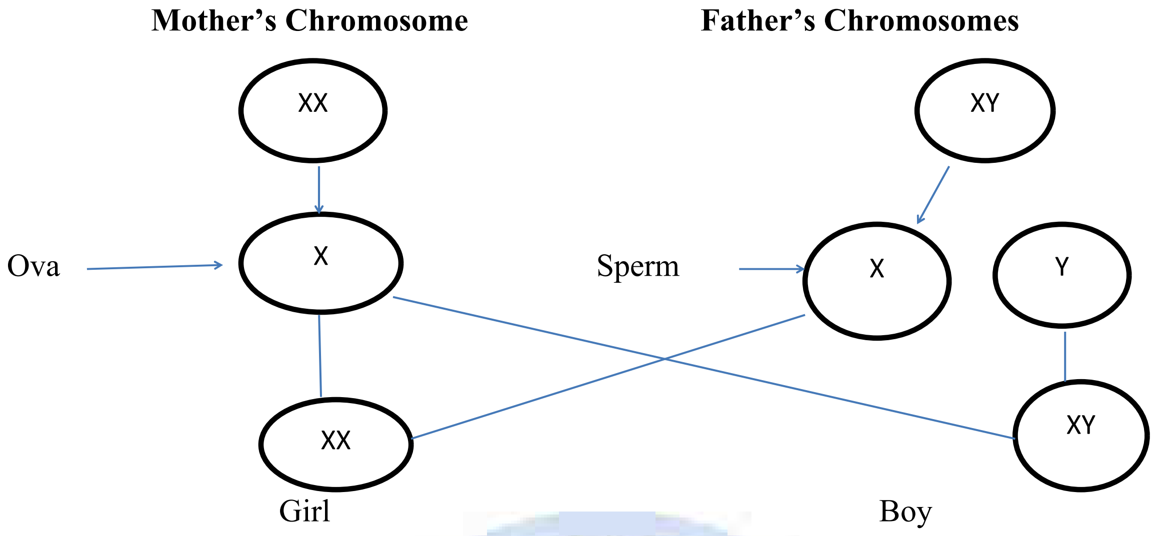
Replication

Ex- The gene for tallness will provide instruction to plant cell to make growth hormone

Due to the excessive secretion of growth hormones, the plant will become tall and on other hand, if plant has the set of gene for dwarfness, then less growth hormone will be produced due to which plant will grow less and become short

11.9 SEX DETERMINATION IN HUMAN BEINGS:

- In human there are 23 pair of chromosomes out of 23 pairs one pair is sex chromosome
- 22 pairs are called autosome and one pair is called sex chromosome
- Male have sex chromosome XY and female have sex chromosome XX
- During reproduction all children receive 'X' chromosome from mother and from father they may receive either 'X' or 'Y' chromosomes
- If a child receive 'X' chromosome from her father will be a girl, and one who inherit a 'Y' chromosome from him will be a boy
- The sex of a child depends on what happens at fertilization
- It is a sperm which determine the sex of the child.



In some animal, Sex determination is also controlled by the environmental factor Ex-

In case of turtle, under high incubation temperature leads to the development of female offspring

In case of lizard, under high incubation temperature leads to the development of male offspring

11.10 SEXUALLY TRANSMITTED DISEASES (STD'S)

Diseases that spread through sexual contact are termed as sexually transmitted diseases. A person can get STD's from an infected person by semen, blood or vaginal and other bodily fluids/discharges. Also, parasites, virus and bacteria can also transmit these diseases from one individual to another.

However, there are instances where the disease can spread through a non-sexual contact such as in the case of mothers to their infants during pregnancy or childbirth, or through shared needles and transfusion of blood from a donor.

STDs can be asymptomatic too and it can happen that individuals that seem perfectly healthy might be unaware that they have been infected. Some of the common STDs are- Gonorrhoea, Chlamydia, Herpes, Syphilis, AIDS.

A person can avoid STD's by practicing simple life principals as:

(i) Not having sex with unknown people and avoiding multiple partners.

(ii) Using condoms that prevents direct sexual contact.

(iii) In case of infection consulting a qualified doctor without shame or guilt owing to social pressure

(iv) Getting complete treatment if diagnosed with disease.

RECAPITULATION POINTS

- Heredity is a transmission of characteristics of parents to offspring through one generation to other.
- Gregor Mendel known as father of genetics.
- Genetics is the scientific study of the mechanism of inheritance of characters from parents to offspring.
- Variation is defined as difference between individual organism or group of organism of any species.
- Variation can be caused by genetically or by environmental factors.
- Mendel did his experiment on garden pea plant (pisum sativum) and he formulate the clear-cut principle of law of heredity.
- The male three basic law of inheritance
  - (i) Law of Dominance
  - (ii) Law of Segregation'
  - (iii) Law of independent assortment
- When parents with different traits are breed, dominant trait are always present in the first generation. Recessive trait is not visible in the first generation but reappear in the second generation.
- Mendel figured out the Ratio of dominant to the recessive traits.
- To cross the two plants with different traits, Mendel collected pollen from a tall plant and pollinated a short plant with it. This created 'Hybrid' varieties.
- Monohybrid cross is a cross between one pair of contrasting characters E.g. Cross between tall and dwarf pea plant.
- Dihybrid cross is a cross between two pairs of contracting characters E.g. shape of seed and colour of seeds and its phenotypic Ratio is 9:3:3:1.
- All the traits or characters controlled by a factors or gene.

- Gene codes for the certain protein or enzymes.
- Sex of child i.e male or female is determined by the sex chromosomes. In male it is 'XY' and in the females it is 'XX'
- After fertilization if the zygote receive 'X' chromosome from mother and 'X' chromosome from father the resulting offspring is a girl.
- If zygote receive 'X' chromosome from mother and 'Y' chromosome from father the resultant child will be a boy.
- Sexually transmitted diseases are caused from an infected person by semen, blood or vaginal and other bodily fluids/discharges.
- Proper care and treatment must be taken in case of STD.S

TERMINAL EXERCISE

Q1 Name the scientific terms used to represent the following:

a) The branch of biology which studies heredity and variation

b) The transmission of traits from parents to off springs

c) Differences in a trait in human being

d) A recognizable feature of an organism

Q2 Why off springs differ from parents?

Q3 Do genetic combination of mother helps in determining sex of a child?

Q4 What is the importance of Variation?

Q5 Explain Mendel's hypothesis.

Q6 Explain Mendel's laws of inheritance in brief.

Q7 What are variations? Give advantages of variations.

Q8 What is law of independent assortment?

Q9 What is a dihybrid cross

Q10 What are the chromosomes XY and XX known as?

Q11 Which of the two, sperm or ovule, decides the sex of child?

Q12 How genes control the characteristics of traits?

Q13 Explain the following terms:

i. Monohybrid and dihybrid cross
ii. Dominant and recessive trait
iii. Homozygous and heterozygous

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 11.1

I) Choose the correct answer:

a) Heterozygous

b) Only one allele of a gene

c) 2

II) Short Answer Question

1. Gregor Mendel

2. De Varies and Carl Correns

3. The cross between one pair of contrast character is called Monohybrid cross E.g Tall plant and dwarf plant and its ratio is 3:1

a) Tall b) Tall c) Tall and dwarf

CHECK YOUR PROGRESS 11.2

I) Short Answer Question

1 **Law of independent assessment: -** This law state that the gene of different character located in different pairs of homologous character are independent of one another in their segregation

2 **Dihybrid cross: -** The cross between two pairs of contrasting character is called dihybrid cross

3 Sex chromosome

DNA Transcription Translation

→ M-RNA → Protein

Replication ↓

Character/Traits

II) Choose the correct answers:

1 a) Law of segregation

2 b) Dominance

3 c) AaBb

4 d) AB, Ab, aB, ab

III) Fill in the blanks

a) Pair

b) Recessive, Dominance

c) Half set

d) Sex, female, male

12

THE ENVIRONMENT WE LIVE IN

INTRODUCTION

In this unit, let us we will learn about environment and its related components and issues. Our body is made up of several systems. In brief, if I consider my body as system then anything surrounding this system is environment. Just imagine in the morning, you have stepped out of your house and are standing in the open field close to your house, and then the house, sunlight, wind, trees and plants, animals around you together constitute 'Environment'.

Fig. 12.1 Environment

An environment consists of living and nonliving components. These components are interdependent. If any component has higher or lower concentration than normal, it directly or indirectly affects the presence or absence of another. Let's assume in a sanctuary only deer are there. There is no predator and plenty of food in the form of grass and green plants is available in the forest. What is expected here? What would happen to the number of deer? In presence of plenty of food and other favorable conditions the number of deer will increase at a high rate. The over population of deer will exert pressure on food supply and grasses will be exhausted. This would result in severe competition (intraspecific competition) for food, space and other required substances for survival. Ultimately a large number of deer would die and population concentration would decrease resulting in increase in the number of grasses (food concentration).

Not only the living and nonliving components, but living components are also related to each other in terms of prey and predators and energy flow. After the death of living beings, the dead and disintegrated components of bodies are added to the environment through several steps of conversion and in cyclic manner individually. These are called as biogeochemical cycles.

In this unit we will learn about living and nonliving components of the environment, the interdependence among the biotic and non-biotic components. We will also learn about the food habit of different animals and their dependence (**predato**r) on other animals (**pre**y). Whether plants or animals, all the living organisms are composed of inorganic and organic substances. The complex organic substances store energy within the chemical bonds of the molecules. After the death of the organism, body decays due to activity of bacteria and fungi and the complex organic substances are broken down into simpler substances. The latter are added to the environment.

Specifically, in **Section 1** we will discuss about the basic knowledge about ecosystem and its abiotic and biotic components.

In **Section 2** we will discuss about food chain, food web and biotic components of different levels of food chain in details.

In **Section 3** we will learn about the flow of energy in food chain, the different types of energy pyramids and 10% law of energy.

Section 4 is dedicated to biogeochemical cycles and their types and importance in maintaining normal ecosystem.

As this unit deals with environment so a close and sincere observation of the surrounding, a field trip, walking in a park or strolling in school garden will help you to understand this unit better.

12.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to

- Recall the definitions of food chain, food web, biogeochemical cycle etc.
- Calculate the flow of energy at each trophic level.
- Analyze why the energy flow drops in each successive trophic level.
- Construct food chain by watching an ecosystem
- Solve day to day life problem (selecting food depending on the necessity of the body)
- Understand the importance of flora and fauna of the surrounding and take proper care of environment
- Take part in debate why afforestation is necessary for proper maintenance of temperature, Carbon di oxide, water and minerals in surrounding
- Understand different types of energy pyramids and will be able to construct different types of energy pyramids.
- Understand the significance of different types of biogeochemical cycles in ecosystem
- Praise the beauty of nature and realize the balance maintained by different types of flora and fauna in the ecosystem
- Discuss the necessity to maintain biodiversity and the significance of biodiversity in maintaining food web

12.2 ECOSYSTEM

Earth is a unique planet in solar system as most probably it is the only planet in universe which supports life. This uniqueness is due to many reasons. The most important reason is its distance from the Sun, which makes Earth not too hot or too cold. The Earth is surrounded by an atmosphere which has oxygen and CO_2 along with other gases. Oxygen and CO_2 are very crucial for survival of organisms. The air envelope also moderates the temperature on the earth surface. Apart from these factors earth has water, which is another crucial substance for survival. Moderate temperate helps to regulate different forms of water. All these factors together make Earth a habitable place. This way earth has evolved a life supporting zone on earth's surface, called as **biosphere**. Although the biosphere measures about 20 kilometers from top to bottom, almost all life exists between about 500 meters below the ocean's surface to about 6 kilometers above sea surface. You must be thinking that living organisms are found everywhere within this specified area of biosphere. Actually, it is not true. At several places in biosphere living organisms do not exist. Some of such places are some parts of glaciers; highly acidic or alkaline soil etc.

Do you know what the different existing forms of life in biosphere are? A part from plants and animals you might have seen other forms of life growing around us. During rainy season green, soft mosses grow on garden soil and plant pots. Mushrooms grow on soil or barks of the trees. Several diseases which affect us are due to some living organisms like bacteria, protozoans, fungi, and nematodes etc. These various forms of life can be divided broadly into three main groups, microbes, plants and animals.

You must be wondering what is environment and what relation it has with ecosystem. The **environment** is everything around us. Whatever is in our surrounding, whether it is living or nonliving together constitute environment.

The term "ecosystem" was first coined by Arthur Roy Clapham by the request of Tansley and used for the first time in a publication by Arthur and Tansley. The word ecosystem has arisen by the combination of two Greek words; "oikos meaning home and systema meaning system. An ecosystem may be natural for example forest, desert, river and artificial or human designed like park, aquarium etc. An **ecosystem** is a geographical area which consists of all the organisms and the physical environment with which these organisms interact. I hope now you have understood how environment and ecosystem are related.

Ecosystem may be natural like forest, river, ocean or artificial or manmade like park, pond, waterlogged rice field, zoo, aquarium etc.

12.2.1 Elements of ecosystem

We have already seen an ecosystem has two elements or components, nonliving physical component or **abiotic compone**nt and living or **biotic** component.

The nonliving physical components of the environment comprise the **atmosphere, hydrosphere** and **lithosphere**. The living or biotic component consists of microbes, plants and animals. These two components together determine the characteristics of organisms of an ecosystem. The abiotic factors are also known as external factors and they have a great impact on the characteristic, growth and survival of the biotic factors.

As you have learnt before, physical components of the environment consist of atmosphere, hydrosphere and lithosphere.

However, most of the ecologists recognize the following four categories of ecological factors:

(i) **Climatic factors** including light, temperature of air, rainfall or precipitation, humidity of air, wind, atmospheric gases.

(ii) **Topographic factors** constitute altitudes, height and direction of mountain ranges and valleys,

(iii) **Edaphic factors** which include formation, physical and chemical nature of soil

(iv) **Biotic factors** consist of microorganisms, plants and animals.

Let us now learn about these factors.

(i) **Climatic factors:** These factors include light, temperature, precipitation, atmospheric gases etc.

Sun is the main source of light and temperature. Sun is continuously radiating heat energy as electromagnetic waves

The atmosphere

The vast expense of gases which envelope the earth is called atmosphere. As we move up at higher altitudes from sea level, atmospheric pressure gradually decreases. Atmosphere close to earth surface is made up of specific gases at particular composition. In average, pure, dry air consists of Nitrogen (78%), Oxygen (21%), Carbon dioxide (0.03%) and rest is constituted by Argon, Helium, Ozone etc. A part from that air also consists of water vapor, solid particles like dust, smoke, ash and microorganisms and spores, pollen etc. presence of larger amount of dust, fog, smoke etc results in poor visibility of the soil.

Fig. 12.2 Atmosphere

Water vapour: It is the most variable gas in the atmosphere. It varies from place to place. Its variation depends on altitude, temperature, type of soil, presence of trees and plants, distance from sea beach etc. for example, at 30^0C a volume of air may contain up to 4% water vapour. At -40^0C it cannot hold more than 0.2%.

Solid particles: The movements of the atmosphere enable the dust and other solid particles to remain suspended in the air. The sources of origin of such solid particles are meteors, dust, smoke, ash, pollen, spores etc. Dust particles in air reflect light rays and give a beautiful red and orange hue during sunrise and sunset. Presence of large amount of water vapour, smoke, ash etc.in air reduces visibility.

(ii) Topographic factors:

The features of earth surface are called topography. Topographic factors include latitude, longitude, altitude of mountain range, direction of mountain range and valleys, steepness of mountain etc. topographic conditions influence the climate of an area by interacting with solar radiation, temperature, humidity, rainfall, latitude, longitude, altitude etc

(iii) Edaphic factors:

Edaphic factors relate to the soil. These factors include soil pH, soil texture, soil moisture, soil aeration, water drainage, mineral salt content etc. although regarded as abiotic factors of ecosystem but soil contains large amount of biotic forms in the form of bacteria, fungi, protozoans, plant roots, worms, arthropods and several other animals belonging to higher groups. The presence of these biotic forms influences the physical and chemical nature of soil. Edaphic factors affect the biotic components of the ecosystem.

(iv) **Biotic factors:** These factors include all living organisms like microorganisms, plants and animals. The living organisms interact with abiotic factors of the surrounding. Abiotic factors of a region influence the characteristics of the organisms.

12.2.2 Interdependence of abiotic and biotic components of Ecosystem

Biotic factors are very much dependent on abiotic factors. In fact, abiotic factors of a particular region determine the characteristics of biotic factors.

Let's us take few examples. In desert, normally temperature is high and atmosphere lacks water vapour. Sunlight is intense and soil has very less water. In such environment, plants are specially developed to have lesser number of leaves to reduce number of stomata and so the rate of transpiration. These plants also bear thorns which are modified leaves. In such plants, main stem (*Opuntia*), branches or petioles (*Acacia*) perform the function of photosynthesis.

Fig. 12.3 *Opuntia* **Fig.** 12.4 *Asparagus* **Fig. 12.5** *Acacia*

In above pictures in *Opuntia* main stem along with its branches have been modified into flat, leaf like structures to perform photosynthesis. In Asparagus, branches of the stem and in Australian *Acacia*, the petioles develop into flattened leaf like photosynthetic organs.

Likewise in cold arctic regions where the temperature is below zero degree and earth surface is covered with ice, the body of the animals remains covered with thick fur (Polar Bear) or feathers (Penguin). Some animals like whale which have adapted in such condition possess very thick fat layer below the skin which acts as insulating layer. The feet of polar bears are flattened and the underside is covered with fur which increases friction and helps them to walk on the ice. The exposed parts of the bodies like ear and nose in arctic fox are reduced to minimize surface area of contact with the surrounding cold temperature. Reptiles cannot survive in such region as reptiles are cold blooded animals. Cold blooded animals are not able to adjust their body temperature and possess the same temperature as the surrounding.

Fig. 12.6 Arctic Fox

Fig.12.7 Penguin

Fig. 12.8 Bottom of paw of Polar Bear

If we see around us we find there is close relationship among abiotic and biotic components. Green plants depend on sunlight, Carbon di oxide, water and minerals for preparing food. All animals depend directly or indirectly for food on plants. We utilize Oxygen for respiration, which is released by plants. A thickly populated area with fewer numbers of plants has more concentration of CO_2 than a thinly populated area with plenty of plants. Thus abiotic and biotic factors of an area are interdependent.

CHECK YOUR PROGRESS 12.1

1. A place is located close to the sea. What will be the expected humidity and temperature at such region? Justify your answer.
2. Crocodiles are not found in Arctic Ocean. Justify your answer.
3. Which is the most variable gas in the environment? State reasons for its variability?

Activity 1

Collect a list of ten plants and ten animals growing in at least 3 different types of surrounding condition and fill up the following table.

S. No.	Name of the organism (mention whether plant or animal)	Type of surrounding condition	Characteristics

Activity 2

Collect pictures of different animals, observe their characteristics and find out the places where they live. Try to find out the characteristic adaptive features.

12.2.3 Food chain and food web

Look at the following picture. What do you see? Grasses and some animals are connected by few arrows, isn't it? On the basis of what are they related? If you observe carefully you will be able to find out they are related by food. Here one is eating and another getting eaten. Can you draw some more pictures like this where the organisms are related through food?

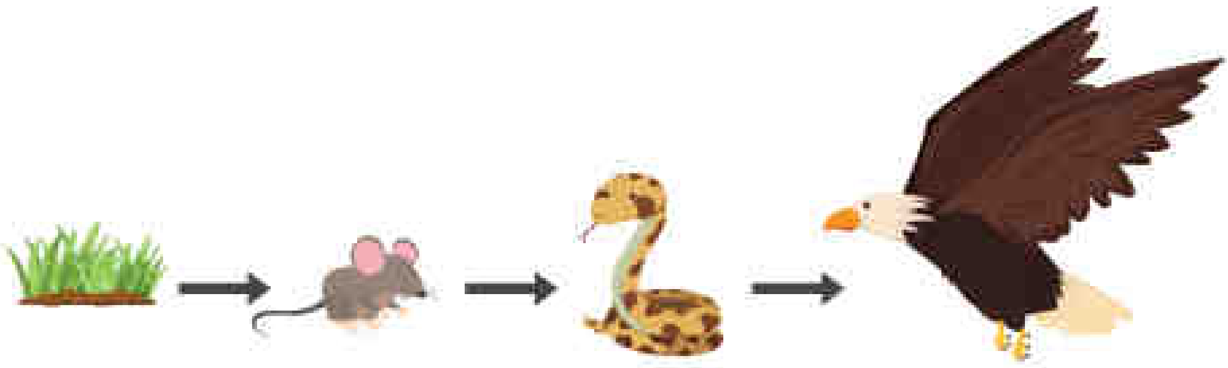


Fig. 12.9 Grassland food chain

12.3 Biosphere and its components

Biosphere consists of all the living components of the earth. They include microorganisms, plants and animals. Green plants take CO_2 from atmosphere and reduce it to carbohydrates with the help of H_2 evolved from water.

In an ecosystem, plants are being eaten by some animals, which in turn are being eaten by some other animals. We all know green plants and few chemosynthetic organisms are solely responsible for food production on the earth. Here food production truly means conversion of inorganic substances into organic substances. Rest of the organisms directly or indirectly depend on green plants for energy stored in food. As green plants are the pioneers in food production so they are called as **primary producers.** Herbivorous animals which feed on green plants are called as **primary consumers**. Grasshopper, deer, cow are the examples of primary consumers. Carnivorous animals feeding on herbivorous animals are called **secondary consumers**. Tigers, lions etc are secondary consumers.

12.3.1 FOOD CHAIN, FOOD WEB

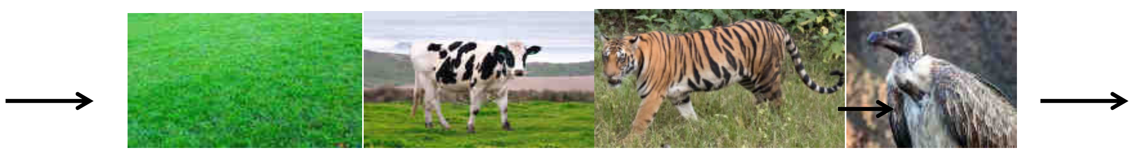
a) Food Chain

In an ecosystem, energy stored passes from primary producers to primary consumer to secondary consumer and then to tertiary consumer in a linked manner. Each link is called as **trophic level**.

The transfer of food energy from the producers, through a series of organisms with repeated eating and being eaten is known as **food chain**.

There are mainly two types of food chains.

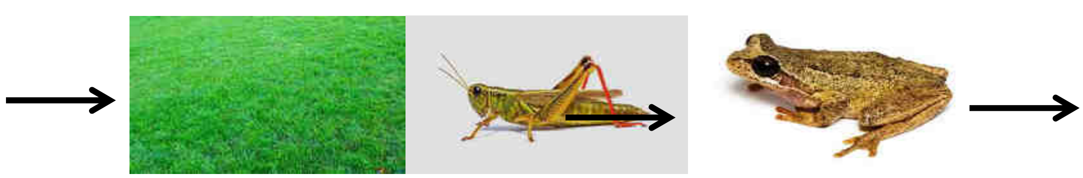
(i) **Grazing food chain.** It starts with green plants (primary producer), which are eaten by grazing animals like cow, buffalo, goat etc (primary consumers). Grazing animals are eaten by carnivorous animals like tigers (secondary consumers). After the death of the tiger hyena/vulture may feed on tigers or tiger's body is decayed and broken down into simpler organic substances and inorganic substances by microbes. These substances get mixed with the soil and provide minerals for the growth of the plants.



Grass Cow Tiger Vulture

Fig. 12.10 Grazing Food Chain

Grazing food chain is most common type of food chain. It is also found in grassland so is called as **grassland food chain.** The other



Grass Grasshopper Frog

Snake Falcon

Fig 12.11 Grassland Food Chain

In ocean food chain microscopic planktons which are **primary producers** are eaten by zooplanktons, the primary consumers. Which in turn are eaten by fish larvae; fish larvae are eaten by small fish and small fish by large fish.

(ii) **Detritus Food Chain**: This type of food chain starts from dead organic matter (DOM) and then moves to microorganisms and then to organisms feeding on detritus (detritivores), then to their predators. Such food chains are thus not directly dependent on solar energy. Such food chain operates in decomposing litter accumulated in forest floor. Detritus food chain also exists in aquatic ecosystem.

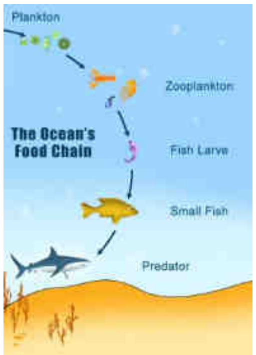


Fig. 12.13 Detritus Food Chain

B) Food Web

Food chains in natural conditions never operate as isolated and single directional sequence but are interconnected with each other forming interlocking system called **Food Web**. For example in a grassland ecosystem, grasses (primary producer) are eaten by grasshoppers, cows, deer (primary consumers). Grasshoppers may be eaten by frogs, birds, lizards, snakes (secondary consumers). Frogs may eaten by birds and snakes. Birds and snakes may be eaten by eagles, larger snakes or mongoose. Thus several food chains are interlinked through food.

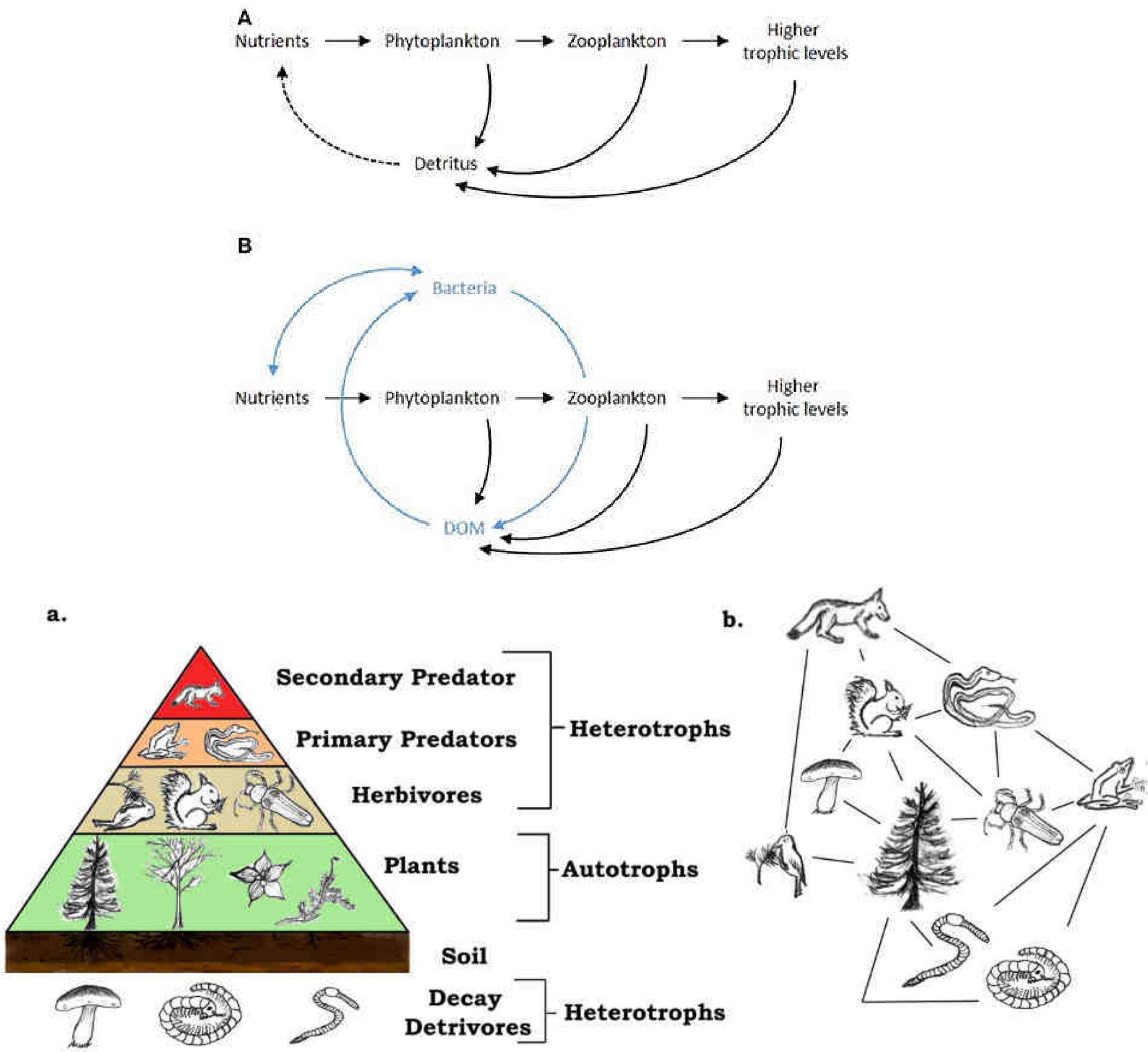


Fig 12.14 Trophic Food Web

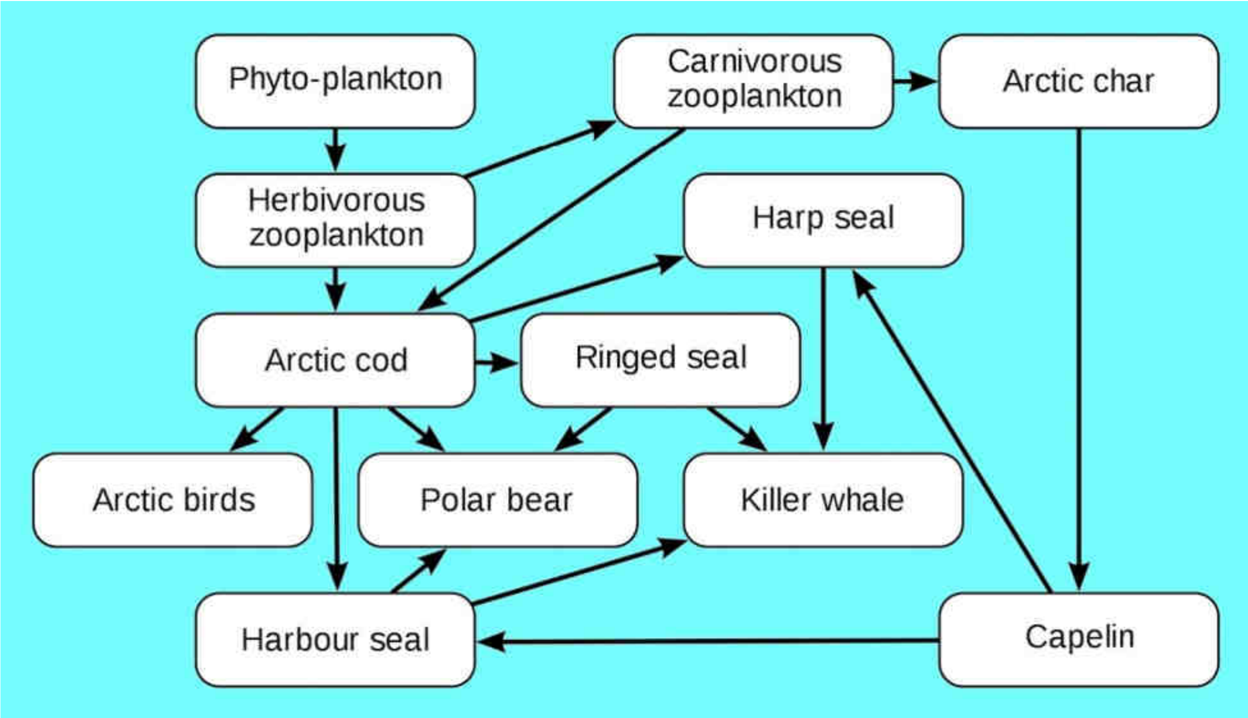


Fig. 12.15 Arctic Food Web

The above are examples of food webs existing in forest and arctic region.

CHECK YOUR PROGRESS 12.2

1. How does food web differ from food chain?
2. Observe your garden and aquarium carefully. Try to form food chain of both the systems. Do you find any difference between two food chains? What causes these differences?

Activity.3

Draw food chain and food web of pond ecosystem and color them.

12.4 ENERGY FLOW IN ECOSYSTEM

In a food chain, energy is provided by the food and there is flow of energy through different trophic levels in unidirectional manner. Plants trap solar energy and convert it into chemical energy. The behavior of energy in ecosystem can be termed **energy flow** due to unidirectional **flow** of energy.

Green plants convert solar energy and store it in the form of food.

- Primary producers in a terrestrial ecosystem can convert about 1% of the total solar energy falling on their leaves.
- Primary consumers feed on primary producers and receive about 10% of total energy converted by green plants. This is because plants utilize some energy for growth, maintenance, development and reproduction of the body. Quite some amount of energy is lost in the form of food.
- Secondary consumers feed on primary consumers and receive only 10% of energy as the rest of the energy is utilized for the development, maintenance of the body, reproduction. A large amount of energy is utilized as heat.

Thus at each tropic level, only 10% energy of what has been received as food is retained. Thus 10% can be taken as the average value for the amount of organic matter that is present at each trophic level and reaches to the next level of consumers. This is called as **10% law of energy**. Since much amount of energy is lost and very little amount of energy is available for next trophic level, so food chain usually does not continue after 4th level. The flow of energy in a food chain is as follows:

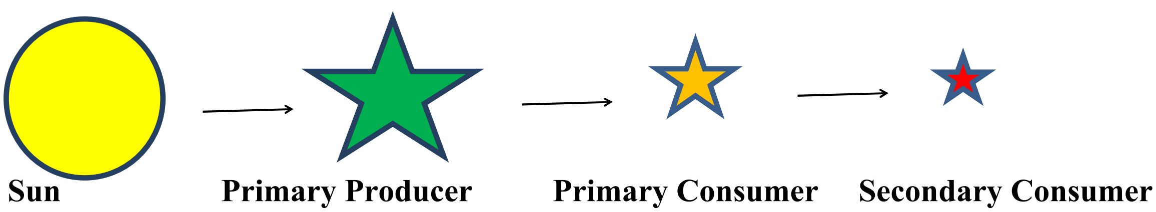
Primary Producer ⟶ Primary consumer ⟶ Secondary consumer ⟶ Tertiary consumers

The above representation states two important characteristics of flow of energy. Firstly energy in a food chain always flows in single direction. Secondly the energy cannot flow in backward direction.

Reymond Lindeman gave 10% of energy transfer law in food chains. According to this law the 10% energy is transferred from one trophic level to the next successive trophic level.

12.4.1 Energy pyramid

From the previous section we have understood the flow of energy reduces at each successive trophic level and it is always unidirectional. If we represent the flow of energy graphically it can be shown by pyramidal shape. This is called as **energy pyramid**. In most of the food chains, energy pyramid is an upright structure.



The above diagram exhibits the flow of energy.

As in each trophic level, a large amount of energy gets wasted so the energy at each level is reduced. The energy available at each successive trophic level reduces by 90% than the previous level. Let us now graphically represent the flow of energy in the form of pyramids. This is called as ecological pyramids or **energy pyramids.**

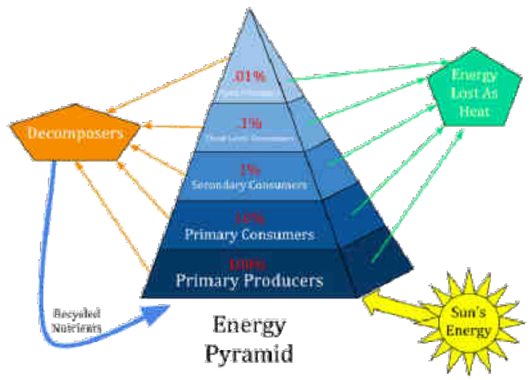


Fig. 12.16 Ecological Pyramids

CHECK YOUR PROGRESS 12.3

1. "Food web is a network of food chains". Justify the statement.
2. Construct and paint a food web including the following organisms

   Wolf, tiger, grass, frog, rabbit, buffalo, banana plant, grass hopper, snake, owl, rat, human, eagle, cow

3. A food chain with more than 4 trophic levels is almost absent. Why?
4. Do you find any difference between two food chains? What causes these differences?

Activity 12.4

- Draw a food web of pond ecosystem.
- Take a walk in the surrounding. Make a list of at least 15 animals found in your surrounding in tabular form categorize them into primary, secondary and tertiary consumers.

12.5 BIOGEOCHEMICAL CYCLE

Plants require large amount of water and different types of nutrients for their growth, maintenance of physiological processes and survival. Carbon, Nitrogen, Sulphur, Phosphorus, Calcium are just few among them. They avail CO2and some amount of water from the atmosphere. Rest of the nutrients is obtained from the soil. Thus these nutrients are constantly required for the survival of organisms. These inorganic substances are absorbed by the plants from the surrounding, converted to organic substances and stored as food. Animals feed on plants (herbivores) or animals (carnivores) and pass on the food to stake holders of next trophic level. After the death of the organisms the locked organic substances are converted to inorganic substances by the activity of decomposers on the dead body. So these substances are never lost but circulate in the ecosystem in cyclic manner. Movement of these substances in cyclic manner is called **biogeochemical or nutrient cycles**. The term biogeochemical refers to the consideration of biological, geological and chemical aspects of each cycle.

Biogeochemical cycle is the cycle in which nitrogen, carbon, and other inorganic elements of the soil, atmosphere, etc. of a region are converted into the organic substances of animals or plants and released back into the environment. Let us learn about some of these cycles.

(i) **Water cycle** (Hydrologic cycle)

Water is one of the most essential requirements for all the living organisms, but the earth has limited supply of it. Water keeps on changing its form and moves from one component to another of ecosystem. It gets stored in different reservoirs like ocean, sea, river, pond and other water storages. It evaporates in the form of water vapour and form cloud, the latter precipitates to come back to the soil which gets absorbed by plant roots. In living organisms water exists in free and bound form. Due to metabolism of the organisms and after their death some of water gets released in atmosphere. Thus water moves in cyclic manner in ecosystem which is known as **hydrologic** or **water cycle**. Hydrologic cycle was defined by the National Research Council (NRC, 1982) the as "**the pathway of water as it moves in its various phases to the atmosphere, to the earth, over and through the land, to the ocean and back to the atmosphere".**

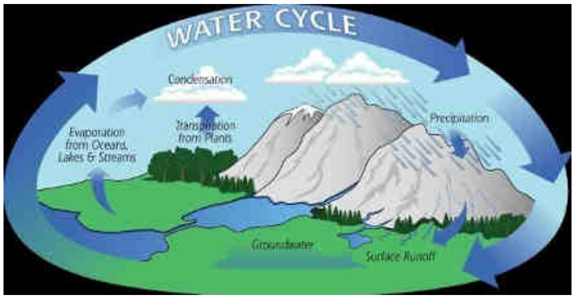


Fig. 12.17 Water cycle

The main force behind this water cycle is sunlight. The evaporation of water from the water bodies is mainly due to solar energy. The evaporated water comes back to the water bodies in the form of precipitation. Due to gravitational pull, a great amount of water moves down through the soil and reaches water table. Some amount of this water is absorbed by plant roots.

(ii) **Gaseous Cycle:** Type of biogeochemical cycle in which reservoir is the air or the oceans (via evaporation). For ex: carbon, oxygen, nitrogen cycle.

a. **Carbon cycle**

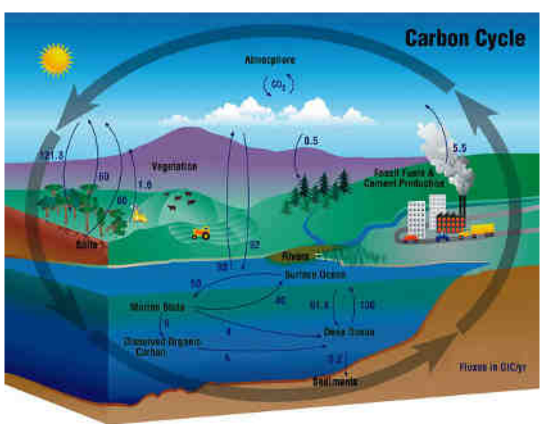


Fig. 12.18 Carbon cycle

Carbon cycle describes the movement of carbon as it is recycled and reused throughout the biosphere, hydrosphere and atmosphere of the earth. Carbon sinks in the land and the ocean each currently take up about one-quarter of anthropogenic carbon emissions each year. This is the most important among all the nutrient cycles of the earth.

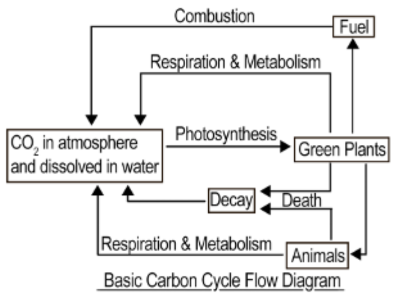


Fig. 12.19 Graphical representation of Carbon cycle

All of us know organisms are made up of organic and inorganic substances and the most important element present in organic substances is carbon. Carbon cycle describes about absorption of CO_2 and conversion of it to organic substances by green plants. Animals receive the organic substances from the plants as food. After the death of organisms organic products are broken down and released in the atmosphere in the form oxides of carbon.

b. **Oxygen Cycle:** It is the biogeochemical cycle that describes the movement of oxygen within atmosphere (air), biosphere and lithosphere. Oxygen is taken up by plants and animals from the air during respiration. The plants return oxygen to the atmosphere during photosynthesis.

c. **Nitrogen cycle:** Nitrogen is one of the most important nutrients required for the survival of organisms. It is one of the basic building materials in proteins, DNA, RNA and many more life forming molecules. It exists in nature in the form of dinitrogen gas(N_2)

Nitrogen is abundantly present in atmosphere, but it is not available to most of the organisms in free form as its very strong trivalent bond. It must get transformed to some chemical, absorbable forms which can be obtained by living organisms.

Nitrogen cycle is the biogeochemical cycle which describes the transformation of nitrogen in various chemical forms and its circulation among atmosphere, terrestrial and marine ecosystems. The conversion of nitrogen can be carried out through both biological and physical processes.

Nitrogen cycle can be studied in the following five different steps:

a) **Nitrogen fixation:** It is a chemical process by which molecular dinitrogen gets converted to NH_3 or some other forms of nitrogen and gets released in soil or aquatic system. The process is called as nitrogen fixation as free escapable nitrogen gets converted mostly to water soluble forms, gets added to the soil and fixed there. Nitrogen fixation takes place (a) **physically** during lightening nitrogen and oxygen combine to form oxides of nitrogen, which dissolve in rain water and reaches to soil, (b) **biologically** by free living microbes present in soil and by symbiotic microbes in the root nodules of certain leguminous plants.

b) **Nitrogen assimilation:** Plants absorb nitrogen in the form of nitrates which remains in water soluble form in soil and prepares amino acids and proteins. These are passed to animals through food chain.

c) **Ammonification:** In animal body, proteins are broken down into simpler substances like **urea**, uric acid, ammonia etc, which are released through urine and excreta. After the death of plants and animals the nitrogenous substances in the body are converted to ammonium compounds. The latter are then converted to ammonia by ammonifying bacteria.

d) **Nitrification:** Conversion of ammonia into nitrate is called nitrification. *Nitrosomonas* and *Nitrobacter* are the bacteria, found in the soil which converts ammonia to nitrate.

e) **Denitrification:** This is the process by which soil nitrites and nitrates are converted to nitrogen, which escapes into atmosphere. *Pseudomonas* and *Clostridium* like soil bacteria reduce soil nitrites and nitrates to nitrogen.

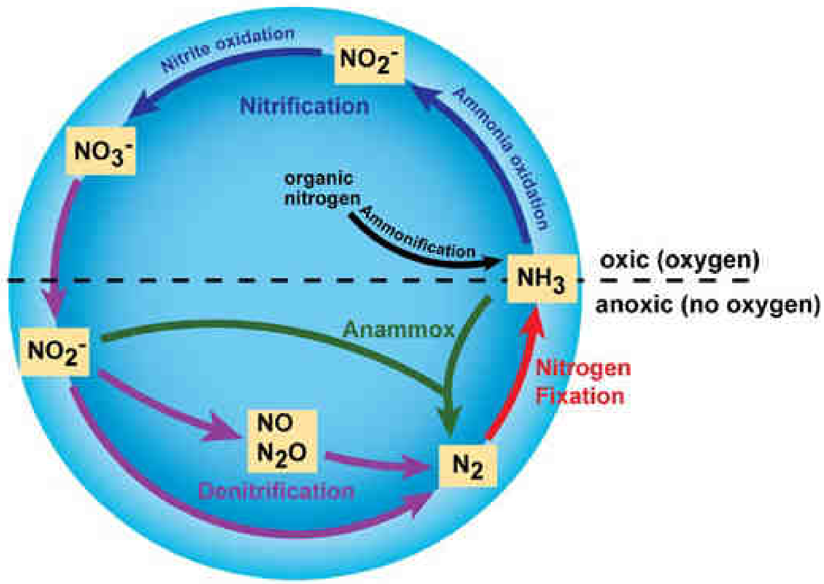


Fig 12.20 Nitrogen cycle

CHECK YOUR PROGRESS 12.4

1. "Denitrifying bacteria reduce soil fertility". Justify the statement.
2. Define nitrogen cycle. Why is it important for an ecosystem?

Activity.5

Nowadays a city has many concrete buildings. How will it affect water cycle? Discuss with your friends and make a report.

RECAPITULATION POINTS

- **Ecosystem:** It is a geographical area where living and nonliving components interact and are linked together through nutrient cycles and energy flows.
- **Abiotic and biotic components:** The nonliving and living components of an ecosystem are called abiotic and biotic components respectively.

- **Food chain and food web:** Food chain states about the link of energy transfer in the form of food among the living organisms starting from primary producers to consumers of different levels. Food web is the interlinking of many food chains.
- **Primary producers and consumers:** Autotrophs, mostly green plants are called as primary producers as they convert inorganic substances into energy rich organic substances, otherwise known as food. . Animals feeding on plants or on other animals are called consumers.
- **Ecological pyramids:** It is a graphical representation of availability of food at each trophic level.
- **Biogeochemical cycles:** The recycling of inorganic substances in between living components and their nonliving surrounding is called biogeochemical cycles.

TERMINAL EXERCISE

I. 1) What are biotic factors?

a. Non living parts of an ecosystem
b. Landforms and waterfalls
c. Living organisms in an ecosystem
d. Earth's weather and climate

2) The recycling of elements in an ecosystem is called

a. Chemical cycle
b. Biogeochemical cycle
c. Biological cycle
d. Geological cycle

II.

1. Form an ecological pyramid of numbers graphically considering a huge banyan tree as primary producer.
2. Assume there is no trash bin near your house. How will you manage daily trash?
3. How does food chain differ from food web?
4. Graphically represent food chain of a pond.
5. Why carbon cycle is important for an ecosystem?
6. What are ecological pyramids?
7. Why energy pyramid of numbers is inverted?
8. What is nitrogen fixation?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 12.1

1. The temperate will be moderate and humidity will be high. Due to cool evening sea breeze both the temperature and humidity will be lower than the daytime.
2. Crocodiles are cold blooded animals and so their body temperature varies with the surrounding temperature. In arctic region the temperature of their blood becomes low and the metabolism gets disturbed.
3. Water vapour is the most variable gas in the environment.

CHECK YOUR PROGRESS 12.2

1. Food chain is the representation of linear flow of nutrients and energy from one trophic level to another. Food web is network of several food chains.
2. Although both garden and aquarium are artificial systems but garden is an open system whereas aquarium is a closed system. The main difference between the two is in the number of trophic levels, the aquarium has fewer numbers of trophic levels than garden.

CHECK YOUR PROGRESS 12.3

1. Food chain is the basic representation of flow of energy in the form of food from producer to consumers. In nature, there are interconnections of different food chains as many consumers are herbivores and depend on green plants for their food. Likewise several secondary consumers may feed on a single type of primary consumers. Thus a large number of food chains become interlinked and form a food web.
2. Draw the food web

3. After 4^{th} trophic level the available energy becomes too less.

4. The difference occurs due to the type of organisms forming food chains. The number of trophic levels depends on the availability of energy in each level. The type of organisms depends on the habitat.

CHECK YOUR PROGRESS 12.4

1. Denitrifying bacteria disintegrates nitrates of the soil to free nitrogen which escapes to atmosphere, thus reduces the soil fertility.
2. All the organisms require a good supply of nitrogen for normal maintenance of growth, development and reproduction. Atmospheric nitrogen is inert and cannot be utilized by organisms. Conversion of nitrogen to nitrate increases soil fertility and thus nitrogen is absorbed by plants. The latter facilitates the entry of nitrogen in food chain.

SUPPLEMENTARY STUDY MATERIAL

- https://en.wikipedia.org/wiki/Food_web
- https://en.wikipedia.org/wiki/Biogeochemical_cycle
- https://www.britanicca.com/science/biogeochemical cycle
- NCERT Text Book of Science – Class X

13

ENVIRONMENTAL ISSUES

INTRODUCTION

You have already learnt meaning and importance of environment in the previous unit. Environment refers to the surrounding in which you live in, perform different activities for your survival and provides sustenance for leading a comfortable life. May it be biotic or abiotic component, producer or consumer from whom you drive your livelihood, different types of cycles you come across that provide you to sustain a comfortable life, for everything you have to be careful. If we do not take care for the healthy sustenance of our environment, we will face its consequences. Deforestation, pollution, urbanization, mismanagement of garbage, careless use of fossil fuels, war etc. affect our environment and we are solely responsible for this.

Besides, this nature also gets destabilised because of our irresponsible behavior and ultimately it also shows its unhappiness in the form of flood, cyclone, landslide etc. which we are unable to control so far. As a result, the equilibrium of the environment gets destabilised bringing misery to the whole human race. We must be aware of the environmental issues responsible for the miseries so that we may be able to minimize its impacts.

Let us try to learn these issues and its causes, and apply the remedial measures in our day-to-day life for sustenance of a comfortable life, at least better than before.

13.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Classify the environmental issues.
- Differentiate between human made and natural environmental issues

- Identify the human made environmental issues like pollution of water, air, noise and plastic and garbage production
- Explain the ill impact of plastic and garbage production as well as the pollution determinant
- Find out the causes of deforestation, urbanisation, depletion of fossil fuel and biomagnification
- Justify the ill effects of greenhouse effect and global warming and ozone layer depletion
- Be aware of the sources and problem of radiation
- Identify the natural environmental issues like flood, cyclone, earthquake, forest fire, tsunami and landslide
- Find out the causes and preventive measures to be taken during the above listed natural environmental issues
- Describe the meaning of sustainable development

13.2 CLASSIFICATION OF ENVIRONMENTAL ISSUES

It is always felt that we should maintain our livelihood in a healthy environment. Even different global summits involving developed or developing countries are regularly held to discuss "Environmental issues". Different components such as biotic and abiotic are found in environment which you have learnt in previous unit. We can find both the components in an environment developed in our surrounding in the form of an ecosystem. In an ecosystem, all organisms such as plants, animals, microorganisms and physical surrounding interact with each other and maintain a balance in nature. All the interacting organisms in an area together with the non-living or abiotic constituents of the environment form an ecosystem.

If you visit a garden, you find different plants, small or big, animals of different types beginning from microorganisms to insects, birds, frogs etc. All these living organisms interact with each other and their growth, reproduction and activities are affected by the abiotic components of the ecosystem. Besides this, when we visit forests, lakes, rivers, ponds, hills etc., we find a colourful picture of plants and animals living in our environment. These have been developed in nature and by nature, hence these are called natural ecosystems. But gardens, aquarium, crop fields etc. are human made or artificial ecosystem whose existence is completely human dependent.

Human activities leading to pollution, deforestation, global warming, urbanisation, radiation etc. play a definite role directly or indirectly in destabilizing the balance of our environment and damage it.

Simultaneously, there are a number of natural events like cyclones, earthquake, volcanic eruption, tsunami etc. which affect the natural as well as artificial ecosystems and thus influence the balance of environment.

Accordingly, environmental issues may be classified as 'human made' and 'natural' and to maintain equilibrium in environment the human race has to look after sustainable development to minimize the adverse impacts on our environment.

13.3 HUMAN MADE ENVIRONMENTAL ISSUES

Our daily activities like drinking, bathing, washing etc. depend on use of natural resources like water. Also, for going to school or work place, we use vehicles which consume fossil fuels and release toxic gases into atmosphere. Clothes, we wear are produced in factories which release toxic chemicals which is discharged into the environment. Food that we eat, is produced from agricultural fields by the use of chemical fertilizers and pesticides, which affect the soil and also get washed to our rivers with rain water.

All these human activities which have an adverse impact on the stability of our environment, create issues which are referred as human made environmental issues. Let us learn different environmental issues arising out of the developmental process and the need of combating for the betterment of human race.

13.3.1 Water pollution

Water is an inorganic, transparent, tasteless, odourless chemical substance. It is the main constituent of earth's hydrosphere and the fluid component of all living organisms. There are different sources of water such as ground water (through well, bore well etc.); Surface water like lake, river, stream, pond, tank etc.; rainwater; sea water.

Water pollution happens when toxic substances enter water bodies like rivers, ponds, lakes, seas etc. The toxic materials get dissolved in water as it is a natural solvent, or remain suspended in water or get deposited on the bed of the water body. Whatever may be the form, it degrades the quality of water. The water is called contaminated and may lead to diseases like diarrhoea, cholera, dysentery, typhoid, polio etc.in human beings.

There are different reasons due to which water gets polluted such as use of chemical fertilizer and pesticides, leakage from sewer lines, mining activities, sewage and waste water, industrial waste, marine dumping, accidental leakage of petroleum and many other humans made activities. Ground water pollution is also a serious issue. It gets polluted when comes in contact with fertilizers, pesticides, water leaching from landfills and septic system. Once the ground water gets polluted it remains unsafe for a very long period to use.

Particularly, plastic is a major source of water pollution.

Fig. 13.3.1 Factory, industries, sewer line emission and dumping of plastics

At best 14 million tonnes of plastics end up in ocean every year and plastics make up 80% of marine debris found from surface water to deep sea sediments. This causes problems not only to marine animals but also to humans. Chlorinated plastic can release harmful chemicals into surrounding soil which can then seep into ground water and other surrounding water sources and also the ecosystem. This causes a range of harmful effects on living beings.

Some activities can be planned to prevent/reduce water pollution:

- Disposal of toxic chemicals effectively so that they are free from polluting water bodies.
- Do not pour fat or grease down the drain
- Use of phosphate free detergent
- Use of less plastic
- Use the items those are easily recyclable
- Do not throw away medicines
- Avoid toilets for throwing household items and many more.

13.3.2 Air pollution

Pure air is a homogenous mixture of gases that surrounds the earth and helps in breathing of people, animals and plants. Air is made up of various gases such as Nitrogen, oxygen, argon, carbon dioxide and water vapours.

Human made air pollution:

Air gets polluted when solid particles and gases are added into the air-smoke from factories, dust, coal fuelled power plants, gas emissions from vehicles. Some air pollutants are poisonous. Inhaling them can increase the chance of health problems. Even air pollution affects us at home. It becomes difficult to escape from it. In some cases, you can see or smell air pollution.

Fig. 13.3.2 Factories, industries and vehicle emissions causing air pollution

Natural sources of air pollution:

Release of harmful hazardous substances into air from natural events like smoke from forest fire, ash and gases from volcanic eruptions, gas like methane emitted from decomposed organic matter in soil, are referred as natural sources of air pollution. Air pollution affects our health and is cause for most respiratory diseases. Lung problems in different forms occur. This help in spreading of bacterial and viral related diseases. It also causes cardiovascular diseases, cancer etc.

Air quality is measured with Air Quality Index (AQI). It shows how clean or polluted the air is.

Fig. 13.3.3 Industrial emission, burning of crop husk, forest fire

Air Quality Index:

AQI	Remark	Color Code	Possible Health Impacts
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

Source: Central Pollution Control Board

Ways to reduce air pollution:

Pollution can be controlled at the source and some of the measures are listed below:

- Using more of public transport
- Least use of plastic bags
- Prevention of forest fire
- Avoiding use of crackers
- Using filters for chimneys in factories
- Avoiding burning of garbage
- Practicing 3R concept – Reduce, Reuse and Recycle
- Prevent ozone depleting activities by reducing emission of choloroflurocarbons.

13.3.3 Noise pollution

Regular exposures to higher level sound cause adverse effects in humans and other living organisms. According to World Health Organisation (WHO), sound levels less than 70 dB (decibels) are not damaging to living organisms regardless of duration of exposure. Production of sound/noise for a longer duration from different sources in the environment, impacts human and animal life in different ways. Noise pollution happens due to vehicles, aircrafts, industrial machineries, loud speakers, crackers etc. It happens even at home due to television, music speakers etc. when used in high volumes.

Noise pollution causes health problems like headaches, high blood pressures, respiratory agitations, heart problems, hearing loss etc. It may even cause psychological stress, reduce productivity, interfere with communication, concentration, many hearing problems, increased anxiety, stress etc.

Prevention/reduction of noise pollution:

Prevention or reduction of noise pollution can be done in different ways within our limits. It is quite possible but there must be will power to meet such exigencies. We must look after the wellbeing of the elderly persons and patients who suffer from noise pollution very much.

Following actions can be taken to prevent/reduce noise pollution:

- Planting more trees
- Regular maintenance of vehicles and machineries
- Lowering the volume of television and music speakers at home
- Lowering the volume of loud speakers and least use of the same in public places
- Turning off appliances when not in use
- Use of ear plugs as and when necessary
- Reduce noise level at source
- Use sound bouncers/hard flat objects such as glass, hard bound floor and tile, adding carpet, furniture even some plants in rooms
- Using acoustic panels where noise production is more.

Noise pollution index:

Average sound level is one of the key noise pollution index. It quantifies noise as a single value of sound level for any desired duration. WHO defines noise level above 65 dB (decibels) as noise pollution. Noise becomes harmful when it exceeds 75 dB and is painful above 120 dB.

13.3.4 Soil pollution

Soil pollution or otherwise known as soil contamination or land pollution is caused by industrial activity, agricultural chemicals or improper disposal of waste materials. It poses risk to human health and/or the ecosystem.

Deforestation is one of the main cause of soil pollution. Living, working or playing in contaminated soil lead to respiratory diseases, skin diseases and other health related problems. Now it is clear that soil pollution is done mostly by human activities.

Fig. 13.6 Industrial dumping, local waste disposal, excessive use of pesticide and fertiliser

Types of soil pollutants:

- Sludge (coming from human, bird and animal excreta into soil). Biological agents work inside the soil to produce manures and digested sludge.
- Agricultural practices (profused use of chemical fertilisers and pesticides)
- Radioactive pollutants
- Urban and industrial waste
- Use of plastics (polycyclic aromatic hydrocarbons)
- Heavy metal pollutants – (Arsenic, cadmium, chromium, mercury, lead, copper and nickel). Sources of heavy metals are mining, industrial production (foundries, smelters, oil refineries, petrochemical plants, pesticide production, chemical industries), untreated sewage, sludge and diffused sources such as metal piping, traffic and combustion by products from coal burning power stations.
- Hydrocarbon as soil pollutant- Sources are coal, petroleum, natural gas. The coal ash, spillage of petroleum products cause soil pollution.

Prevention of soil pollution:

Soil pollution can be reduced or controlled in the following ways:

- Minimum use of pesticides
- Judicious use of fertilisers
- Growth of seeds can be controlled through improved cropping technique not in chemical means.
- Special pits should be selected for dumping wastes
- Controlled grazing and forest management
- Quality solid waste treatment
- Recycle and reuse the products
- Promote use of natural manure

13.3.5 Plastic and garbage production and its disposal

Plastic is everywhere in our life. It is used in product packaging, cosmetic ingredients, textiles, mobile phones and even in chewing gums. Every year 500 billion plastic bottles are produced worldwide. Plastics in the ocean is already more than 100 million tonnes of waste. It is forecasted that by 2050, sea and oceans could contain more plastic than fish. The average life of a single use plastic is 12-15 minutes, but it can take up to 500 years to disappear according to ‘Life out of plastic’. Govt. of India (December 6, 2021) has warned that India’s plastic waste generation has more than doubled in last five years. Maharashtra generated the largest amount of plastic waste (410,000 metric tonnes) in India in 2019 and Sikkim, Mizoram, and Tripura contributed the least to plastic waste generation. In 2020, the production volume of performance plastics in India was around 1.7 million metric tonnes. This shows it is high time now to bring a check on production and use of plastic in our country.

Reduction of plastic consumption can lessen its impact on the environment. Minimising the consumption of plastic is much simpler. There are some measures which you can adopt to reduce use of plastics:

- Avoid the use of single use plastics like drinking straw etc.
- Go for shopping with a cloth bag
- Stop using chewing gums. If at all you are interested, you can opt for natural and organic chewing gums.
- Avoid buying packaged product. Instead, you can buy more bulk food.
- Spread awareness to those who are around you about reducing use of plastics.
- Separate plastic garbage and send it for recycling. Don’t mix with organic garbage.
- Avoid using cosmetics that use microplastics. Use biodegradable brush and wear natural fabrics.
- Choose to reuse the plastics as far as possible.

GARBAGE:

Garbage is discarded or useless material, whatever may be the source. Some sources of garbage or waste are industrial waste, commercial waste, domestic waste and agricultural waste. General composition of waste generated in India is - food (about 24%), plastic 18%, paper and paper board (about 12%), rubber, and leather and textiles comprise over 11%.

There are seven most common types of garbage. They are:

- Liquid and solid household waste which is known as 'Municipal waste'.
- Hazardous waste- It may be toxic, inflammable, reactive
- Medical/hospital waste
- Construction and demolition debris
- Green waste- Waste from vegetable, tree, branches etc.
- Recyclable waste- Paper, cardboard, metal etc.
- Electrical waste

These are small but may create serious issues which shall be taken care.

Fig 13.3.5 Garbage disposal

Prevention/reduction of garbage waste:

Mostly the garbage or waste become cause of water pollution. There are some effective steps to prevent pollution because of production of waste.

- Repair, rather than replace broken household Items
- Replace single use plastic packaging, bottles and containers with reusable products.
- Reduce consumer waste
- Put waste in an appropriate place (in a compost pit prepared in your garden, container supplied by municipality, handover the dry waste and wet waste separately to municipality agents etc.)
- Reuse paper and plastics
- Convert old sheets, towels and clothing into wash rags.
- Follow the principle of ‘4Rs’ (Reduce, Reuse, Recycle, Rethink)

13.3.6 DEFORESTATION

Deforestation is the purposeful clearing of forest land. Forests have been cleared for agriculture and animal grazing. Moreover, it solves the purpose of construction, fuel requirement and manufacturing of usable things. Timber is useful in many ways for the society. Mining and establishment of industries requires clearing of forests.

Deforestation has also some positive effects. Cutting some specific trees provide scope for regeneration of plants, improved habitat for many species, management of forest health and help in shaping forest for future that ultimately provides good revenue.

But unethical selfish motives cause maximum deforestation which is incredibly harmful. Forests are most useful resources and provide us clean air, food, materials, natural habitats for a range of animals, climatic support etc. Even deforestation causes soil erosion, flood, destruction of forest habitat and the loss of biological diversity of both plants and animals. Deforestation also leads to excess of carbon dioxide in the atmosphere, climate crisis, desertification, global warming etc.

PREVENTION OF DEFORESTATION:

There are different ways of preventing deforestation. You must develop a feeling against deforestation and for any step being taken by you there must be a follow up action. The follow up action contribute a lot to meet the challenges of the environmental issues. The suggested activities are:

- Planting trees and taking care of it till they are grown up
- Use less paper and cardboard and use recycled products
- Protect wild animals and take steps through different organisations to prevent poaching.
- Less use of firewood
- Respect the rights of indigenous people and wild animals.
- Raise awareness among the peer and others in your locality.
- Support individuals or organisations that fight deforestation

- Report against illegal logging.
- Take active initiative in afforestation or reforestation activities.

Afforestation is an activity of plantation of trees on a land where no forest was existing since long (about 50 years back according to UNFCC -United Nations Framework Convention on Climate Change).

While, reforestation refers to replanting of trees on more recently deforested land. These two activities resolve problems created by deforestation in a particular area.

Fig. 13.3.6 Deforestation and afforestation

13.3.7 URBANISATION

Urban places are more consumer friendly as compared to rural areas. All sort of facilities and basic amenities are better available including employability and higher wages, better transportation facilities, more education opportunities, internet connections, more modernised equipment, as compared to rural areas. This attracts rural folk to move gradually to urban places leading to expansion of existing cities and towns. Hence, urbanisation refers to the population shift from rural areas to urban. The corresponding change in the population in both the areas and the ways in which societies adapt to this change are quite challenging.

Urbanisation allow the cities to grow and higher percentage of population comes to live in the city. Various causes of urbanisation are industrialisation, commercialisation, employment opportunities, modernisation and changes in modes of living, social benefits and services and rural/urban transformation.

Urbanization leads to excessive increase in city population leading to development of slums, poor nutrition, population related health conditions, communicable diseases, poor sanitation and housing conditions. Urbanization puts excessive pressure on demand for natural resources and facilities – food, water, energy etc., leading to environmental issues in terms of increase in pollution, increase in garbage and plastic waste, increase in discharge of wastewater. These environmental issues further deteriorate the overall quality of a city's life. The issues arising out of urbanisation can be put under control by different ways:

- Reducing the migration of people from rural to urban areas by creating employment opportunities in villages and small towns.
- Promoting urban agriculture with the help of slum dwellers in particular and urban population in general
- Making them aware of healthy diets
- Reducing and managing food waste
- Boosting green spaces for healthier environment
- Population control
- Creation of more employment opportunities
- Provision of essential services

Fig. 13.3.7 Urban area and slum

13.3.8 DEPLETION OF FOSSIL FUEL

If we keep using fossil fuels at our current rate it is estimated that all our fossil fuels will be depleted by 2060.

Fossil fuels are a finite resource and non – renewable. Once it is used, it cannot be created artificially. As you know, fossil fuels are made from decomposition of plants and animals. These fuels are found in the Earth's crust and contain carbon and hydrogen which after burning gives energy. Coal, petroleum and natural gases are examples of fossil fuels. They are named so because they were formed from the fossilised, buried remains of plants and animals, millions of years ago.

Reserves of fossil fuels are finite and not available everywhere on Earth. Gulf countries like Iran, Saudi Arabia etc have rich petroleum reserves, India and Australia have good reserves of Coal and countries like Russia and Norway are rich in Natural gas reserves.

Fossil fuels are used to run our vehicles, produce electricity, warm our houses as well as in production of substances like steel. Thus, our dependence of fossil fuels is very high. Almost 60% of electricity in India is produced using coal. Almost 75% of petrol and diesel used in our country is imported and about Rs. 7 lakh crore are spent every year, in its import.

Also, when fossil fuels are burnt, they release toxic gases into the atmosphere which contributes to the formation of smog and acid rain. These gases pollute our environment and affect our health.

Hence, we need to reduce the use of fossil fuels which will 3 benefits for us:

1. Conservation of fossil fuels reducing their depletion
2. Reduction in air pollution, cleaning our air and leading to better health
3. Saving of money, both personal as well as government's, which could be utilized for other developmental activities

Hence, we have to shift to other sources of energy than fossil fuels.

Prevention of fossil fuel depletion:

- Use more public transport.

- Optimum use of air conditioners and heaters at home.
- Use of more solar and wind energy.
- Optimum use of electric current at home.
- Use of more biogas in our day-to-day life.

13.3.9 BIOMAGNIFICATION

In the food chain, smaller organisms are eaten by higher organisms, which leads to transfer of energy and matter from one organism to another.

Biomaginification refers to increase in concentration of toxins with every step in a food chain.

Example: The toxic materials which contains heavy metals such as mercury, arsenic, chromium, lead, cadmium etc. reaches river bed through industrial waste and sewage. These are consumed by microorganisms which in turn are consumed by small fishes and then they are eaten by big fishes. Big fishes are consumed by human beings. The contaminated river water is used for watering crops and vegetables which become rich with toxic materials and these are consumed by human beings. In each stage of consumers, the toxic chemicals get magnified and when it reaches human beings the highest consumer, they suffer most from the ill effects of these heavy metals/toxic materials. In each stage of the consumer, the concentration of toxic materials increases 10 times i.e., by the time it reaches human beings the concentration becomes very high and suffering becomes the worst.

Causes of biomagnification:

- Products used in agriculture containing higher concentration of inorganic chemicals like pesticides and fertilizers.
- Industrial activities releasing the wastes carrying higher concentration of toxic materials.
- Organic contaminants: organic substances like manures and biosolids
- Mining by products like copper, cobalt, zinc, lead and several other toxic materials get subsequently biomagnified.

Effects of biomagnification:

People suffer from cancer, respiratory diseases, kidney problems, heart disorders, reproduction and development of all animals, destruction of coral reefs, disruption of natural food chain and ecosystem.

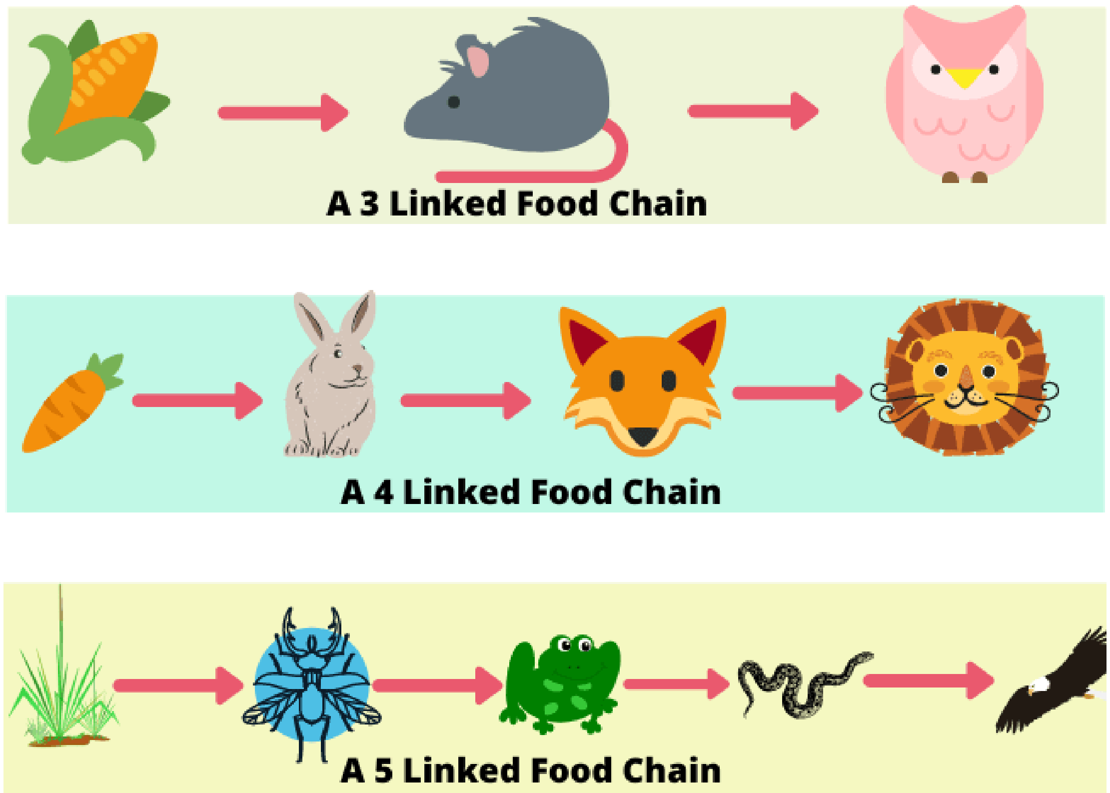


Fig. 13.3.8 Figure of food chain

Prevention of biomagnification:

All of us have to be conscious about biomagnification process and steps need to be taken with all seriousness. Following steps can be taken to prevent biomagnification:

- Avoid fishing/fishes from contaminated areas
- Avoid toxic chemical pesticides
- Avoid putting harmful substances into water system
- Cleaning of contaminated locale
- Elimination of the use of some heavy metals
- Institutions using toxic substances must be very careful for biomagnification

13.3.10 GREENHOUSE EFFECT AND GLOBAL WARMING:

Greenhouse effect is a process that warms the Earth's surface and the lowest layer of atmosphere (troposphere). It is caused by the presence of water vapour, carbon dioxide, methane and certain other gases in air. These gases are known as greenhouse gases and water vapour has the largest effect in keeping the Earth warm.

The atmosphere allows sunlight to reach Earth's surface. As Earth's surface is heated it radiates the part of this energy back towards space as infrared radiation. This radiation tends to be trapped by the green houses gases in the atmosphere, and reflected back to Earth's surface, raising its temperature.

Greenhouse effect is beneficial for the Earth in keeping it warm and maintaining the greenery as well as life in it. However, increase in concentration of greenhouse gases leads to increase in greenhouse effect which in turn is leading to global warming and so the climate change.

Causes of global warming:

The major causes of greenhouse effects are

- Deforestation creating imbalance in the atmosphere
- Burning of fossil fuels by our industries and vehicles
- Industrial waste creating imbalance in nature
- Smog and air pollution
- Acidification of water bodies

Impact of global warming:

The impact of global warming includes the following:

- Melting of glaciers leading to drying of rivers
- Rise in ocean level leading to submergence of land adjoining seas
- Ocean acidification impacting the marine life
- Extinction of species and migration of animals
- Extreme weather events like drought and heavy precipitation leading to floods

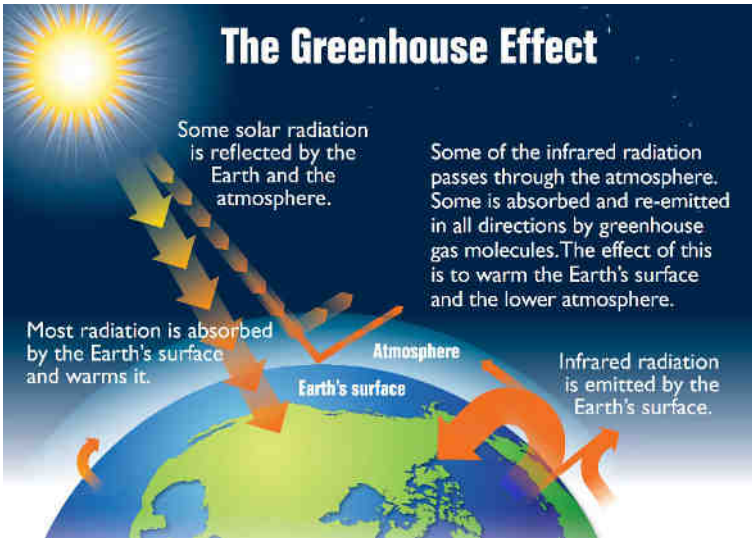


Fig. 13.3.9 Greenhouse effect

Activity 13.17

What steps can you take to reduce global warming in your surrounding?

13.3.11 OZONE LAYER DEPLETION

Ozone (O_3) layer present in the stratosphere prevents the entry of harmful ultraviolet rays from Sun into Earth. Ozone depletion occurs when chlorine and bromine atoms come into contact with ozone in the stratosphere. Chemical reaction between chlorine and bromine atoms and the ozone molecules leads to breaking of Ozone molecule. It is estimated that each chlorine atom released into atmosphere can destroy upto 1 Lakh ozone molecules.

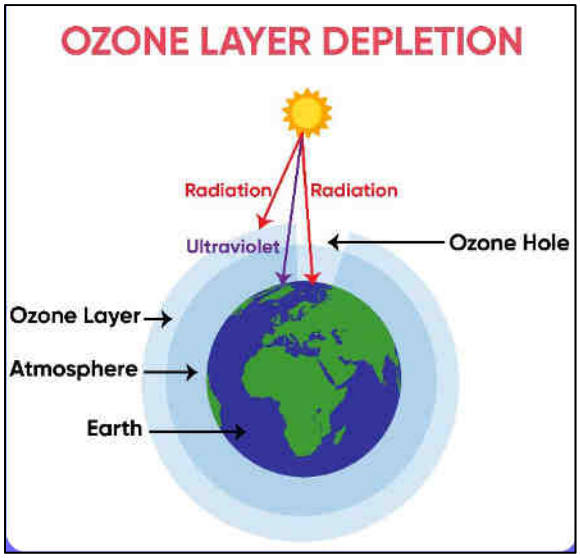


Fig. 13.3.10 Ozone layer depletion

Cause of ozone depletion:

Ozone depletion and ozone hole takes place due to release of choloroflurocarbons (CFC) in the atmosphere. In addition to this the following also plays an important role for the same:

- Unregulated rocket launches
- Nitrogenous compounds
- Foam blowing agents
- Halocarbon solvents

Effects of ozone depletion:

Following effects are observed due to ozone depletion:

- Ozone layer depletion causes ultraviolet rays to reach the Earth which is harmful for living organisms
- Skin cancer
- It damages our immune system
- It can lead to cataract in eyes and human ageing of the skin
- Sunburns in humans and animals

Prevention of ozone depletion:

Following are the means by which ozone layer depletion can be prevented to some extent:

- Minimise use of vehicles
- Use eco-friendly household cleaning products
- Avoid rampant use of pesticides
- Avoid manufacturing and use of gases dangerous to ozone layer

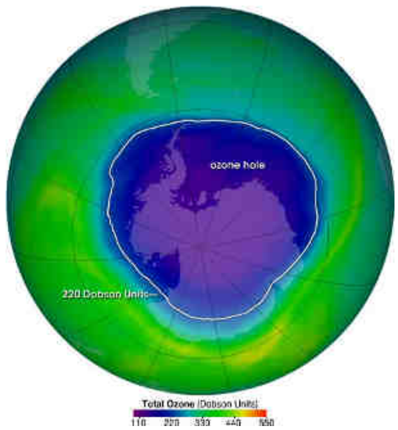


Fig. 13.3.11 Ozone hole

13.3.12 RADIATION

Source: Radioactive elements that occur naturally are Polonium, Rubidium, Thorium, Uranium, Radium, Samarium and Lutetium. Thorium commonly occurs in monazite. Monazite is an atomic mineral that occurs naturally in the coastal sands in certain areas. Besides monazite there are few other minerals known as THORITE (Thorium, Uranium and Silicate), THOROGUMMITE (Thorium, Uranium, Silicate hydroxide). MONAZITE has Cerium, Lanthanum, Thorium, Neodymium, Yttrium phosphate and many other minerals are also available. Uraninite (Uranium dioxide) is highly radioactive mineral.

Radioactive minerals can be identified with special instruments that detect radiation. Radiation is energy that comes from a source and travels through space. Electromagnetic radiations like gamma rays have an electric field and a magnetic field associated with it and travel with the speed of light. There are four major types of radiation 'alpha', 'beta', 'gamma' and X rays. They differ in mass, energy and how deeply they harm people and objects.

Examples of radiation:

Following examples need to be observed carefully in our environment. The simple examples are:

- Ultraviolet light from the Sun
- X-rays from the X-ray machine
- Sound waves from stereo
- Microwaves from a microwave oven
- Heat from a stove
- Visible light from a candle
- Electromagnetic radiation from mobile phone
- Alpha particles emitted from the radioactive decay of uranium.
- A laser beam
- Radio waves

Radiation therapy is very much in use for medical treatment which has got side effects also. Alpha rays are the weakest and can be blocked by human skin and gamma rays are the strongest and only dense elements like lead can block them.

Ill effects of radiation:

It is said that radiation also affects us negatively. We are very familiar with the name of atomic warfare. We remember the effects of atomic war on Nagasaki and Hiroshima in Japan during Second World War in 1945.These atomic explosions killed almost 1.5 to 2.5 lakh people almost immediately. People who remain alive after the explosion faced long term health effects like cancer and cardiovascular diseases, which spread genetically to generation after generation. Hence, we must be aware of the ill effects of radiation including the atomic war. During our regular life also we come across the effects of radiation. Few of those are mentioned here.

Radiation damages intestine, stomach, blood vessels, bone marrow which prepare blood cells.

Preventive measures against radiation:

Time: Radiation takes time to reach you which indicate that distance between you and source is more thereby causing less effect.

Distance: As you maintain distance from fire due to generation of heat likewise the dose of radiation decreases as you increase your distance from the source.

Shielding: Barriers of lead, concrete or water provide protection from radiation. For gamma rays it is difficult to penetrate such barriers. Beta particles are stopped by aluminium foils and alpha rays can be blocked by a few pieces of paper.

CHECK YOUR PROGRESS 13.1

1. **Select the correct statement from the options given under each item.**
   i. **Environmental problems exist because of:**
      A. Human made
      B. Nature made
      C. Both human and natural
      D. Neither human nor natural

   ii. **Plastic is a pollutant for pollution of ……..**
      A. Water only
      B. Air only
      C. Soil only
      D. All of the above

   iii. **Using loud speaker in a high pitch is a pollutant for …….**
      A. Sound/noise
      B. Water
      C. Air
      D. Soil

   iv. **Greenhouse effect in a large context is responsible for what …….**

A. Deforestation
B. Urbanisation
C. Global warming
D. Water pollution

v. **Radiation of gamma rays can be prevented by what?**

A. Concrete structure
B. Aluminium sheets
C. Paper sheets
D. Zinc sheets

vi. **Food chain is responsible for amplifying the toxic in living beings. What is the name of the process?**

A. Greenhouse effect
B. Radiation
C. Water pollution
D. Biomagnification

2. Match the following given in Column 'A' with that of 'B'

Column 'A'	Column 'B'
A. Ozone layer depletion	i. Alpha ray
B. Radiation	ii. Slum
C. Depletion of fossil fuel	iii. Sewage
D. Urbanisation	iv. Noise pollution
E. Water pollution	v. Ozone hole
	vi. Thermal power plant
	vii. Maximum toxification in human

3. Answer the following:

i. Who is known as 'Waterman' of India?

ii. How can you do rain water harvest in your house?

iii. What is the major source of marine water pollution?

iv. Why must the chimney of factories be covered with net/filter?

v. What is the meaning of RED in AQI (Air Quality Indiex)?

vi. Why must you separate dry and wet garbage before you hand it over to municipality vehicle?

4. Correct the following sentences with one or two words by changing underlined words:

i. Waste paper, cardboard etc. should be burnt.

ii. Protect air, forest by more use of fire wood.

iii. Pollution related health condition, poor nutrition and sanitation are result of deforestation.

iv. Install solar panels on your roof at home to prevent ozone layer depletion.

v. Avoid fishing from contaminated water as fishes may have more toxic heavy metals due to water pollution.

vi. Smog pollution may be the impact of greenhouse effect.

Activity 13.3.1

Make an observation of your environment. Prepare a list of processes by which air, water, noise and soil are polluted. All the processes noted in different localities need to be discussed in the study centre to find out the degree of awareness of the students.

Activity 13.3.2

Prepare a list of small-scale conservation activities for conservation of water in our country.

Activity 13.3.3

Prepare a list of at least seven household activities by which you can prevent or reduce water pollution.

Activity 13.3.4

Prescribe five activities you can take to prevent/reduce air pollution

Activity 13.3.5

List the causes of noise pollution in your locality.

Activity 13.3.6

Make list of activities which you can take up to reduce/prevent noise pollution in your locality.

Activity 13.3.7

Find out reasons of noise pollution even if there is high noise production at source (i) Cinema hall (ii) Language laboratories

Activity 13.3.8

Prepare a list for reducing soil pollution in your locality.

Activity 13.3.9

Prepare a list for reducing plastic waste in your surroundings.

Activity 13.3.10

Prepare a list of household garbage in your locality. Suggest the means of overcoming the challenges you all face.

Activity 13.3.11

Suppose some unused vacant space/land is there in nearby areas of your school or home. Draw a plan of action so that you can take up plantation activity in the vacant place.

Activity 13.3.12

Give suggestions to develop quality of life of slum dwellers

Activity 13.3.13

Name five activities that you can do daily to reduce use of fossil fuel

Activity 13.3.14

Observe your locality. Find out the process of biomagnification in your surroundings. Suggest means to prevent it.

Activity 13.3.15

What steps can you take to reduce global warming in your surrounding?

Activity 13.3.16

Discuss five measures to protect you from radiation

13.4 NATURAL ENVIRONMENTAL ISSUES

Environmental issues are defined as harmful effects to earth and its natural systems due to the action of humans directly. Some issues also occur due to indirect effect of human action or simply from natural causes. Most of issues which occur due to indirect impact of human actions but are known as natural issues are flood, cyclone, forest fire, land slide etc. Some of the issues that occur directly in nature are earthquake, tsunami etc. Whatever may be the immediate cause of the issues, ultimately the environment gets damaged and the dwellers (all living organisms) suffer.

Some things to do to save our planet earth as a student are:

- Reduce paper consumption
- Save electricity and water
- Bring reusable bags to the market
- Walk to school or take a bicycle or bike depending upon the distance
- Prevent food waste
- Stop littering
- Download an environmental app in your mobile
- Establish an Environmental club in your school/locality
- Any other activity you feel worthy to start/join

13.4.1 Flood

You all know what flood is. Some of you may have experienced also. Flood is an overflow of water from a river that submerges nearby land and habitat. It continues to remain in the submerged land till the water level comes down in the river bed. It is one type of natural disaster and occurs due to heavy rainfall during rainy season in the catchment areas or storm surge from a tropical cyclone or tsunami in coastal areas or rapid snowmelt on the mountain peaks.

Floods have large social consequences for humans beings. The impact of flooding includes loss of human life, damage to properties, destruction to crops, loss of livestock and cause of health hazards.

There are three types of floods:

- River floods- When water level run over river banks due to heavy rainfall in catchment areas

- Flash flood- An excessive amount of rain due to cloud burst etc. in a short period (usually within 6 hours) in hill zones.
- Coastal flood- Much larger water bodies usually during high tide in sea enter into coastal area.

River flood water can be controlled through barrages and dams and used for irrigation. Dams also form an ecosystem that supports fish and other aquatic animals, birds and other wildlife. During flood lot of alluvium flows down and the submerged land becomes fertile.

Prevention and making use of flood water:

- Warning systems must be set up so that people get sufficient time to save themselves and their livestock.
- Water harvesting system is to be used to store rain water preventing it to rundown unnecessarily.
- Plant trees (afforestation) strategically to prevent flood.
- Construction of barrage, dams in river bed and by two sides of river banks.
- Diversion of flood water in some other way to sea.
- Construction of sea wall to prevent tide from entering in the coastal areas.

Fig. 13.4.1 Flood affected areas

13.4.2 CYCLONE

A large system of winds that circulate about a centre of low atmospheric pressure in an anticlockwise direction in the north of equator in a clockwise direction in the South of equator.

Cyclones are characterised by inward spiralling winds that rotate about a zone of low pressure. The zone is known as eye of the cyclone. Cyclone is caused due to transfer of water vapour and heat from the warm ocean to the atmosphere. The warm moist air rises, expands and cools getting saturated, releasing latent heat through the conduction of water vapour.

Fig. 13.15 Cyclone

The study about the cyclone and forecasting about it is done by meterological department. The effects of tropical cyclones are heavy rainfall and flood, strong wind, large storm surges near landfall, land slide, very high tide over flooding coastal areas, loss of life, damage to properties.

In 2000, the World Meteorological Organisation (WMO) agreed to start assigning names for cyclones over the North Indian Ocean basin since September 2004, using a list of names suggested by the countries surrounding the ocean basin. The countries are Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand.

Types of cyclones as per severity:

Sl. No.	Types of disturbance	Wind speed in km/hr	Wind speed in knots
1	Deep depression	49-61	27-33
2	Cyclonic storm	61-88	33-47
3	Severe cyclonic storm	88-117	47-63
4	Super cyclone	More than 221	More than 120

Source: Indian Meteorological Dept. Each cyclone is named differently in order to avoid confusion in case of simultaneous occurrence of TCs over a region and keep a clear distinction among different cyclones. Use of short, distinctive given names in written as well as spoken communications is quicker and less subject to error. Moreover, it helps in creating awareness of its development and effectively disseminate warnings to much wider audience. Indian Meteorological Department is the agency responsible for naming the cyclones in south Asia.

Precaution from cyclonic effects:

- If your area is under cyclone warning, get away from low lying areas/beaches to the sheltering house.
- Leave much early before the landfall of the cyclone
- If your house is securely built on high ground, take shelter in the safe part of the house
- Trim tree around your home
- Listen to radio for information
- Stay indoors during cyclone
- Switch off electrical switches
- Keep your doors and windows shut

13.4.3 EARTHQUAKE

An earthquake is a sudden, rapid shaking of the ground. It causes fire, ground rupture, tsunamis, landslides or avalanches.

You all have experienced earthquakes in a smaller or greater degree. It is caused by sudden movement along faults within the earth. The movement releases 'hured-up' 'elastic strain' energy in the form of seismic waves. This is propagated through the earth and cause the ground surface to shake.

There are four different types of earthquakes- tectonic, volcanic, collapse and explosion.

a. A tectonic earthquake occurs when the earth crust breaks due to geological forces on rocks and adjoining plates that cause physical and chemical changes.
b. A volcanic earthquake occurs from tectonic forces which result in conjunction with volcanic activity.

c. A collapse earthquake are small earthquakes in underground mines and caves etc. that are caused by seismic waves produced from the explosion of rocks on the surface.
d. An explosion earthquake is the result of the detonation of a nuclear and/or chemical device.

(Source: UN-SPIDER Knowledge Portal)

Preventive measures to be taken to during earthquakes.

We cannot prevent earthquakes but we can restrict the damages. Stay away from the roads, move away from the buildings, stay in an open area, protect your head and neck with your arms or any way possible on your part. If near sea shore move to high place.

Few other measures can be taken up for personal safety:

- If you cannot stand on the ground, try to sit or remain seated so that you are not knocked down.
- If you are in a moving vehicle, stop as quickly and safely as possible.
- If you are outside, stay outside.
- If you are in a high rise building, stay inside and stay calm, try to get someone's attention.
- Do not stand in a doorway, you are safer under a table.

In addition to these, you can take programmes on earthquakes awareness, preparedness, prediction and warning systems. These measures may reduce the disruptive impacts.

13.4.4 Forest Fire

Forest fire is also known as wild fire, bush fire, wild land fire or rural fire.

Forest fire is an unplanned, uncontrolled fire in an area from combustible vegetation during summer. More than four out of every five fires are caused by people. Naturally occurring forest fire are most frequently caused by lightning. There are also other natural causes like volcanic eruption, falling of big meteor, coal fire etc. Depending on the circumstances, law has been enacted to prevent fire by human beings. Still it is continuing every year during summer season. You can see forest fire at night like a necklace on hill ranges.

Effects of forest fire:

There is a heavy loss to valuable timber resources, loss of biodiversity and extinction of plants and animals, loss of wildlife habitat, loss of natural vegetation and reduction in forest cover.

Types of forest fire:

a. Ground fire: Occurs below materials such as leaves and peat. These fires are slow moving, but when left unattended can take out large areas. This type of fire can hibernate below the surface during winter and re-emerge under favourable conditions.
b. Crown fire: Pose the highest risk by far due to their fast spreading behaviour. They develop on top of trees and in some cases can jump from one tree top to other and spread very fast.
c. Surface fire: These are most tame fires and can be put out relatively easily. These fires occur at the surface and create least amount of destruction.

(Lyndon G., Celeste Pomerantz, Jason Donev, 2019)

Prevention of forest fire:

Forest fires can be prevented in the following ways:

- Obey local laws regarding open fires, or camp fires.
- Keep all inflammable objects away from fire in forest areas.
- Keep ready forest fighting tools nearby and handy in forest areas.
- Take care of disposing of fire sources.
- Never leave a source of fire unattended.
- Call 911 and inform authorities about the forest fire and your location.
- Keep sufficient water in reserve.
- Keep doors and windows of your house closed but unlocked.
- Do not have fire prone plantation of trees like eucalyptus etc. which are banned.

Negative effects of forest fire:

Forest fires have negative effects and you should be aware of such effects of forest fires:

- Forest fire cause 32% of global carbon monoxide and 10% of methane emissions as well as over 86% of soot emissions.

- About 84% of the ecoregions of conservation of global species diversity are at risk from forest fires.
- Changes in forest fire regions is one of the most significant threats to global biodiversity.

Source: Peter Hirschberger (2016)

Fig. 13.4.3 Forest fire

13.4.5 Tsunami

Tsunami is created due to earthquake, volcanic eruption, and other under water explosions in seas, oceans and lakes that have potential to generate tsunami. Tsunami is a series of extremely long water waves caused by aforesaid forces. These forces create waves in all directions away from their source in a very big way.

The sources of 71 percent of all occurrences of tsunami is at the "ring of fire" (series of volcanoes in deep ocean trenches in Pacific Ocean). The height of tsunami waves sometimes reach 100 feet (30.5 m). These walls of water (Tsunami borne) cause wide spread destruction when they crash ashore.

In deep water, tsunami moves very fast and has a long wavelength and a small amplitude. As it enters shallower water, it slows down and the wavelength decreases. This makes the wave taller. As waves slow down, they start to bunch together. So they have shorter wavelength than before. It grows taller and taller in height near the coast. The multiple waves of tsunami rush ashore like fast rising tide hit ashore with powerful current.

Preventive measures from hazards of tsunami:

- Go to higher place so that water cannot reach you
- If your house is on a higher place keep yourself away from window and door. Be on the side of a wall so that even if water enters your house you are away from the force of water.

Fig. 13.4.4 Tsunami

13.4.6 Land slide

Movement of a mass of rock/ debris down a slope under the direct influence of gravity is referred as landslide which may lead to large deformation and displacement. It happens in mountainous areas. It causes disastrous accidents. Earthquake and severe rainfall are important factors in triggering landslide. Landslide carries down to the vertically different types of debris particle such as materials with mainly fine particles, materials with even gradation and materials with mainly coarse particles.

Once a landslide occurs the rate of soil erosion by water, gravity and wind increases. Rain can get into rocks and cause them to become unstable. When unstable rock and soil get wet, they get heavier and start sliding. There are four types of sliding such as fall and toppling, slides (rotational and translational), flows and creep.

Effects of landslide:

The effects of landslides can be extensive. These are

- Loss of human life, property, livestock and crops
- Destruction of infrastructure
- Damage to land
- Loss of natural resources
- Disastrous flooding
- Great impact on health system and essential services like water and electricity supply and communication system.

Fig. 13.4.5 Landslide

Prevention of landslides:

As we see there are various direct methods of preventing landslides. These include:

- Modifying slope geometry
- Using chemical agents to reinforce slope materials
- Installing structures such as piles and retaining walls with iron nets
- Grouting rock joints and fissures
- Diverting debris pathways
- Rerouting surface and underwater drainage

13.4.7 SUSTAINABLE DEVELOPMENT

According to UNESCO, Sustainable Development is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable development is described as an approach to developing or growing by using resources in a way that allows for them to replenish and continue to exist for future generations. It is also about balancing the diverse needs of different communities to create a better quality of life for all.

Activities leading to Sustainable Development

Any activity which reduces the use of non-renewable resources and reduces the release chemical waste into the environment, can be considered as an activity leading to Sustainable Development.

Example 1- The household garbage from cooking organic matter may be reused by using it as a resource (manure) for kitchen garden. Here, the vegetables are used and the skin of the same are peeled and used to prepare manure through a compost pit. The manure can be used in the kitchen garden.

Example 2- Generating wind energy to provide power for homes and other buildings to meet their household requirements.

You will get detailed information about sustainable development in Unit 14.

CHECK YOUR PROGRESS 13.2

1. **Select the correct response from the options given under each item.**
   i. **The pollution of water is due to:**
      A. Carbon dioxide
      B. Both human made and natural
      C. Human made only
      D. Natural only

   ii. **The centre of cyclone is known as …………..**
      A. Epicentre
      B. Hypocentre

C. Focus
D. All of the above

iii. **During earthquake the location below the earth's surface where earthquake starts is called ………….**

A. Epicentre
B. Hypocentre
C. Focal point
D. Centre

iv. **…. is uncontrolled burning of plants in a natural setting spread based on environmental condition**

A. Plant fire
B. Wild animal fire
C. Common fire
D. Wild fire

2. **Answer the following:**

i. How tsunami takes place?
ii. Where does landslide take place?
iii. What is the cause of flood?
iv. Tapping wind energy is an example of what?

3. **Match the following**

Column 'A'	**Column 'B'**
A. Flood	i. Tsunami
B. Cyclone	ii. Cloud burst
C. Earthquake	iii. Wind pressure
D. Forest fire	iv. Sustainable development
E. Landslide	v. Overflowing of water from river
	vi. Hill ranges

Activities-2

Activity 13.4.1

Observe your landform and make a list of flood preventing measures for your area stating the reasons thereof.

Activity 13.4.2

Draw an action plan to remain safe at your home during cyclone

Activity 13.4.3

Draw an action plan to stay safe in your school and home during earthquake.

Activity 13.4.4

Suppose you stay nearby a forest area. Draw a plan of action to prevent forest fire in your locality.

Activity 13.4.5

List 10 activities that you may take leading to sustainable development. Practice it for 10 days. Make a chart with date and time when you practiced a particular activity

RECAPITULATION POINTS

There are different environmental issues. Some of the environmental issues are human made and some are natural. To have control over environmental issues we have to be careful and we are to be very cautious to manage issues. For the sustainable development to be taken care we should control the nature to our benefits for sustenance of our livelihood. The human made environmental issues are quite challenging and to control them, we need to identify them and take remedial actions. The human made environmental issues are

- Air, water, noise, soil pollution etc.
- Plastic and garbage production and its disposal
- Deforestation and its control
- Urbanisation and its management
- Depletion of fossil fuel and controlling its use
- Biomagnification and its management
- Greenhouse effect and global warming and their control
- Ozone layer depletion and the protection of the ozone layer
- Radiation and the process of surviving from its ill effects

Natural:

Flood, cyclone, earthquake, forest fire, tsunami, landslide: Cause of their occurrence and the process of protection from the hazards.

Concept of sustainable development.

TERMINAL EXERCISE

1. Identify causes of air, water, noise and soil pollution.
2. How will you reduce air, water, noise and soil pollution?

3. What are the impacts of plastic on life?
4. How is the garbage being disposed of?
5. Suppose you live in a forest. What steps can you take to check forest fire?
6. Why does urbanisation take place? What measures you must take to maintain a healthy life in slum areas?
7. What steps should you take to check depletion of fossil fuel?
8. What relationship the biomagnification and food web have?
9. To reduce global warming what remedial measures should be taken?
10. How the radiation becomes harmful for life management?
11. How does tsunami take place? What preventive measures can be taken for survival?
12. How does deforestation become the cause of landslide?
13. What is the meaning and types of sustainable development?
14. How to escape from the effect of cyclone?
15. What is the meaning of cyclonic landfall?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 13.1

1. i. – C
   ii. – D
   iii. – A
   iv. – C
   v. – A
   vi. - D

2. Column 'A' Column 'B'

Column 'A'	Column 'B'
A	V
B	VII
C	I
D	VI
E	II

F	III

3. i. Sri Rajendra Singh
   ii. By draining full rainwater to a corner where a big tank or small well inside soil will be prepared
   iii. Plastic
   iv. Prevent air pollution
   v. Unhealthy
   vi. For recycling

4. i. Recycle
   ii. LPG gas
   iii. Urbanisation
   iv. Fossil fuel
   v. Biomagnification
   vi. Global warming

CHECK YOUR PROGRESS 13.2

1. i. – B
   ii. – A
   iii. – B
   iv. – D
2. i. Earthquake under sea
   ii. Barren hill ranges
   iii. Heavy rainfall in catchment areas
   iv. Sustainable development

3. Column A Column B

Column A	Column B
i	V
ii	III
iii	I
iv	VI

v II

SUPPLEMENTARY STUDY MATERIAL

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2. NCERT (2008). Science Text Book for Class IX.
3. Verma, P. S. (2021). ICSE Biology Science for Class 9, 10. Part-3 Oswaal Books. New Delhi.
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14 SUSTAINABLE DEVELOPMENT

INTRODUCTION

You have already learnt meaning and importance of environment in the previous unit. Environment refers to the surrounding in which you live in, perform different activities for your survival and provides sustenance for leading a comfortable life. May it be biotic or abiotic component, producer or consumer from whom you drive your livelihood, different types of cycles you come across that provide you to sustain a comfortable life, for everything you have to be careful. If we do not take care for the healthy sustenance of our environment, we will face its consequences. Deforestation, pollution, urbanization, mismanagement of garbage, careless use of fossil fuels, war etc. affect our environment and we are solely responsible for this.

Besides, this nature also gets destabilised because of our irresponsible behavior and ultimately it also shows its unhappiness in the form of flood, cyclone, landslide etc. which we are unable to control so far. As a result, the equilibrium of the environment gets destabilised bringing misery to the whole human race. We must be aware of the environmental issues responsible for the miseries so that we may be able to minimize its impacts.

Let us try to learn these issues and its causes, and apply the remedial measures in our day-to-day life for sustenance of a comfortable life, at least better than before.

14.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Differentiate between human made and natural environmental issues
- Identify the human made environmental issues like pollution of water, air, noise and plastic and garbage production
- Explain the ill impact of plastic and garbage production as well as the pollution determinant

- Find out the causes of deforestation, urbanisation, depletion of fossil fuel and biomagnification
- Justify the ill effects of greenhouse effect and global warming and ozone layer depletion
- Be aware of the sources and problem of radiation
- Identify the natural environmental issues like flood, cyclone, earthquake, forest fire, tsunami and landslide
- Find out the causes and preventive measures to be taken during the above listed natural environmental issues
- Describe the meaning of sustainable development

14.2 CLASSIFICATION OF ENVIRONMENTAL ISSUES

It is always felt that we should maintain our livelihood in a healthy environment. Even different global summits involving developed or developing countries are regularly held to discuss "Environmental issues". Different components such as biotic and abiotic are found in environment which you have learnt in previous unit. We can find both the components in an environment developed in our surrounding in the form of an ecosystem. In an ecosystem, all organisms such as plants, animals, microorganisms and physical surrounding interact with each other and maintain a balance in nature. All the interacting organisms in an area together with the non-living or abiotic constituents of the environment form an ecosystem.

If you visit a garden, you find different plants, small or big, animals of different types beginning from microorganisms to insects, birds, frogs etc. All these living organisms interact with each other and their growth, reproduction and activities are affected by the abiotic components of the ecosystem. Besides this, when we visit forests, lakes, rivers, ponds, hills etc., we find a colourful picture of plants and animals living in our environment. These have been developed in nature and by nature, hence these are called natural ecosystems. But gardens, aquarium, crop fields etc. are human made or artificial ecosystem whose existence is completely human dependent.

Human activities leading to pollution, deforestation, global warming, urbanisation, radiation etc. play a definite role directly or indirectly in destabilizing the balance of our environment and damage it.

Simultaneously, there are a number of natural events like cyclones, earthquake, volcanic eruption, tsunami etc. which affect the natural as well as artificial ecosystems and thus influence the balance of environment.

Accordingly, environmental issues may be classified as ‘human made’ and ‘natural’ and to maintain equilibrium in environment the human race has to look after sustainable development to minimise the adverse impacts on our environment.

14.3 HUMAN MADE ENVIRONMENTAL ISSUES

Our daily activities like drinking, bathing, washing etc. depend on use of natural resources like water. Also, for going to school or work place, we use vehicles which consume fossil fuels and release toxic gases into atmosphere. Clothes, we wear are produced in factories which release toxic chemicals which is discharged into the environment. Food that we eat, is produced from agricultural fields by the use of chemical fertilizers and pesticides, which affect the soil and also get washed to our rivers with rain water.

All these human activities which have an adverse impact on the stability of our environment, create issues which are referred as human made environmental issues. Let us learn different environmental issues arising out of the developmental process and the need of combating for the betterment of human race.

Activity 14.1

Make an observation of your environment. Prepare a list of processes by which air, water, noise and soil are polluted. All the processes noted in different localities need to be discussed in the study centre to find out the degree of awareness of the students.

14.3.1 Water Pollution

Pollution (water, air, noise and soil)

Water pollution:

Water is an inorganic, transparent, tasteless, odourless chemical substance. It is the main constituent of earth's hydrosphere and the fluid component of all living organisms. There are different sources of water such as ground water (through well, bore well etc.); Surface water like lake, river, stream, pond, tank etc.; rainwater; sea water.

Activity 14.2

Prepare a list of small-scale conservation activities for conservation of water in our country.

Water pollution happens when toxic substances enter water bodies like rivers, ponds, lakes, seas etc. The toxic materials get dissolved in water as it is a natural solvent, or remain suspended in water or get deposited on the bed of the water body. Whatever may be the form, it degrades the quality of water. The water is called contaminated and may lead to diseases like diarrhoea, cholera, dysentery, typhoid, polio etc.in human beings.

There are different reasons due to which water gets polluted such as use of chemical fertilizer and pesticides, leakage from sewer lines, mining activities, sewage and waste water, industrial waste, marine dumping, accidental leakage of petroleum and many other human made activities. Ground water pollution is also a serious issue. It gets polluted when comes in contact with fertilizers, pesticides, water leaching from landfills and septic system. Once the ground water gets polluted it remains unsafe for a very long period to use.

Particularly, plastic is a major source of water pollution.

Fig. 14.2 Factory, industries, sewer line emission and dumping of plastics

At best 14 million tonnes of plastics end up in ocean every year and plastics make up 80% of marine debris found from surface water to deep sea sediments. This causes problems not only to marine animals but also to humans. Chlorinated plastic can release harmful chemicals into surrounding soil which can then seep into ground water and other surrounding water sources and also the ecosystem. This causes a range of harmful effects on living beings.

Some activities can be planned to prevent/reduce water pollution:

- Disposal of toxic chemicals effectively so that they are free from polluting water bodies.
- Do not pour fat or grease down the drain
- Use of phosphate free detergent
- Use of less plastic

- Use the items those are easily recyclable
- Do not throw away medicines
- Avoid toilets for throwing household items and many more.

Activity 14.3

Prepare a list of at least seven household activities by which you can prevent or reduce water pollution.

14.3.2 Air pollution

Pure air is a homogenous mixture of gases that surrounds the earth and helps in breathing of people, animals and plants. Air is made up of various gases such as Nitrogen, oxygen, argon, carbon dioxide and water vapours.

Human made air pollution:

Air gets polluted when solid particles and gases are added into the air-smoke from factories, dust, coal fuelled power plants, gas emissions from vehicles. Some air pollutants are poisonous. Inhaling them can increase the chance of health problems. Even air pollution affects us at home. It becomes difficult to escape from it. In some cases, you can see or smell air pollution.

Fig. 14.3 Factories, industries and vehicle emissions causing air pollution

Natural sources of air pollution:

Release of harmful hazardous substances into air from natural events like smoke from forest fire, ash and gases from volcanic eruptions, gas like methane emitted from decomposed organic matter in soil, are referred as natural sources of air pollution. Air pollution affects our health and is cause for most respiratory diseases. Lung problems in different forms occur. This help in spreading of bacterial and viral related diseases. It also causes cardiovascular diseases, cancer etc.

Air quality is measured with Air Quality Index (AQI). It shows how clean or polluted the air is.

Fig. 14.4 Industrial emission, burning of crop husk, forest fire

Air Quality Index:

AQI	Remark	Color Code	Possible Health Impacts
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

Source: Central Pollution Control Board

Ways to reduce air pollution:

Pollution can be controlled at the source and some of the measures are listed below:

- Using more of public transport
- Least use of plastic bags
- Prevention of forest fire

- Avoiding use of crackers
- Using filters for chimneys in factories
- Avoiding burning of garbage
- Practicing 3R concept – Reduce, Reuse and Recycle
- Prevent ozone depleting activities by reducing emission of cholorofluro carbons.

Activity 14.6

Prescribe five activities you can take to prevent/reduce air pollution

14.3.3 Noise pollution

Regular exposures to higher level sound cause adverse effects in humans and other living organisms. According to World Health Organisation (WHO), sound levels less than 70 dB (decibels) are not damaging to living organisms regardless of duration of exposure. Production of sound/noise for a longer duration from different sources in the environment, impacts human and animal life in different ways. Noise pollution happens due to vehicles, aircrafts, industrial machineries, loud speakers, crackers etc. It happens even at home due to television, music speakers etc. when used in high volumes.

Noise pollution causes health problems like headaches, high blood pressures, respiratory agitations, heart problems, hearing loss etc. It may even cause psychological stress, reduce productivity, interfere with communication, concentration, many hearing problems, increased anxiety, stress etc.

Prevention/reduction of noise pollution

Prevention or reduction of noise pollution can be done in different ways within our limits. It is quite possible but there must be will power to meet such exigencies. We must look after the wellbeing of the elderly persons and patients who suffer from noise pollution very much.

Following actions can be taken to prevent/reduce noise pollution:

- Planting more trees
- Regular maintenance of vehicles and machineries
- Lowering the volume of television and music speakers at home
- Lowering the volume of loud speakers and least use of the same in public places
- Turning off appliances when not in use
- Use of ear plugs as and when necessary
- Reduce noise level at source
- Use sound bouncers/hard flat objects such as glass, hard bound floor and tile, adding carpet, furniture even some plants in rooms
- Using acoustic panels where noise production is more.

Activity 14.7

List the causes of noise pollution in your locality.

Activity 14.8

Make list of activities which you can take up to reduce/prevent noise pollution in your locality.

Activity 14.9

Find out reasons of noise pollution even if there is high noise production at source

(i) Cinema hall
(ii) Language laboratories

Noise pollution index:

Average sound level is one of the key noise pollution index. It quantifies noise as a single value of sound level for any desired duration. WHO defines noise level above 65 dB (decibels) as noise pollution. Noise becomes harmful when it exceeds 75 dB and is painful above 120 dB.

14.3.4 Soil pollution

Soil pollution or otherwise known as soil contamination or land pollution is caused by industrial activity, agricultural chemicals or improper disposal of waste materials. It poses risk to human health and/or the ecosystem.

Deforestation is one of the main cause of soil pollution. Living, working or playing in contaminated soil lead to respiratory diseases, skin diseases and other health related problems. Now it is clear that soil pollution is done mostly by human activities.

Fig. 14.6 Industrial dumping, local waste disposal, excessive use of pesticide and fertiliser

Types of soil pollutants:

- Sludge (coming from human, bird and animal excreta into soil). Biological agents work inside the soil to produce manures and digested sludge.
- Agricultural practices (profused use of chemical fertilisers and pesticides)
- Radioactive pollutants
- Urban and industrial waste

- Use of plastics (polycyclic aromatic hydrocarbons)
- Heavy metal pollutants – (Arsenic, cadmium, chromium, mercury, lead, copper and nickel). Sources of heavy metals are mining, industrial production (foundries, smelters, oil refineries, petrochemical plants, pesticide production, chemical industries), untreated sewage, sludge and diffused sources such as metal piping, traffic and combustion by products from coal burning power stations.
- Hydrocarbon as soil pollutant- Sources are coal, petroleum, natural gas. The coal ash, spillage of petroleum products cause soil pollution.

Prevention of soil pollution

Soil pollution can be reduced or controlled in the following ways:

- Minimum use of pesticides
- Judicious use of fertilisers
- Growth of seeds can be controlled through improved cropping technique not in chemical means.
- Special pits should be selected for dumping wastes
- Controlled grazing and forest management
- Quality solid waste treatment
- Recycle and reuse the products
- Promote use of natural manure

Activity 14.10

Prepare a list for reducing soil pollution in your locality.

14.3.5 Plastic and garbage production and its disposal

Plastic is everywhere in our life. It is used in product packaging, cosmetic ingredients, textiles, mobile phones and even in chewing gums. Every year 500 billion plastic bottles are produced worldwide. Plastics in the ocean is already more than 100 million tonnes of waste. It is forecasted that by 2050, sea and oceans could contain more plastic than fish. The average life of a single use plastic is 12-15 minutes, but it can take up to 500 years to disappear according to 'Life out of plastic'. Govt. of India (December 6, 2021) has warned that India's plastic waste generation has more than doubled in last five years. Maharashtra generated the largest amount of plastic waste (410,000 metric tonnes) in India in 2019 and Sikkim, Mizoram, and Tripura contributed the least to plastic waste generation. In 2020, the production volume of performance plastics in India was around 1.7 million metric tonnes. This shows it is high time now to bring a check on production and use of plastic in our country.

Reduction of plastic consumption can lessen its impact on the environment. Minimising the consumption of plastic is much simpler. There are some measures which you can adopt to reduce use of plastics:

- Avoid the use of single use plastics like drinking straw etc.
- Go for shopping with a cloth bag
- Stop using chewing gums. If at all you are interested, you can opt for natural and organic chewing gums.
- Avoid buying packaged product. Instead you can buy more bulk food.
- Spread awareness to those who are around you about reducing use of plastics.
- Separate plastic garbage and send it for recycling. Don't mix with organic garbage.
- Avoid using cosmetics that use microplastics. Use biodegradable brush and wear natural fabrics.
- Choose to reuse the plastics as far as possible.

Activity 14.11

Prepare a list for reducing plastic waste in your surroundings.

GARBAGE:

Garbage is discarded or useless material, whatever may be the source. Some sources of garbage or waste are industrial waste, commercial waste, domestic waste and agricultural waste. General composition of waste generated in India is - food (about 24%), plastic 18%, paper and paper board (about 12%), rubber, and leather and textiles comprise over 11%.

There are seven most common types of garbage. They are:

- Liquid and solid household waste which is known as ‘Municipal waste’.
- Hazardous waste- It may be toxic, inflammable, reactive
- Medical/hospital waste
- Construction and demolition debris
- Green waste- Waste from vegetable, tree, branches etc.
- Recyclable waste- Paper, cardboard, metal etc.
- Electrical waste

These are small but may create serious issues which shall be taken care.

Fig. 14.7 Garbage disposal

Prevention/reduction of garbage waste:

Mostly the garbage or waste become cause of water pollution. There are some effective steps to prevent pollution because of production of waste.

- Repair, rather than replace broken household Items
- Replace single use plastic packaging, bottles and containers with reusable products.
- Reduce consumer waste
- Put waste in an appropriate place (in a compost pit prepared in your garden, container supplied by municipality, handover the dry waste and wet waste separately to municipality agents etc.)
- Reuse paper and plastics
- Convert old sheets, towels and clothing into wash rags.
- Follow the principle of '4Rs' (Reduce, Reuse, Recycle, Rethink)

Activity 14.12

Prepare a list of household garbage in your locality. Suggest the means of overcoming the challenges you all face.

14.3.6 DEFORESTATION

Deforestation is the purposeful clearing of forest land. Forests have been cleared for agriculture and animal grazing. Moreover, it solves the purpose of construction, fuel requirement and manufacturing of usable things. Timber is useful in many ways for the society. Mining and establishment of industries requires clearing of forests.

Deforestation has also some positive effects. Cutting some specific trees provide scope for regeneration of plants, improved habitat for many species, management of forest health and help in shaping forest for future that ultimately provides good revenue.

But unethical selfish motives cause maximum deforestation which is incredibly harmful. Forests are most useful resources and provide us clean air, food, materials, natural habitats for a range of animals, climatic support etc. Even deforestation causes soil erosion, flood, destruction of forest habitat and the loss of biological diversity of both plants and animals. Deforestation also leads to excess of carbon dioxide in the atmosphere, climate crisis, desertification, global warming etc.

PREVENTION OF DEFORESTATION

There are different ways of preventing deforestation. You must develop a feeling against deforestation and for any step being taken by you there must be a follow up action. The follow up action contribute a lot to meet the challenges of the environmental issues. The suggested activities are:

- Planting trees and taking care of it till they are grown up
- Use less paper and cardboard and use recycled products
- Protect wild animals and take steps through different organisations to prevent poaching.
- Less use of firewood
- Respect the rights of indigenous people and wild animals.
- Raise awareness among the peer and others in your locality.
- Support individuals or organisations that fight deforestation
- Report against illegal logging.
- Take active initiative in afforestation or reforestation activities.

Afforestation is an activity of plantation of trees on a land where no forest was existing since long (about 50 years back according to UNFCC -United Nations Framework Convention on Climate Change).

While, reforestation refers to replanting of trees on more recently deforested land. These two activities resolve problems created by deforestation in a particular area.

Fig. 14.8 Deforestation and afforestation

Activity 14.14

Suppose some unused vacant space/land is there in nearby areas of your school or home. Draw a plan of action so that you can take up plantation activity in the vacant place.

14.3.7 URBANISATION

Urban places are more consumer friendly as compared to rural areas. All sort of facilities and basic amenities are better available including employability and higher wages, better transportation facilities, more education opportunities, internet connections, more modernised equipment, as compared to rural areas. This attracts rural folk to move gradually to urban places leading to expansion of existing cities and towns. Hence, urbanisation refers to the population shift from rural areas to urban. The corresponding change in the population in both the areas and the ways in which societies adapt to this change are quite challenging.

Urbanisation allow the cities to grow and higher percentage of population comes to live in the city. Various causes of urbanisation are industrialisation, commercialisation, employment opportunities, modernisation and changes in modes of living, social benefits and services and rural/urban transformation.

Urbanization leads to excessive increase in city population leading to development of slums, poor nutrition, population related health conditions, communicable diseases, poor sanitation and housing conditions. Urbanization puts excessive pressure on demand for natural resources and facilities – food, water, energy etc., leading to environmental issues in terms of increase in pollution, increase in garbage and plastic waste, increase in discharge of wastewater. These environmental issues further deteriorate the overall quality of a city's life. The issues arising out of urbanisation can be put under control by different ways:

- Reducing the migration of people from rural to urban areas by creating employment opportunities in villages and small towns.
- Promoting urban agriculture with the help of slum dwellers in particular and urban population in general
- Making them aware of healthy diets

- Reducing and managing food waste
- Boosting green spaces for healthier environment
- Population control
- Creation of more employment opportunities
- Provision of essential services

Fig. 14.9 Urban area and slum

Activity 14.14

Give suggestions to develop quality of life of slum dwellers

14.3.8 DEPLETION OF FOSSIL FUEL

If we keep using fossil fuels at our current rate it is estimated that all our fossil fuels will be depleted by 2060.

Fossil fuels are a finite resource and non – renewable. Once it is used, it cannot be created artificially. As you know, fossil fuels are made from decomposition of plants and animals. These fuels are found in the Earth's crust and contain carbon and hydrogen which after burning gives energy. Coal, petroleum and natural gases are examples of fossil fuels. They are named so because they were formed from the fossilised, buried remains of plants and animals, millions of years ago.

Reserves of fossil fuels are finite and not available everywhere on Earth. Gulf countries like Iran, Saudi Arabia etc have rich petroleum reserves, India and Australia have good reserves of Coal and countries like Russia and Norway are rich in Natural gas reserves.

Fossil fuels are used to run our vehicles, produce electricity, warm our houses as well as in production of substances like steel. Thus our dependence of fossil fuels is very high. Almost 60% of electricity in India is produced using coal. Almost 75% of petrol and diesel used in our country is imported and about Rs. 7 lakh crore are spent every year, in its import.

Also, when fossil fuels are burnt they release toxic gases into the atmosphere which contributes to the formation of smog and acid rain. These gases pollute our environment and affect our health.

Hence, we need to reduce the use of fossil fuels which will 3 benefits for us:

1. Conservation of fossil fuels reducing their depletion
2. Reduction in air pollution, cleaning our air and leading to better health
3. Saving of money, both personal as well as government's, which could be utilized for other developmental activities

Hence we have to shift to other sources of energy than fossil fuels.

Prevention of fossil fuel depletion:

- Use more public transport.
- Optimum use of air conditioners and heaters at home.
- Use of more solar and wind energy.
- Optimum use of electric current at home.
- Use of more biogas in our day-to-day life.

Activity 14.15

Name five activities that you can do daily to reduce use of fossil fuel

14.3.9 BIOMAGNIFICATION

In the food chain, smaller organisms are eaten by higher organisms, which leads to transfer of energy and matter from one organism to another.

Biomaginification refers to increase in concentration of toxins with every step in a food chain.

Example: The toxic materials which contains heavy metals such as mercury, arsenic, chromium, lead, cadmium etc. reaches river bed through industrial waste and sewage. These are consumed by microorganisms which in turn are consumed by small fishes and then they are eaten by big fishes. Big fishes are consumed by human beings. The contaminated river water is used for watering crops and vegetables which become rich with toxic materials and these are consumed by human beings. In each stage of consumers, the toxic chemicals get magnified and when it reaches human beings the highest consumer, they suffer most from the ill effects of these heavy metals/toxic materials. In each stage of the consumer, the concentration of toxic materials increases 10 times i.e. by the time it reaches human beings the concentration becomes very high and suffering becomes the worst.

Causes of biomagnification

- Products used in agriculture containing higher concentration of inorganic chemicals like pesticides and fertilizers.
- Industrial activities releasing the wastes carrying higher concentration of toxic materials.
- Organic contaminants: organic substances like manures and biosolids
- Mining by products like copper, cobalt, zinc, lead and several other toxic materials get subsequently biomagnified.

Effects of biomagnification

People suffer from cancer, respiratory diseases, kidney problems, heart disorders, reproduction and development of all animals, destruction of coral reefs, disruption of natural food chain and ecosystem.

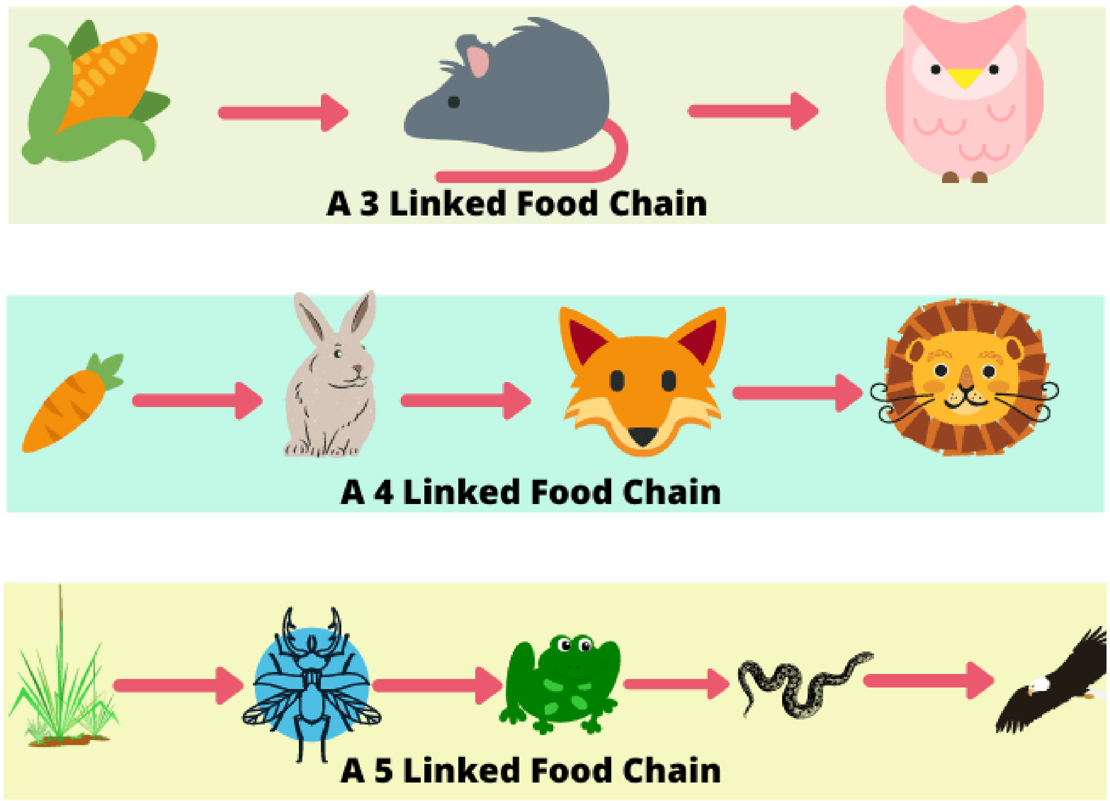

Fig. 14.10 Figure of food chain

Prevention of biomagnification

All of us have to be conscious about biomagnification process and steps need to be taken with all seriousness. Following steps can be taken to prevent biomagnification:

- Avoid fishing/fishes from contaminated areas
- Avoid toxic chemical pesticides
- Avoid putting harmful substances into water system
- Cleaning of contaminated locale
- Elimination of the use of some heavy metals
- Institutions using toxic substances must be very careful for biomagnification

Activity 14.16

Observe your locality. Find out the process of biomagnification in your surroundings. Suggest means to prevent it.

14.3.10 GREENHOUSE EFFECT AND GLOBAL WARMING:

Greenhouse effect is a process that warms the Earth's surface and the lowest layer of atmosphere (troposphere). It is caused by the presence of water vapour, carbon dioxide, methane and certain other gases in air. These gases are known as greenhouse gases and water vapour has the largest effect in keeping the Earth warm.

The atmosphere allows sunlight to reach Earth's surface. As Earth's surface is heated it radiates the part of this energy back towards space as infrared radiation. This radiation tends to be trapped by the greenhouses gases in the atmosphere, and reflected back to Earth's surface, raising its temperature.

Greenhouse effect is beneficial for the Earth in keeping it warm and maintaining the greenery as well as life in it. However, increase in concentration of greenhouse gases leads to increase in greenhouse effect which in turn is leading to global warming and so the climate change.

Causes of global warming

The major causes of greenhouse effects are

- Deforestation creating imbalance in the atmosphere
- Burning of fossil fuels by our industries and vehicles
- Industrial waste creating imbalance in nature
- Smog and air pollution
- Acidification of water bodies

Impact of global warming

The impact of global warming includes the following:

- Melting of glaciers leading to drying of rivers
- Rise in ocean level leading to submergence of land adjoining seas
- Ocean acidification impacting the marine life
- Extinction of species and migration of animals
- Extreme weather events like drought and heavy precipitation leading to floods

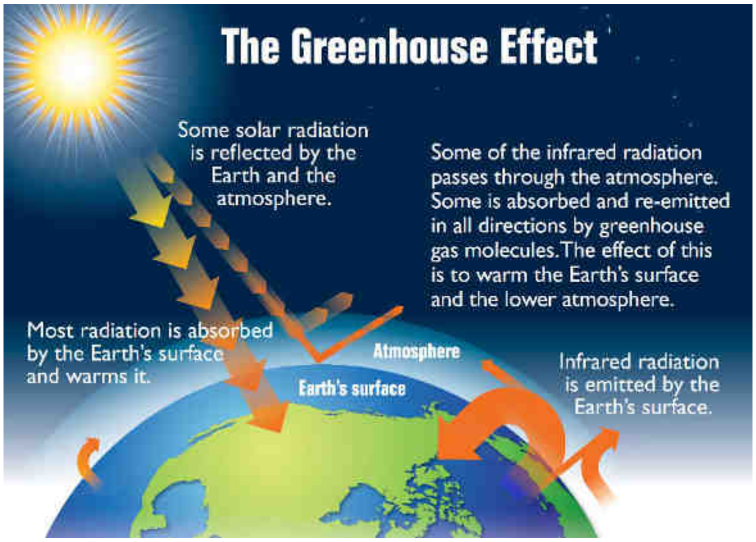

Fig. 14.11 Greenhouse effect

Activity 14.17

What steps can you take to reduce global warming in your surrounding?

14.3.11 OZONE LAYER DEPLETION

Ozone (O_3) layer present in the stratosphere prevents the entry of harmful ultraviolet rays from Sun into Earth. Ozone depletion occurs when chlorine and bromine atoms come into contact with ozone in the stratosphere. Chemical reaction between chlorine and bromine atoms and the ozone molecules leads to breaking of Ozone molecule. It is estimated that each chlorine atom released into atmosphere can destroy upto 1 Lakh ozone molecules.

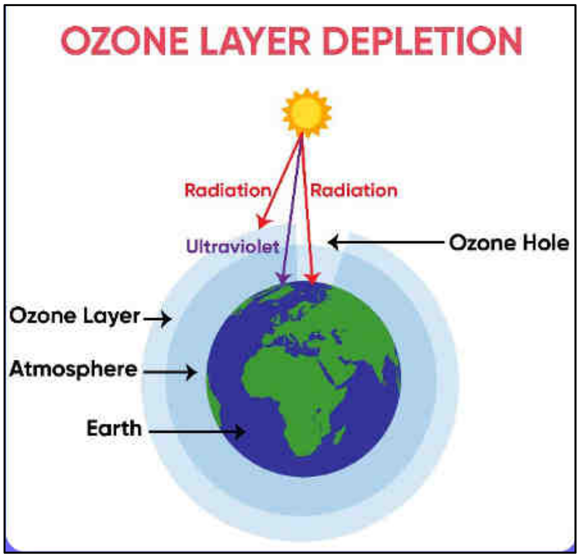

Fig. 14.12 Ozone layer depletion

Cause of ozone depletion

Ozone depletion and ozone hole takes place due to release of choloroflurо carbons (CFC) in the atmosphere. In addition to this the following also plays an important role for the same:

- Unregulated rocket launches
- Nitrogenous compounds
- Foam blowing agents
- Halocarbon solvents

Effects of ozone depletion

Following effects are observed due to ozone depletion:

- Ozone layer depletion causes ultraviolet rays to reach the Earth which is harmful for living organisms
- Skin cancer
- It damages our immune system
- It can lead to cataract in eyes and human ageing of the skin
- Sun burn in humans and animals

Prevention of ozone depletion

Following are the means by which ozone layer depletion can be prevented to some extent:

- Minimise use of vehicles
- Use eco-friendly household cleaning products
- Avoid rampant use of pesticides
- Avoid manufacturing and use of gases dangerous to ozone layer

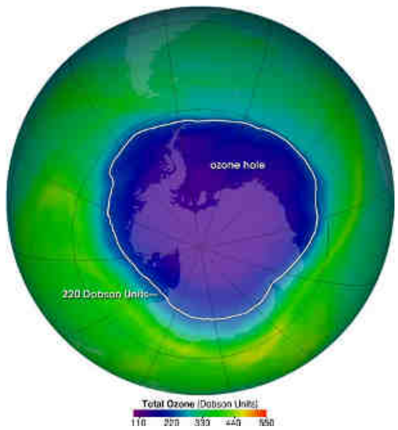

Fig. 14.14 Ozone hole

14.3.12 RADIATION

Source: Radioactive elements that occur naturally are Polonium, Rubidium, Thorium, Uranium, Radium, Samarium and Lutetium. Thorium commonly occurs in monazite. Monazite is an atomic mineral that occurs naturally in the coastal sands in certain areas. Besides monazite there are few other minerals known as THORITE (Thorium, Uranium and Silicate), THOROGUMMITE (Thorium, Uranium, Silicate hydroxide). MONAZITE has Cerium, Lanthanum, Thorium, Neodymium, Yttrium phosphate and many other minerals are also available. Uraninite (Uranium dioxide) is highly radioactive mineral.

Radioactive minerals can be identified with special instruments that detect radiation. Radiation is energy that comes from a source and travels through space. Electromagnetic radiations like gamma rays have an electric field and a magnetic field associated with it and travel with the speed of light. There are four major types of radiation 'alpha', 'beta', 'gamma' and X rays. They differ in mass, energy and how deeply they harm people and objects.

Examples of radiation

Following examples need to be observed carefully in our environment. The simple examples are:

- Ultraviolet light from the Sun
- X-rays from the X-ray machine
- Sound waves from stereo
- Microwaves from a microwave oven
- Heat from a stove
- Visible light from a candle
- Electromagnetic radiation from mobile phone
- Alpha particles emitted from the radioactive decay of uranium.
- A laser beam
- Radio waves

Radiation therapy is very much in use for medical treatment which has got side effects also. Alpha rays are the weakest and can be blocked by human skin and gamma rays are the strongest and only dense elements like lead can block them.

Ill effects of radiation

It is said that radiation also affects us negatively. We are very familiar with the name of atomic warfare. We remember the effects of atomic war on Nagasaki and Hiroshima in Japan during Second World War in 1945.These atomic explosions killed almost 1.5 to 2.5 lakh people almost immediately. People who remain alive after the explosion faced long term health effects like cancer and cardiovascular diseases, which spread genetically to generation after generation. Hence we must be aware of the ill effects of radiation including the atomic war. During our regular life also we come across the effects of radiation. Few of those are mentioned here.

Radiation damages intestine, stomach, blood vessels, bone marrow which prepare blood cells.

Preventive measures against radiation:

Time: Radiation takes time to reach you which indicate that distance between you and source is more thereby causing less effect.

Distance: As you maintain distance from fire due to generation of heat likewise the dose of radiation decreases as you increase your distance from the source.

Shielding: Barriers of lead, concrete or water provide protection from radiation. For gamma rays it is difficult to penetrate such barriers. Beta particles are stopped by aluminium foils and alpha rays can be blocked by a few pieces of paper.

Activity 14.18

Discuss five measures to protect you from radiation

CHECK YOUR PROGRESS 14.1

1. **Select the correct statement from the options given under each item.**

   i. **Environmental problems exist because of:**
      - A. Human made
      - B. Nature made
      - C. Both human and natural
      - D. Neither human nor natural

   ii. **Plastic is a pollutant for pollution of ……..**
      - A. Water only
      - B. Air only
      - C. Soil only
      - D. All of the above

   iii. **Using loud speaker in a high pitch is a pollutant for …….**
      - A. Sound/noise
      - B. Water
      - C. Air
      - D. Soil

   iv. **Greenhouse effect in a large context is responsible for what …….**
      - A. Deforestation

B. Urbanisation
C. Global warming
D. Water pollution

v. **Radiation of gamma rays can be prevented by what?**

A. Concrete structure
B. Aluminium sheets
C. Paper sheets
D. Zinc sheets

vi. **Food chain is responsible for amplifying the toxic in living beings. What is the name of the process?**

A. Greenhouse effect
B. Radiation
C. Water pollution
D. Biomagnification

2. **Match the following given in Column 'A' with that of 'B'**

Column 'A'	**Column 'B'**
A. Ozone layer depletion	i. Alpha ray
B. Radiation	ii. Slum
C. Depletion of fossil fuel	iii. Sewage
D. Urbanisation	iv. Noise pollution
E. Water pollution	v. Ozone hole
	vi. Thermal power plant
	vii. Maximum toxification in human

3. **Answer the following:**

i. Who is known as 'Waterman' of India?
ii. How can you do rain water harvest in your house?
iii. What is the major source of marine water pollution?

iv. Why must the chimney of factories be covered with net/filter?

v. What is the meaning of RED in AQI (Air Quality Indiex)?

vi. Why must you separate dry and wet garbage before you hand it over to municipality vehicle?

4. Correct the following sentences with one or two words by changing underlined words:

i. Waste paper, cardboard etc. should be burnt.

ii. Protect air, forest by more use of fire wood.

iii. Pollution related health condition, poor nutrition and sanitation are result of deforestation.

iv. Install solar panels on your roof at home to prevent ozone layer depletion.

v. Avoid fishing from contaminated water as fishes may have more toxic heavy metals due to water pollution.

vi. Smog pollution may be the impact of greenhouse effect.

14.4 NATURAL ENVIRONMENTAL ISSUES

Environmental issues are defined as harmful effects to earth and its natural systems due to the action of humans directly. Some issues also occur due to indirect effect of human action or simply from natural causes. Most of issues which occur due to indirect impact of human actions but are known as natural issues are flood, cyclone, forest fire, land slide etc. Some of the issues that occur directly in nature are earthquake, tsunami etc. Whatever may be the immediate cause of the issues, ultimately the environment gets damaged and the dwellers (all living organisms) suffer.

Some things to do to save our planet earth as a student are:

- Reduce paper consumption
- Save electricity and water
- Bring reusable bags to the market
- Walk to school or take a bicycle or bike depending upon the distance
- Prevent food waste

- Stop littering
- Download an environmental app in your mobile
- Establish an Environmental club in your school/locality
- Any other activity you feel worthy to start/join

14.4.1 Flood

You all know what flood is. Some of you may have experienced also. Flood is an overflow of water from a river that submerges nearby land and habitat. It continues to remain in the submerged land till the water level comes down in the river bed. It is one type of natural disaster and occurs due to heavy rainfall during rainy season in the catchment areas or storm surge from a tropical cyclone or tsunami in coastal areas or rapid snowmelt on the mountain peaks.

Floods have large social consequences for humans beings. The impact of flooding includes loss of human life, damage to properties, destruction to crops, loss of livestock and cause of health hazards.

There are three types of flood:

- River floods- When water level run over river banks due to heavy rainfall in catchment areas
- Flash flood- An excessive amount of rain due to cloud burst etc. in a short period (usually within 6 hours) in hill zones.
- Coastal flood- Much larger water bodies usually during high tide in sea enter into coastal area.

River flood water can be controlled through barrages and dams and used for irrigation. Dams also form an ecosystem that supports fish and other aquatic animals, birds and other wildlife. During flood lot of alluvium flows down and the submerged land becomes fertile.

Prevention and making use of flood water:

- Warning systems must be set up so that people get sufficient time to save themselves and their livestock.

- Water harvesting system is to be used to store rain water preventing it to rundown unnecessarily.
- Plant trees (afforestation) strategically to prevent flood.
- Construction of barrage, dams in river bed and by two sides of river banks.
- Diversion of flood water in some other way to sea.
- Construction of sea wall to prevent tide from entering in the coastal areas.

Activity 14.19

Observe your landform and make a list of flood preventing measures for your area stating the reasons thereof.

Fig. 14.14 Flood affected areas

14.4.2 CYCLONE

A large system of winds that circulate about a centre of low atmospheric pressure in an anticlockwise direction in the north of equator in a clockwise direction in the South of equator. Cyclones are characterised by inward spiralling winds that rotate about a zone of low pressure. The zone is known as eye of the cyclone. Cyclone is caused due to transfer of water vapour and heat from the warm ocean to the atmosphere. The warm moist air rises, expands and cools getting saturated, releasing latent heat through the conduction of water vapour.

Fig. 14.15 Cyclone

The study about the cyclone and forecasting about it is done by meterological department. The effects of tropical cyclones are heavy rainfall and flood, strong wind, large storm surges near landfall, land slide, very high tide over flooding coastal areas, loss of life, damage to properties.

In 2000, the World Meteorological Organisation (WMO) agreed to start assigning names for cyclones over the North Indian Ocean basin since September 2004, using a list of names suggested by the countries surrounding the ocean basin. The countries are Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand.

Types of cyclone as per severity:

Sl. No.	Types of disturbance	Wind speed in km/hr	Wind speed in knots
1	Deep depression	49-61	27-33
2	Cyclonic storm	61-88	33-47
3	Severe cyclonic storm	88-117	47-63
4	Super cyclone	More than 221	More than 120

Source: Indian Meteorological Dept. Each cyclone is named differently in order to avoid confusion in case of simultaneous occurrence of TCs over a region and keep a clear distinction among different cyclones. Use of short, distinctive given names in written as well as spoken communications is quicker and less subject to error. Moreover, it helps in creating awareness of its development and effectively disseminate warnings to much wider audience.

Indian Meteorological Department is the agency responsible for naming the cyclones in south Asia.

Precaution from cyclonic effects:

- If your area is under cyclone warning, get away from low lying areas/beaches to the sheltering house.
- Leave much early before the landfall of the cyclone
- If your house is securely built on high ground, take shelter in the safe part of the house
- Trim tree around your home
- Listen to radio for information
- Stay indoors during cyclone
- Switch off electrical switches
- Keep your doors and windows shut

Activity 14.20

Draw an action plan to remain safe at your home during cyclone

14.4.3 EARTHQUAKE

An earthquake is a sudden, rapid shaking of the ground. It causes fire, ground rupture, tsunamis, landslides or avalanches.

You all have experienced earthquakes in a smaller or greater degree. It is caused by sudden movement along faults within the earth. The movement releases 'hured-up' 'elastic strain' energy in the form of seismic waves. This is propagated through the earth and cause the ground surface to shake.

There are four different types of earthquakes- tectonic, volcanic, collapse and explosion.

a. A tectonic earthquake occurs when the earth crust breaks due to geological forces on rocks and adjoining plates that cause physical and chemical changes.

b. A volcanic earthquake occurs from tectonic forces which result in conjunction with volcanic activity.
c. A collapse earthquake are small earthquakes in underground mines and caves etc. that are caused by seismic waves produced from the explosion of rocks on the surface.
d. An explosion earthquake is the result of the detonation of a nuclear and/or chemical device.

(Source: UN-SPIDER Knowledge Portal)

Preventive measures to be taken to during earthquakes.

We cannot prevent earthquakes but we can restrict the damages. Stay away from the roads, move away from the buildings, stay in an open area, protect your head and neck with your arms or any way possible on your part. If near sea shore move to high place.

Few other measures can be taken up for personal safety:

- If you cannot stand on the ground, try to sit or remain seated so that you are not knocked down.
- If you are in a moving vehicle, stop as quickly and safely as possible.
- If you are outside, stay outside.
- If you are in a high rise building, stay inside and stay calm, try to get someone's attention.
- Do not stand in a doorway, you are safer under a table.

In addition to these, you can take programmes on earthquakes awareness, preparedness, prediction and warning systems. These measures may reduce the disruptive impacts.

Activity 14.21

Draw an action plan to stay safe in your school and home during earthquake.

14.4.4 FOREST FIRE

Forest fire is also known as wild fire, bush fire, wild land fire or rural fire.

Forest fire is an unplanned, uncontrolled fire in an area from combustible vegetation during summer. More than four out of every five fires are caused by people. Naturally occurring forest fire are most frequently caused by lightning. There are also other natural causes like volcanic eruption, falling of big meteor, coal fire etc. Depending on the circumstances, law has been enacted to prevent fire by human beings. Still it is continuing every year during summer season. You can see forest fire at night like a necklace on hill ranges.

Effects of forest fire:

There is a heavy loss to valuable timber resources, loss of biodiversity and extinction of plants and animals, loss of wildlife habitat, loss of natural vegetation and reduction in forest cover.

Types of forest fire:

a. Ground fire: Occurs below materials such as leaves and peat. These fires are slow moving, but when left unattended can take out large areas. This type of fire can hibernate below the surface during winter and re-emerge under favourable conditions.
b. Crown fire: Pose the highest risk by far due to their fast spreading behaviour. They develop on top of trees and in some cases can jump from one tree top to other and spread very fast.
c. Surface fire: These are most tame fires and can be put out relatively easily. These fires occur at the surface and create least amount of destruction.

(Lyndon G., Celeste Pomerantz, Jason Donev, 2019)

Prevention of forest fire:

Forest fires can be prevented in the following ways:

- Obey local laws regarding open fires, or camp fires.
- Keep all inflammable objects away from fire in forest areas.
- Keep ready forest fighting tools nearby and handy in forest areas.
- Take care of disposing of fire sources.
- Never leave a source of fire unattended.
- Call 911 and inform authorities about the forest fire and your location.
- Keep sufficient water in reserve.
- Keep doors and windows of your house closed but unlocked.
- Do not have fire prone plantation of trees like eucalyptus etc. which are banned.

Negative effects of forest fire:

Forest fires have negative effects and you should be aware of such effects of forest fires:

- Forest fire cause 32% of global carbon monoxide and 10% of methane emissions as well as over 86% of soot emissions.
- About 84% of the ecoregions of conservation of global species diversity are at risk from forest fires.
- Changes in forest fire regions is one of the most significant threats to global biodiversity.

Source: Peter Hirschberger (2016)

Fig. 14.16 Forest fire

Activity 14.22

Suppose you stay nearby a forest area. Draw a plan of action to prevent forest fire in your locality.

14.4.5 Tsunami

Tsunami is created due to earthquake, volcanic eruption, and other under water explosions in seas, oceans and lakes that have potential to generate tsunami. Tsunami is a series of extremely long water waves caused by aforesaid forces. These forces create waves in all directions away from their source in a very big way.

The sources of 71 percent of all occurrences of tsunami is at the "ring of fire" (series of volcanoes in deep ocean trenches in Pacific Ocean). The height of tsunami waves sometimes reach 100 feet (30.5 m). These walls of water (Tsunami borne) cause wide spread destruction when they crash ashore.

In deep water, tsunami moves very fast and has a long wavelength and a small amplitude. As it enters shallower water, it slows down and the wavelength decreases. This makes the wave taller. As waves slow down, they start to bunch together. So they have shorter wavelength than before. It grows taller and taller in height near the coast. The multiple waves of tsunami rush ashore like fast rising tide hit ashore with powerful current.

Preventive measures from hazards of tsunami:

- Go to higher place so that water cannot reach you
- If your house is on a higher place keep yourself away from window and door. Be on the side of a wall so that even if water enters your house you are away from the force of water.

Fig. 14.17 Tsunami

14.4.6 Land slide

Movement of a mass of rock/ debris down a slope under the direct influence of gravity is referred as landslide which may lead to large deformation and displacement. It happens in mountainous areas. It causes disastrous accidents. Earthquake and severe rainfall are important factors in triggering landslide. Landslide carries down to the vertically different types of debris particle such as materials with mainly fine particles, materials with even gradation and materials with mainly coarse particles.

Once a landslide occurs the rate of soil erosion by water, gravity and wind increases. Rain can get into rocks and cause them to become unstable. When unstable rock and soil get wet, they get heavier and start sliding. There are four types of sliding such as fall and toppling, slides (rotational and translational), flows and creep.

Effects of landslide:

The effects of landslides can be extensive. These are

- Loss of human life, property, livestock and crops
- Destruction of infrastructure
- Damage to land
- Loss of natural resources
- Disastrous flooding
- Great impact on health system and essential services like water and electricity supply and communication system.

Fig. 14.18 Landslide

Prevention of landslides:

As we see there are various direct methods of preventing landslides. These include:

- Modifying slope geometry
- Using chemical agents to reinforce slope materials
- Installing structures such as piles and retaining walls with iron nets
- Grouting rock joints and fissures

- Diverting debris pathways
- Rerouting surface and underwater drainage

14.5 SUSTAINABLE DEVELOPMENT

According to UNESCO, Sustainable Development is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable development is described as an approach to developing or growing by using resources in a way that allows for them to replenish and continue to exist for future generations. It is also about balancing the diverse needs of different communities to create a better quality of life for all.

Activities leading to Sustainable Development

Any activity which reduces the use of non-renewable resources and reduces the release chemical waste into the environment, can be considered as an activity leading to Sustainable Development.

Example 1- The household garbage from cooking organic matter may be reused by using it as a resource (manure) for kitchen garden. Here, the vegetables are used and the skin of the same are peeled and used to prepare manure through a compost pit. The manure can be used in the kitchen garden.

Example 2- Generating wind energy to provide power for homes and other buildings to meet their household requirements.

Fig. 14.19 Solar energy production

You will get detailed information about sustainable development in Unit 14.

Activity 14.23

List 10 activities that you may take leading to sustainable development. Practice it for 10 days. Make a chart with date and time when you practiced a particular activity

CHECK YOUR PROGRESS 14.2

1. **Select the correct response from the options given under each item.**
   i. **The pollution of water is due to:**
      A. Carbon dioxide
      B. Both human made and natural
      C. Human made only
      D. Natural only

   ii. **The centre of cyclone is known as …………..**
      A. Epicentre
      B. Hypocentre
      C. Focus
      D. All of the above

   iii. **During earthquake the location below the earth's surface where earthquake starts is called ………….**
      A. Epicentre
      B. Hypocentre
      C. Focal point
      D. Centre

   iv. **…. is uncontrolled burning of plants in a natural setting spread based on environmental condition**
      A. Plant fire
      B. Wild animal fire
      C. Common fire
      D. Wild fire

2. **Answer the following:**

i. How tsunami takes place?
ii. Where does landslide take place?
iii. What is the cause of flood?
iv. Tapping wind energy is an example of what?

3. Match the following

Column 'A'	Column 'B'
A. Flood	i. Tsunami
B. Cyclone	ii. Cloud burst
C. Earthquake	iii. Wind pressure
D. Forest fire	iv. Sustainable development
E. Landslide	v. Overflowing of water from river
	vi. Hill ranges

RECAPITULATION POINTS

- There are different environmental issues.
- Some of the environmental issues are human made and some are natural.
- To have control over environmental issues we have to be careful and we are to be very cautious to manage issues.
- For the sustainable development to be taken care we should control the nature to our benefits for sustenance of our livelihood.
- The human made environmental issues are quite challenging and to control them, we need to identify them and take remedial actions.
- The human made environmental issues are

a) air, water, noise, soil pollution etc.
b) Plastic and garbage production and its disposal
c) Deforestation and its control
d) Urbanisation and its management
e) Depletion of fossil fuel and controlling its use
f) Biomagnification and its management
g) Greenhouse effect and global warming and their control

h) Ozone layer depletion and the protection of the ozone layer

i) Radiation and the process of surviving from its ill effects

- Natural disasters are flood, cyclone, earthquake, forest fire, tsunami, landslide:
- According to UNESCO, Sustainable Development is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

TERMINAL EXERCISE

1. Identify causes of air, water, noise and soil pollution.
2. How will you reduce air, water, noise and soil pollution?
3. What are the impacts of plastic on life?
4. How is the garbage being disposed of?
5. Suppose you live in a forest. What steps can you take to check forest fire?
6. Why does urbanisation take place? What measures you must take to maintain a healthy life in slum areas?
7. What steps should you take to check depletion of fossil fuel?
8. What relationship the biomagnification and food web have?
9. To reduce global warming what remedial measures should be taken?
10. How the radiation becomes harmful for life management?
11. How does tsunami take place? What preventive measures can be taken for survival?
12. How does deforestation become the cause of landslide?
13. What is the meaning and types of sustainable development?
14. How to escape from the effect of cyclone?
15. What is the meaning of cyclonic landfall?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 14.1

1. i. – C

   ii. – D

   iii. – A

   iv. – C

   v. – A

   vi. - D

2. Column 'A' Column 'B'

Column 'A'	Column 'B'
A	V
B	VII
C	I
D	VI
E	II
F	III

3. i. Sri Rajendra Singh
   ii. By draining full rainwater to a corner where a big tank or small well inside soil will be prepared
   iii. Plastic
   iv. Prevent air pollution
   v. Unhealthy
   vi. For recycling

4. i. Recycle
   ii. LPG gas
   iii. Urbanisation
   iv. Fossil fuel
   v. Biomagnification
   vi. Global warming

CHECK YOUR PROGRESS 14.2

1. i. – B
   ii. – A
   iii. – B
   iv. – D
2. i. Earthquake under sea
   ii. Barren hill ranges
   iii. Heavy rainfall in catchment areas
   iv. Sustainable development

3. Column A Column B

i	V
ii	III
iii	I
iv	VI
v	II

SUPPLEMENTARY STUDY MATERIAL

1. NCERT (2008). Science Text Book for Class VIII.
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3. NCERT (2008). Science Text Book for Class X.
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7. Lyndon, G., Celeste Pomerantz, JosonDonev (2019). Energy Education. University of Calgary. Youtube.
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15 MEETING ENVIRONMENTAL CHALLENGES

INTRODUCTION

In the previous Chapter, you have learned the different environmental issues. These environmental issues are the challenges for the society. To meet the environmental challenges, we have to define certain goals to overcome it. We should care of the environmental challenges rather than transferring it to the coming generations. Goals are something which helps and encourages us to achieve the objectives to meet the targets. For instance, you have set a objective of minimising the usage of plastic bags for grocery and food items. You can fixthe aim of the reduction of the use of plastic bags by ten percent reduction in the coming twelve months.

15.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

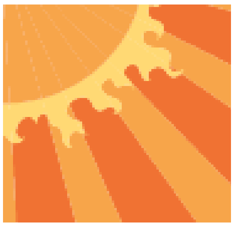
- List the goals to meet the different environmental challenges;
- What has to be done to meet the environmental challenges;
- Who can put their efforts to achieve the goals of solving the issues related to the environment;
- Cultural and scientific practices which can help reduce the loss caused to the environment; and
- Describe the various organisations involved in the protection of environment.

15.2 GOALS TO MEET ENVIRONMENTAL CHALLENGES

Goals are the targets which describes what is to be protected to save the environment and the society. Goals provide an assurance for the coming for providing fresh air, a fit breathing atmosphere and several other reasons to enjoy our environment and natural habitat.

To achieve the goals for meeting the challenges of the environment we should put a joint work from the complete society i.e. public agencies, business communities, participant organisations and last but very important i.e. every one of us. There are several government organisations which have been given the work of fulfilling the objectives to meet the different challenges of the environment. These organisations are working to complete the work given to them. We will learn in detail about these in the latter half of this chapter.

15.2.1 Goals to Meet the Environmental Challenges



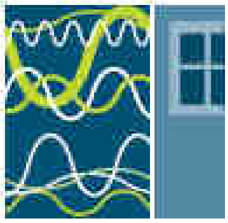
1. Reduce Climate Influence: Different gases including Carbon Dioxide which are out into the atmosphere due to the different actions by us are creating more heat and hence the climate is being warmer day by day. In India as well as the rest of the world, the most important reason for this change in the climate is the use of fossil fuels which includes oil and coal to produce heat and electricity, which are mostly used in cars, buses as wellas for manufacturing purposes.

2. Clean Air: If we breathe polluted air, then it may be harmful for our health.Air pollution is also responsible for the reduction in our being alive. We can die due to various dieseases caused by polluted air. The most harmful impurities to our health are the polluted elements which we inhale, ozone particles and hydrocarbons.

3. Natural Acidification Only: We can find soils, lakes and water courses in the forest to be acidic naturally, but due to the addition of the acidic pollutants from the atmosphere which makes them more acidic in nature. Due to this process, it creates an impact on the plants and animals and also erosion rises. Erosion or Corrosion creates harm to us, for example, to the old monuments and their remains as well as the rivers. It may affect the humans who are using drinking water from the wells which are acidic in nature

4. Non-Toxic Environment: Various different productsuse dangerous chemicals which can cause harm the environment and which may be consumed by plants, animals and humans.

Environmental stages of many ingredients are very high which causes difficulties for humas as well as the environment. Out of the total population of the country, almost 3-5% people have cadmium in their kidneys. Insome places, such as old factory and petrol pumps, soils are seriouslypolluted.



5.A Safe Radiation Environment: Particle Emission or Radiation was continuously a part of our normal setting, created from galaxy, the sun, and of course dangerous constituents in the soil and in human bodies. In the past, researchers have established ways of making radiation and using its properties in studies, health care and manufacturing, for example use of the X-ray machines and uranium in atomicdevices.

Radiation can happen in the form of electromagnetic fields, for example mobile phones which creates radio waves and magnetic fields from power lines. Radiation can be helpful, but also canbe harmful. To minimise its destructive properties on individuals and the atmosphere, all actions concerning radiation need to be right. Radiation should be useful rather than harmful to us. The amount of radiation shoulbe restricted as far as possible.

6. Right Quality Groundwater: Ground water is significant for human beings as it is the source of our drinking water and also for the environment of plants and animals. Releases of environmentally risky materials may pollute this water supply – insecticides are one example, mainly in farming areas. Sodium chloride (common salt) NaClde posited on the roads also gets mix with the ground water, which has adverse impact on the quality of the water and can cause rust in the water pipes.

7. Dense Forests: Forests cover over one fifth the area of our country. The presence and dominant tree types of the forests are a creation of the country's weather and our past. Forests provide exclusive home to diversity in animal and plant classes. Dense Forests similarly are anvital foundation of renewable resources and also as an destination for picnics or excursion tours.

8. Healthy Living Atmosphere: Villages and Cities should give us adecent, fitto live environment and add to a worthy regional and comprehensive setting. Natural and traditional properties should be secured and sustained. Structures and facilities must be situated and planned keeping in view the environmental values and in a manner to encourage ecological organisation of land, water and supplementary resources.

15.3 EFFORTS TOWARDS ATTAINING GOALS

1. **Efforts to Reduce Climate Influence:**With world-wided ischarges growing, the presence of carbon dioxide gas and other greenhouse gases has shown a balanced increase. Hence, to stop this grow thunder 2°C temperature, releases of these gases essentialyshould be around zero. Attaining the essentialchange in the society requires the efforts of people as well as collaboration of other associations to decrease emissions. India will have zero greenhouse gas emissions as early as possible.

2. Efforts for getting Clean Air: A key source of air pollution, particularly in cities is road traffic. Smoke from the cars, buses and other vehiclescompriseelements, nitrogen dioxide and organic mixtures which forms the ground-level ozone. Vehicular traffic also is the reason for thereleaseof scratch particles, released from road sides by dotted tyres. On the positive end, we have advanced engines and fuels which cause less harm to the environment, but thisprogressisof no use due to the increase in the traffic. In severalcities, air superiority is also decreased by release of particles and organic mixtures from the burning of wood. There are laws and other policies, but it is not certain when we can expect the quality of the air to be good, which may take several years.

3. Efforts to Natural Acidification Only: Retrievalof the normal environment is a very slow process. The lakes and rivers in India has shown a slow progress despite a severedecrease in completereleases of sulphur dioxide and nitrogen oxides in the last 20 years. Out of the ten lakes in India, one lake is still found to be acidic in nature due to the negligence of people.

Forest soils and groundwater takes more time to improve. Winds are the cause for the deposition of the acidic pollutants in the water. The majortask is to decrease the acidic releases from the vehicles.

4. Efforts to increase the Non-Toxic Environment: The occurrence of skin cancer – the main reason of which is contactwithultraviolet (UV) radiation – remainsincreasing. To avoid this, we should reduce our external exposure. For this we have to change the standard of living and our behaviour to personal look and sunbathing.

Releases of radioactive materials from nuclear plants are usually very low and do not have any health risk to the people. Consumed nuclear fuel leftovers radioactive for a veryextendedperiod,hence a permanent depositoryrequires to be made for it.

There are presently two regions in which studies has recognised a danger of possibly damaging effects on health from contact to electromagnetic fields. One area is low-frequency magnetic fields from electric lines and the other area is radio waves from mobile phones. We shouldtakedefiniteprotections. When we are planning to construct a new house, suggestions should be followed with respect to magnetic fields from electric lines. We can decrease the exposure to the mobile phones by the use of the hands free or ear phones.

5. Efforts to A Harmless Radiation Environment: Firmconstituentswhich are in the environment or deposited in goods and structures can affect people and the environment for aextended period. Progress in consumption and increase in the manufacturing of different chemicals and other goods, we have increased the risk of spreading of hazardous materials. In several cases, we are not aware of the effect of chemicals on our health and how it affects our environment.

Risks from the chemical substancesessentialy be decreased with the information of the dangerous properties of elements, information on their usage and also in particular cases, rules to limit their use. Charitableprocedures, such as Eco-labelling, environmental management systems in manufacturing industries and carbon-based farming, have also given an addition to progress. Hence to decrase the expansion of these hazardous materials, we have to comply with all these measures.

6. Efforts to Increase Good Quality Groundwater: In general, due to the demand, the pressure on groundwater is growing. The pressure is increasing due to people in rural area still depend on the groundwater as their primary source of drinking water. To avoid groundwater pollution, water shield areas has to be made.

A mountain or hills on the land are vital sources of drinking water. Due to these mountains and hills, stones are deposited, which are important for the supply of energy as well as recreation. On the other hand, we can use the small stones or pebbles from them which can be used to make concrete or for some other purposes.

Due to the creation ofadditionaldefence areas, the government can guard deposits of stones against misuse. We should be known about surface waters impact on groundwater. Several theories have mentioned that the Pollutants such as mercury and nutrients might have beenmoved from groundwater to lakes and rivers, but till date we don’t have any information about these processes.

7. Efforts to Increase Dense Forests: To preserve important forest and nature reserves, they need to be protected. It is essential to manage our forests so that we can improve their standards. In Cities, woods with great number of people visiting have to be achieved using ways which will help them to look additionalybeautiful and reachable.
Materialswhich make soil acidic are created when trees are reaped, but this act can be balanced if we can recycle the ash from the wood to the forests.
Biggertask is to make people acquainted with the different ways of forests so that they can be protected and natural and cultural values of forestsshould be grown. It is important to note that it takes a longer duration to happen the different environmental effects.

8. Efforts for ‘aHealthy’ Living Environment: For a healthy living environment, important challenges containpreserving the old buildings, decreasing the influences of vehicular noise and reducingdangerous waste. At every level in the society, positive action is needed and we shouldthink of our environment when building the roads and homes.

The design of the building and the process of the construction is also very important. In addition to this, we should change to renewable energy sources and maintainabletransport of means. In the planning of the actual building, currentgoverningguidelines, specifically the Planning and Building Policies, should be taken care so that we can protect our environment. Municipal Corporation shoulddesign and plan policies which are essential in attainingfit living environment.

Activity 15.1
Prepare your individual goals to meet the environmental challenges at your home

CHECK YOUR PROGRESS 15.1

Q.1 Which city in India has all the public road transport running on CNG?

Q.2 What are the main environmental challenges?

Q.3 To preserve our forests, what has to be done?

Q.4 What is groundwater contamination?

15.4 ROLE OF VARIOUS STAKEHOLDERS

We have to team up to attain the environmental goals. For this, every person should change their Each one of us as individuals can change our practices and the way they consume products and accept a greener life. Apart from the individuals, Othersestablishments such as Government, government agencies, municipal corporations and business establishmentsare more accountable for the achievement of the objectives.

GOVERNMENT

Indian Government collects information on the developmentof the work regarding the goals to meet the environmental challenges. This collected data forms the baseto make the different regulations and rules of Government.Governmentthen designs the bill on schemes and strategies so that the work should be completed.

GOVERNMENT AGENCIES

Various government agencies realted to environment have their precisedutiestoattain the environmental objectives. All these agencies within their jurisdication work and contribute to achieve the targetsrelated to the environmental excellence objectives. These government agencies work in collaboration with private organisations, NGO's and business houses.

LOCAL AND REGIONAL

At the local and regional levels, it is important to take efforts in attaining the environmental objectives. To achieve these environmental objectives, we have to take care of environment while preparing the house or building design, plan the roads accordingly so that there is no harm to the environment.Local Bodies like Municipal Corporations have the responsibility to take follow up regarding the achievement of the environmentalgoals in their individualregion.The environmental goals are vital tool for viablegrowth in view of the Municipal Corporation. For example, they are used in framework planning, inspection plans, planning waste, energy programmes and plans related to climate.

BUSINESS ORGANISATIONS AND NGO'S

The efforts taken by the different business establishments with respect to the environment in view of manufacturing, transportation and technicalgrowth are important for attaining the environmental objectives. Non-Governmental organisations (NGO) also helps by changing public view and evolvingan sympathetic approach towards transformation in order to achieve the environmental goals.

15.5 CULTURAL AND SCIENTIFIC PRACTICES

We as human being depend on the environment and natural assets to satisfy needs and withstandfitness. Many people want to explore the natural resources but on the other hand they make them dirty by throwing waste.We have to stop these human activities, otherwise harmful environment can have an adverse effect on people, animals, plants, waterbodies, and nature as a whole.

Environment is affected by the various kind of the beliefs and values. Cities and industrial civilisations have the highestinfluence on the environment, who use various means to fuel their actions. At some locations, environment has been given more importance over the laws and rituals, on the other hand the other place doesn't give importance to the environment. The outcomes of these rules are frequentlyclear: Some regions have low pollution regardless ofmanufacturingaction, while other regions with same activity are extremelycontaminated.

We can say that the pollution in our country is increased due to the over population. Due to several Hindu festivals such as Diwali, Holi, Durga Puja, and Ganesh Puja, and traditional activities such as cremations, water and airpollution increases which in turn affects the nature and human health.

15.5.1 Various Indian Cultural Practices

1. Holi: The festival of 'Holi' is proving to be an environmental risk due to the toxic

colours used during the celebrations. Holi is a main festival among others which are celebrated in our country with extremepassion. Holisymbolizes the start of spring season and is a carnival of colours. It starts a night before with HolikaDahaninwhichpeople gathers firewoodtoburn them. But this has an opposite impact on our surrounding environment.

In Holi, gases such as carbon dioxide and carbon monoxide are released and theparticulatematter levels increases.The next day is the fortunate day of Holi, where the celebrations include use of artificial colours, water balloons and load music. All of these actions add to pollution. Due to the high noise of the loudspeakers, it feels irritant for the infants and also creates health issues to the senior citizens and is a reason for the noise pollution. Colours which are used in celebration are made from chemicals which are very harmful for human beings.These colours are not easy to remove and hence these colours mixed with chemicals when gets into wells, rivers or lakes as well as soil, they gets spoiled.

If we make certain changes in the celebration of Holi and play natural colours, then it would be more better for all of us. We should find the substitutes for the harmful colours and use organic ones. Also we should not waste water for rain dance and can use flowers for the same. We must avoid burning of the woods.

2. God/Goddess Immersion: Statues of God/Goddess, used flowers

andearthenvessels are thrown in the water bodies. Hindu religion allows people to use water sources such as rivers, lakes and wells for religional rituals due to faith.

Dippingfigures of God/Goddess in the rivers or lakes is very comman among the various Indial festivals. When we throw the statues of God/Goddess, we also dip the decoration part along with it which are not eco-friendly, which pollutes the lakes and rivers. Apart from this, these human action also disturbs the vegetation. In India, mostly in the months of September-October which is the festival period, thousands of statues are submerged.

3. Cremation: The increasing influence of many Hindu ritualshad made a

heavyweight on the environment. Subsequently, many people are demanding to guard the environment withoutnegotiatingwiththe essence of different Hindu beliefs. We can take the example of cremation in Hindus. In Hundus, Cremation is an important stage to free the soul from the body and is constantlydone in or nearby rivers.

Keeping in mind the population of our country, cremation preference had made great burden on the country's rivers. Due to cremation process near rivers, the leftovers gets mixed with river water and the ecosystem gets ruined. Our rivers are already blocked due to the household waste and are in dying condition with riverGangaclogged with filth and decay, river Yamuna's ecosystem is mostly dead and the Godavari, Krishna and Kaveri rivers hardlygoing into the Bay of Bengal. RiverGangais now one of the greatesttoxic rivers in the world, but is also the key source of drinking water for most of Indians.

4. Diwali Celebration: In most of the regions in India, during Diwali, we can find people having fireworks with very harsh and load fire crackers bursting. With our government imposing several prohibitions during last many years on the use of crackers, still nothing has changed. Many people very much know what they are doing and are having the knowledge of the damaging influences of fire crackers, still they buy them. The substances used in the sparklers and rockets are tremendously destructive and reason for heavy loss.

During fireworks, people bursting the fire crackers comes in contact with their chemical and are at high risk. Fireworks produce the smoke which contains mostly fine deadly dust (particulate matter) whichsimply enter the human lungs. This smoke contains a combination of sulphur-coal mixes, heavy metals and other deadly elements or gases. If a person inhales these gases, then he may experience shortness of breath. Deadly substances like Lead, Magnesium and Nitrate also are freed in air, when fireworks occur leading to crucial health difficulties. India's most polluted city, Delhi is unbreathable and the bursting of fireworks during Diwali makes it unlivable.

Solution to all these is to have eco-friendly Diwali with green fireworks with no smoke and smell, also they will not produce any noise pollution.

AMAZING FACTS

United Nations (UN) stated the responsibilities of humanbeings to valueappropriate human rights such as –

1. Preservation of environment.
2. Conservation of good position of environment.
3. Avoidance of any damage to the environment.
4. Admittherestrictions regarding the use of nature.

15.5.2 Various Scientific Practices

1. **Use of Refrigerators:** The essentialgoal for buying a refrigerator is to save food

items and vegetables from getting spoiled.Thecoldtemperature support food items keep fresh for longer period. Refrigerators use the basic science of slowing the bacteria activities (which all food contains) hence food items remain fresh and it takes more time for food to spoil. Pots with earthen base is an alternate arrangement for keeping food items fresh for a shorter duration.

2. **Water Purifier:** Water purifiers and households are indispensable and has a place

in every kitchen. These purifiers are of two types, first who use the chemicals and second one who use an electro-static charge fordestroyinggerms and viruses. Instead of modern sophisticated water purifiers , we can use slow sand filters to filter water.

3. Mining: Weareexcavating petroleum products from the earth's layer, which are

used for oiland gas. We are aware that, there are limited source of petroleum products, hence we should not misuse them after a certain limit, otherwise it may trigger air pollution and subsequently global warming. Instead of petrol and diesel, we can use battery operated bicycles, cars, buses and other vehicles.

4. Crockery and Utensils: Cutlery and Utensilsboth plays an important role for the purpose of eating and serving of food, although crockery characteristically a container in which we put food, while cutlery includesspoons, forks, etc. used by both cooks and restaurantsfor making and eatingfood. Earthen cups and glasses are eco-friendly, which we should use rather than steel utensils and spoons.

5. Pesticides and Fertilizers: Most of the Pesticides and Fertilizers pollute soil, water, flora and fauna. Pesticides and Fertilizers not only killsbugs, but are harmful in nature for birds, fishes and non-target shrubs. In place of the Pesticides and Fertilizers, we should use Bio pesticides and Bio fertilizers, which can boost food supplies, making agriculture greener, safer and more efficient.

6. Soil Fumigation Procedures: Soil fumigation means disinfection of the soil, making soil free from any contamination. It is usually done with the help of the chemicals which might have adverse effects on the environment, can be enormouslyhazardous to people and also leaves behindpoisonous remains in plants. Hence, farmers should think of advanced and new procedures or methods for soil fumigation. Few steps like use of pesticides with fumigants in less quantity can help.

AMAZING FACT

SIKKIM IS 100% ORGANIC STATE!

Sikkim, a north-eastern state became India's first organic state in 2016. In Sikkim, farming is done with the help of the organic compost, without using pesticides with chemicals. It helps in making farming more eco-friendly and enhanced produce.Farmers in Sikkim use pits for the preparation of the organic compost, for which farmers are given mandatory training. Hence production and export of foodgrains has seen tremendous growth.

Activity 15.2
Make a visit to any agriculturalcentre situated near your residence and make a table of normally used pesticides and fertilizers and their influences on humans and environment.

CHECK YOUR PROGRESS 15.2

1. Name the three stakeholders in saving environment.
2. How does cremation in rivers affect the environment?
3. Is God/Goddess Immersion in rivers good or bad?
4. Which human activities are responsible for air pollution during Diwali?
5. Is banana leaf an alternative to steel plate?
6. Why should we use Bio-Pesticides?
7. Can we replace our Refrigerator?

15.6 AGENCIES WORKING FOR ENVIRONMENT PROTECTION

1. India Meteorological Department (IMD): The India Meteorological Department was started in 1875 by the Britishers at Shimla, Himachal Pradesh. IMD has its head office in Pune, Maharashtra and its Regional Offices are in Mumbai, Kolkata, Chennai, Nagpur and Delhi. IMD prepares maps on daily basis for the prediction regarding the weather, which are available twice in a day. Apart from predicting the weather conditions, IMD is also involved in the research related to the climate readings, climatic forecasts using radarandestimateswith respect to rainfall using satellites.

IMD also helps other departments like aviation, shipping, agriculture, irrigation, marine oil exploration, etc. by giving information regarding weather conditions. It helps the departments by providing information of natural disasters like dust and sand storms, heavy rainfall, hot and cold waves, etc. Highly advanced satellites are used across different places to receive the data.

2. Central Pollution Control Board (CPCB): Central Pollution Control Board is a legitimate organisation, which was formed in 1974 under the Water (Prevention and Control of Pollution) Act, 1974. CPCB was provided with the controls and powers under the Air (Prevention and Control of Pollution) Act, 1981. The main role of the CPCBis to recommend the Central Government regarding avoidance of water and air pollution and also take necessary steps to stop the pollution so that the air quality gets better.

3. National Green Tribunal (NGT): The National Green Tribunal had its foundation in 2010 under the National Green Tribunal Act, 2010. NGT was formed to give momentum to the legal cases related to the environment protection and forest preservation. It also takes care of the lawful rights with respect to environment and provides necessary reimbursement to the individuals for the damage caused due to natural incidents.

NGT is a dedicatedorganisation for handling various issues related to environment. It also helps in prompt justice to the needy and also minimises the burden of the high courts.NGT has a directive that any case registered need to be addressed within six months. NGT's Main Sitting Place is Delhi, while the other sittings are in Bhopal, Pune, Kolkata and Chennai.

4. Ministry of Environment, Forest and Climate Change (MoEFCC): The Ministry of Environment, Forest and Climate Change (MoEFCC) manages the Central Government's administration with respect to thepreparation, advertising, direction and supervision of different government policies regarding forest and environment. Ministry of Environment, Forest and Climate Change coordinates for the United Nations Environment Programme (UNEP), South Asia Co-operative Environment Programme (SACEP), International Centre for Integrated Mountain Development (ICIMOD) and United Nations Conference on Environment and Development (UNCED).

The extensivegoals of the Ministry are:

- Safeguarding of jungles and flora and fauna
- Avoidance and control of pollution
- Afforestation and renewal of ruinedregions
- Protection of the environment and
- Warranting the wellbeing of wildlife

In India, Central Pollution Control Board (CPCB) taken surveys regarding noise pollution in Bangalore, Kanpur, Mumbai, Hyderabad, Chennai, Jaipur, Delhi and Kolkata. In the surveys, it was established that in these cities the level for noise pollution was expectedly higher than the set limit. Almost same condition is of every major city in other countries.

Activity 15.3
List the methods of saving one litre of water/day at your home.

REMEMBER THIS

How can we decrease waste?

- Only take print outs when it is important.
- Print on both the sides of the paper.
- When you go out for shopping, take your own cloth bag.
- You can make organic compost from kitchen waste.

- You can donate your clothes/house items to old age homes or orphanage rather than just throwing in waste.
- Say NO to plastic bags in shops and marketplaces.

CHECK YOUR PROGRESS 15.3

1. IMD stands for ________________________________
2. CPCB was formed in the year _______
3. NGT has its head office in __________
4. Ministry of Environment, Forest and Climate Change takes care of ____________ and _____________ policies.

RECAPITULATION POINTS

- Different Goals to meet the various environmental challenges.
- What should be our efforts which we can put to preserve our environment and to attain the goals to meet the environmental challenges?
- Government, Government Agencies, Society and You can help in meeting the goals of the environmental challenges.
- We have learnt about the different cultural practices like Holi, Diwali, Immersion of God/Goddess, etc. which are not good for environmental in the manner in which we are celebrating them and should be changed.
- Also we have seen Scientific practices such as use of refrigerator, steel utensils and use of pesticides and fertilizers, etc. which can be stopped or changed to organic or natural.
- IMD,CPCB,NGT and Ministry of Environment, Forest and Climate Change play an significantpart in safeguarding our environment

TERMINAL EXERCISES

1. Describe any five Goals to meet the environmental challenges with the help of examples for each goal.

2. How are cultural practices responsible for affecting the environment? Explain by giving examples.
3. Mention any two scientific practices which are harmful to environment.
4. List any three stakeholders whose role is important.
5. Describe the agencies involved in protection of environment.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 15.1

1. Delhi
2. Pollution, Global warming, Overpopulation, Waste disposal, Ocean acidification, Loss of biodiversity, Deforestation, Ozone layer depletion
3. Forest areas need to be restored or managed in ways that enhance their values.
4. Groundwater contamination occurs due to the release of environmentally risky materials in water supply – insecticides are one example, mainly in farming areas.

CHECK YOUR PROGRESS 15.2

1. Government, Government Agencies And Society
2. Cremation releases chemicals into the atmosphere, including carbon monoxide, sulphur dioxide, heavy metals, and mercury emissions which are particularly harmful.
3. Bad
4. Bursting of fire crackers
5. Yes
6. We should use Bio pesticides because they can increase food supplies, making agriculture greener, safer and more efficient.
7. Yes

CHECK YOUR PROGRESS 15.3

1. India Meteorological Department
2. 1974
3. New Delhi
4. Environmental, Forestry

16

HEALTH AND HYGIENE

INTRODUCTION

What is Good Health? Good health may be interpreted differently by different people. It may vary for an athlete or an office worker. It may have a different meaning for urban life and different for a village dweller. Good health varies much with the kind of physical or mental activities that one undertakes.

Working in an open field may sound daunting for an office worker and the person may not be able to undertake any activity which requires hard physical labour. Does that mean the person is unhealthy? The office worker is able to do his routine work which may require psychological tensions and presence of mental strength. Thus in both cases different aspects of being healthy are seen.

The current generation is highly aware of health & hygiene than their elders. They are regularly monitoring the food they take in and are very particular about their exercise regime and fitness programs.

In this chapter we will learn about the importance of good health & hygiene at personal and community level. We will understand the importance of keeping physically fit and eating balanced diet. We will also look at some common diseases and recognize the significance of immunization.

16.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Define 'Health' & 'Hygiene'. Recognize Signs of Social, mental and physical health. Discuss all three aspects for complete health.
- Explain the role of personal and community hygiene; why community hygiene isas important as personal hygiene.
- Justify the promotion of community health as an important measure to keep up the social well-being of one and all.
- Express awareness about advantages of Yoga as a means of holistic approach towel ness.
- Identify common Communicable and non-communicable diseases from their symptoms and how to prevent them from spreading.
- Analyse the importance of Balanced diet in maintaining good health.

- Compare and differentiate between congenital and acquired diseases.
- Create awareness about immunization.

16.2 MEANING OF HEALTH&HYGIENE

Good health is a blessing. People who enjoy good health are happy and free from tension. So how can you define health? Is it purely physical comfort? Health is a condition where all your body systems work in perfect sync with each other.

WHO [World Health Organization] is the specialized health agency of the United Nations. Health is defined by WHO '***as a state of complete physical, mental and social well-being and not merely the absence of disease'.***

World Heath Day: April 7- consciousness about keeping healthy.

Can you think of some sayings regarding health?

Activity 16.2a

Complete the following:

Health is ____________________

An apple a day____

A healthy body harbours a____

Health and hygiene go hand in hand. Hygiene can be defined as a practice to keep self and surroundings clean in order to prevent the spread of disease and keep healthy.

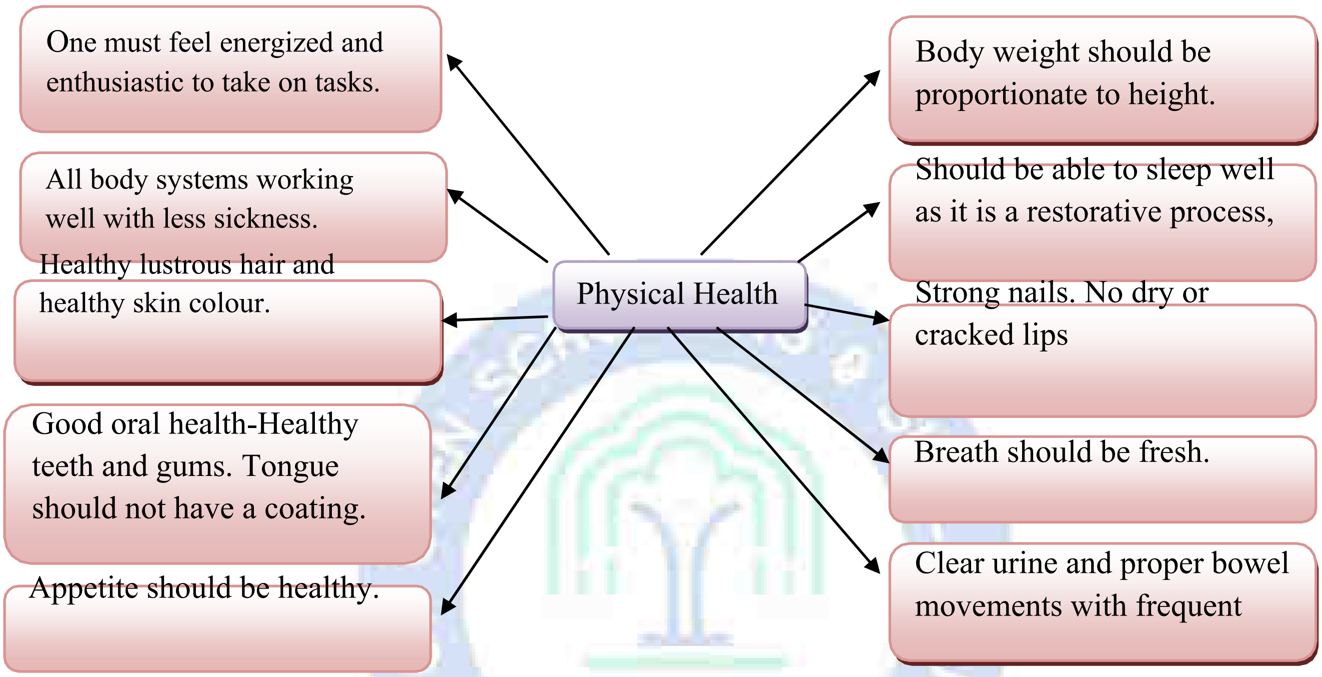
According to WHO '***Hygiene refers to conditions and practices that help to maintain health and prevent the spread of diseases'***. Hygiene is often equated with being clean. However, at personal level it includes good practices such as trimming nails and taking bath regularly. Community hygiene includes keeping the surroundings clean.

Activity 16.2b

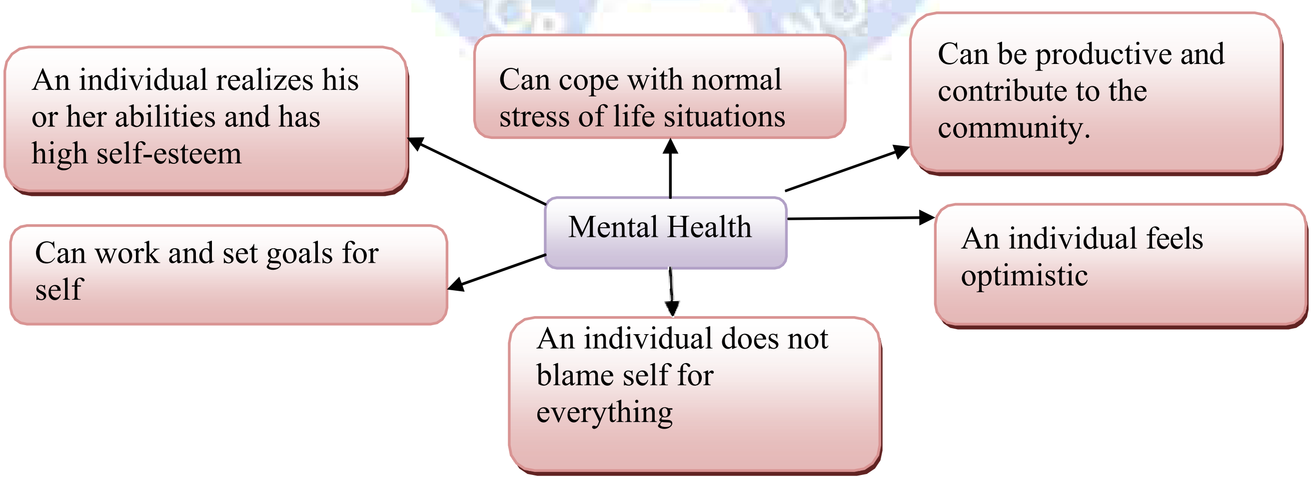
Have you wondered why so much emphasis is laid on washing hands often especially now a days? Discuss with your partner and write down three hygienic values of this action.

16.2.1Signs of Social, Mental and Physical health

Physical health is of utmost importance in order to function normally. It is a state wherein the body is able to perform in all areas of physical activities such as sports, occupation and daily chores.

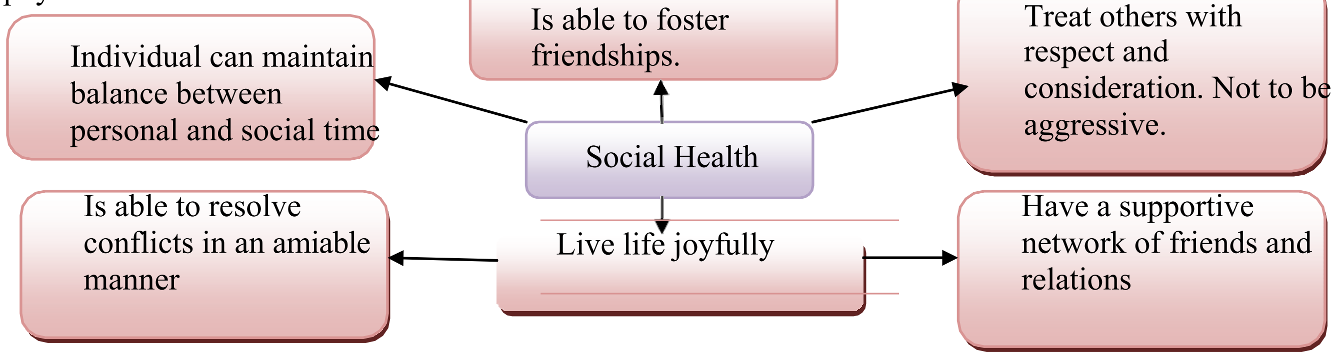


16.2 2 Mental health refers to cognitive, behavioral and emotional well being. It is not merely absence of any mental disorder. It is about the way a person can deal with stressful situation and how he feels or behaves.



16.2.2 Social Health is the ability of an individual to have meaningful interaction with others.

Human beings are social creatures by nature. They ought to have healthy relationships in order to remain in cheerful state. Having good social health has a positive bearing on mental and physical health as well.



Activity 16.2

Do you recall a time when you were sick? What did you feel like? Did you visit a doctor?

Now recall a time when you were in good health. What did you feel at that time?

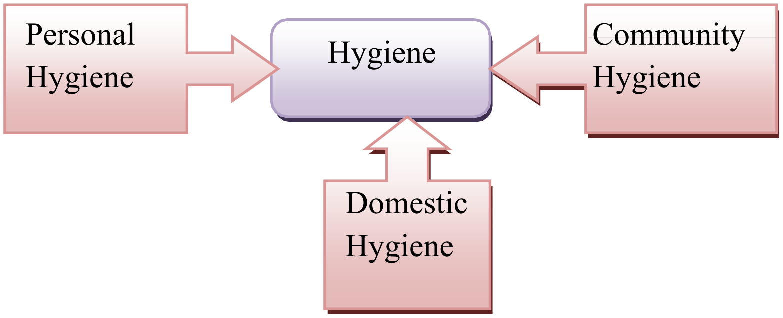
When sick	What did it feel like	When healthy	What did it feel like
You			
Others			

CHECK YOUR PROGRESS 16.1

1. Full form of WHO is……………………………..
2. To enjoy complete fitness one must have,………………and……….health.
3. What is the WHO definition of Hygiene?

16.3 HYGIENE

The word 'Hygiene' is derived from a Greek word ***hygies*** (Hygiea=Goddess of health), meaning healthy and sound. Maintaining good personal and community hygiene is very important to promote good health. It is essential to follow certain good habits to ensure hygiene which in turn will help us to live a long, healthy and disease-free life and work efficiently in respective spheres, be it school or occupation.



16.3.1 Personal Hygiene

Personal hygiene entails maintaining cleanliness and grooming of external body.

Does it matter if you forget to brush your teeth? Or forget to take a bath? Look at the following figure 16.1. How many of these personal hygiene tasks do you perform daily or regularly?

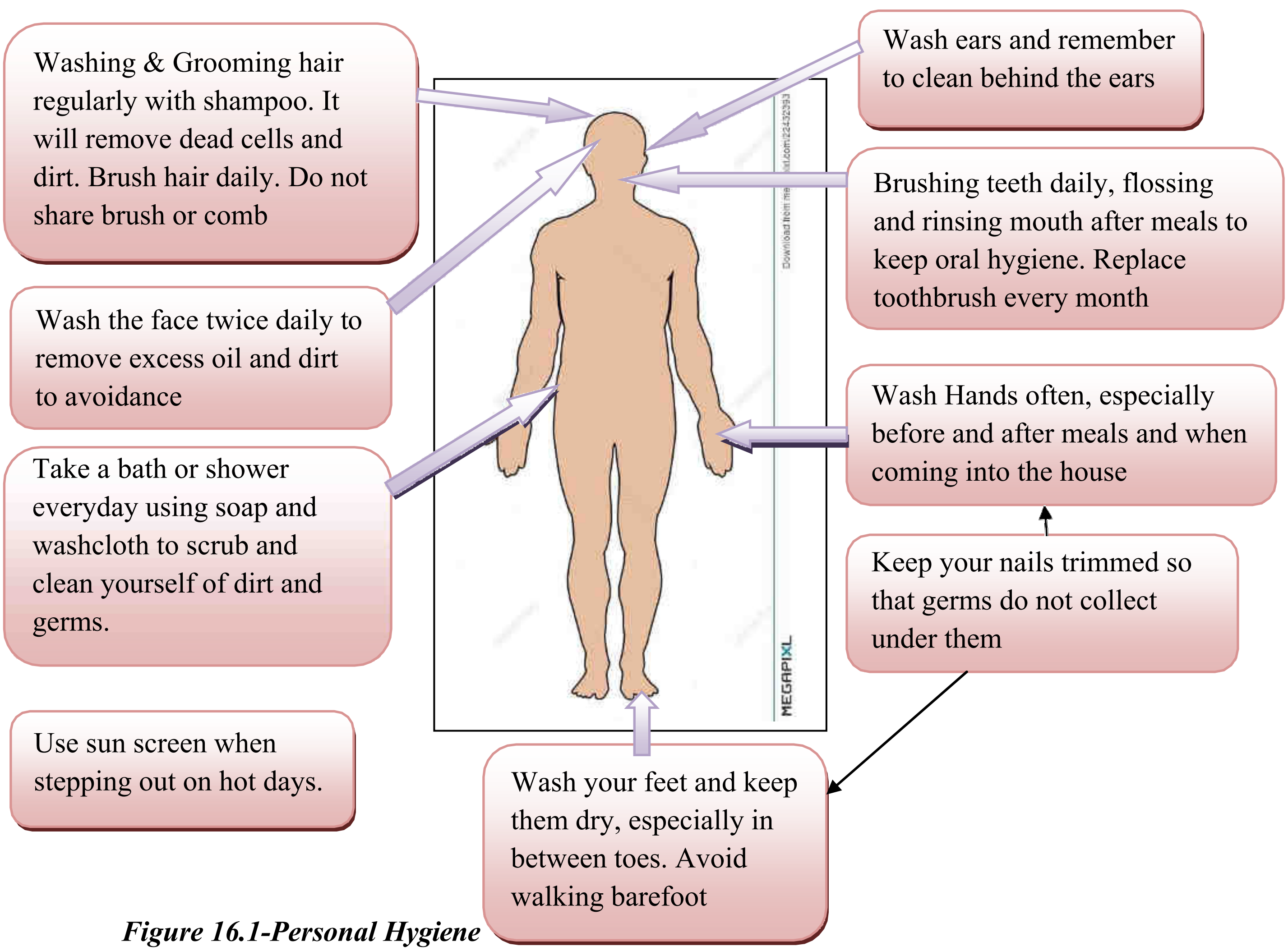


Figure 16.1-Personal Hygiene

16.3.2 Community Hygiene

Community hygiene is described as collective effort of a community to maintain health and prevent illness in the group. It is essential in order to keep all members of the community especially those with weak immunity, children and elderly away from diseases. Community hygiene, when followed, can help save many a lives by preventing infections.

Some practices to uphold community hygiene are listed below:

- Sweeping the floors and keeping dirt off the floor to prevent environmental pollution.
- Keeping the garbage in a designated bin and disposing it off as per the guidelines.
- Keeping livestock away from households.
- Using toilets to urinate and defecate instead of doing it in the open.
- Water sources should be protected and potable water should be provided for all.
- Drainage and waste water disposal should be done with care.

16.3.3 Domestic Hygiene

A clean home can reduce the risks of illness. It helps you and your family to live a safe and comfortable life. Hence domestic hygiene is vital.

Some ways to keep your house in a hygienic condition are listed below.

- Dusting the surfaces with a broom or a cloth removes dead flakes of human skin, dust mites etc.
- Bed linen should be changes every week or fortnight as it will harbor dust mites and human droppings.
- Washing hands before eating will help remove any unwanted particles.
- Keep the footwear used outdoors outside the house to avoid any contaminants from entering the house.
- Use cleaning agents to mop the floor to kill germs
- Clean the bathtub, sinks etc in the bathroom with anti-bacterial agents regularly
- Kitchen should be kept clean. The counters, stove tops etc should be cleaned after cooking. Lemon, baking soda and vinegar can be used instead of harmful chemicals in kitchen cleaning.

CHECK YOUR PROGRESS 16.2

Below is given a table of various good hygiene practices. Put a tick against each in the correct column- personal, community or domestic hygiene

Hygiene Habits	Personal	Community	Domestic
Using cleaning agents to mop			
Brushing & flossing teeth daily			
Keeping garbage in designated bins			
Bathing or taking shower daily			
Washing & grooming hair regularly			
Trimming nails			
Cleaning bathtub, sink etc			
Using toilets rather than open spaces to defecate			
Keeping livestock away from household			

16.4 BALANCEDDIET

Balanced diet is a diet which contains required amount of essential nutrients such as carbohydrates, fats, proteins, vitamins, minerals, roughage and water to keep the body healthy and disease free. Eating a balanced diet means choosing a wide variety of food and drinks from different food groups.

Balanced diet is important as it leads to good physical and mental health. It helps in proper growth of the body and increases resistance to diseases. It helps to work to our full capacity.

Components of Balanced Diet

Carbohydrates- Give energy to body cells. E.g. Sugar, starch. Sources are Cereals, bread, pasta, potato etc

Proteins- nutrients that are essential for growth, repair and maintenance of body tissues. Sources are egg, fish, meat, milk etc.

Fats- these are needed for energy and warmth. They are essential for absorption of Vitamins A &D. E.g. butter, ghee,

Minerals- Many minerals such as Iron, Calcium, Potassium are vital for proper functioning of the body

Vitamins- help in a number of chemical reactions in the body. Different Vitamins help with different functions. E.g. Vitamin A improves vision while Vitamin C is good for skin. A good source of vitamins is fresh fruits & vegetables.

Water is needed to prevent the body from dehydrating and maintain fluid levels

Roughage- Referred to as fibres are a type of carbohydrate that a human body cannot digest. However, it is required as it gives bulk to the food and regulates bowel movement.

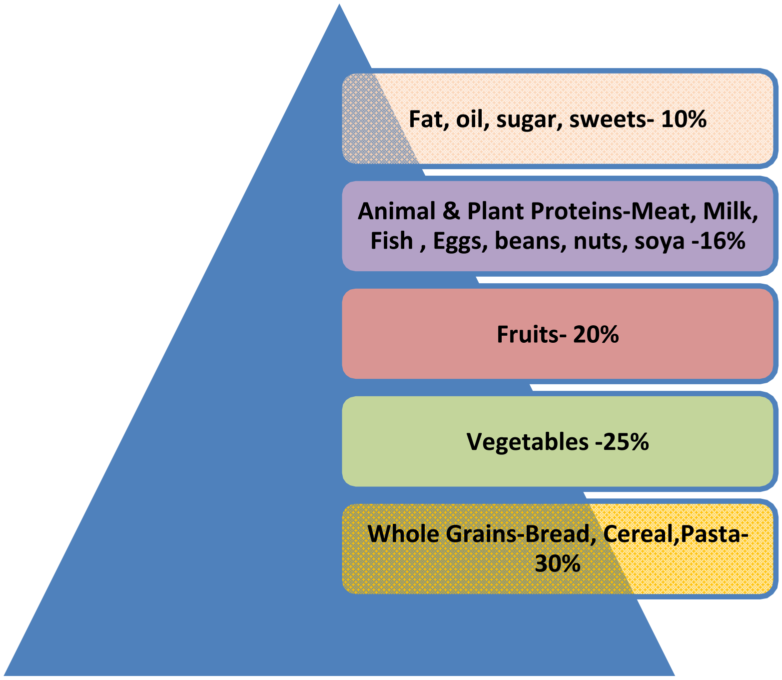


Fig 16.2

A Balanced diet will vary with age, sex and the type of work that one does. Growing children will require a diet rich in proteins while a hardworking labourer will need more of carbohydrates or energy giving food. A pregnant lady and a nursing mother will need a protein rich diet to cater to the needs of growing baby.

VITAMIN	OTHER NAMES	EXAMPLES OF PHYSIOLOGICAL FUNCTIONS
Vitamin A	Retinol, retinoic acid, retinal, carotenoid	Growth, maintenance of skin, bone development, maintenance of myelin, maintenance of vision
Vitamin B_1	Thiamine	Growth, appetite, digestion, nerve activity, energy production
Vitamin B_2	Riboflavin	Growth and development of foetus, redox systems, and respiratory enzymes; maintenance of mucosal, epithelial, and eye tissues
Vitamin B_3	Nicotinamide, niacinamide, nicotinic acid, niacin	Maintenance of NAD and NADP, coenzyme in lipid catabolism, oxidative deamination
Vitamin B_5	Pantothenic acid	Lipid metabolism, protein metabolism, part of coenzyme A in carbohydrate metabolism
Vitamin B_6	Pyridoxine, pyridoxol, adermine	Growth; protein, CHO, and lipid metabolism; coenzyme in amino acid metabolism
Vitamin B_7	Biotin, protective factor X	Growth; maintenance of skin, hair, bone marrow, and sex glands; biosynthesis of aspartate and unsaturated fatty acids
Vitamin B_9	Folic acid, folacin, folinic acid	Synthesis of nucleic acid, differentiation of embryonic nervous system
Vitamin B_{12}	Cobalamin	Coenzyme in nucleic acid, protein, and lipid synthesis; maintenance of epithelial cells and nervous system
Vitamin C	Ascorbic acid	Absorption of iron, antioxidant, growth, wound healing, formation of cartilage, dentine, bone and teeth, maintenance of capillaries
Vitamin D	Vitamin D_3, cholecalciferol, calcitriol	Normal growth, Ca and P absorption, maintains and activates alkaline phosphatase in bone, maintains serum calcium and phosphorus levels
Vitamin E	Tocopherol, Tokopharm, tocotrienols	Antioxidant, growth maintenance, aids absorption of unsaturated fatty acids, maintains muscular metabolism and integrity of vascular system and central nervous system
Vitamin K	Prothrombin factor, menaquinones	Blood-clotting mechanisms, electron transport mechanisms, growth, prothrombin synthesis in liver

CHECK YOUR PROGRESS 16.3

1. List the 7 food groups. For each group write down some examples of food/drink

2. Write a brief description of what each group is needed for in the body

16.5 COMMUNITY HEALTH

Community health is defined as the aspect of public health which deals with maintenance, protection and improvement of the health status of the community of people as a whole. It ensures equal access to health resources, even in remote rural areas.

Community Health Components

- Providing essential services such as screening and counseling
- Educating people on the benefits of prevention of diseases.
- Minimizing costs to health care.
- Helping people to afford medical, dental, and mental health care services
- Establishing community health centres, mobile clinics and outreach programs
- Identify health issues within a specific community by health care workers

16.6 YOGA

The word Yoga is derived from the Sanskrit word 'Yuj' meaning 'to join' or 'to unite'. It is an art and science of healthy living which involves a type of mind-body exercise through different physical postures called 'Asanas'. Its practice leads to the union of individual consciousness with that of Universal consciousness, to create harmony and peace between body and mind.

The practice of Yoga started with the start of civilization, originating thousands of years ago. Lord Shiva is seen as the first yogi. Present times, Yoga education is being given by many institutions and is part of curriculum in many schools.

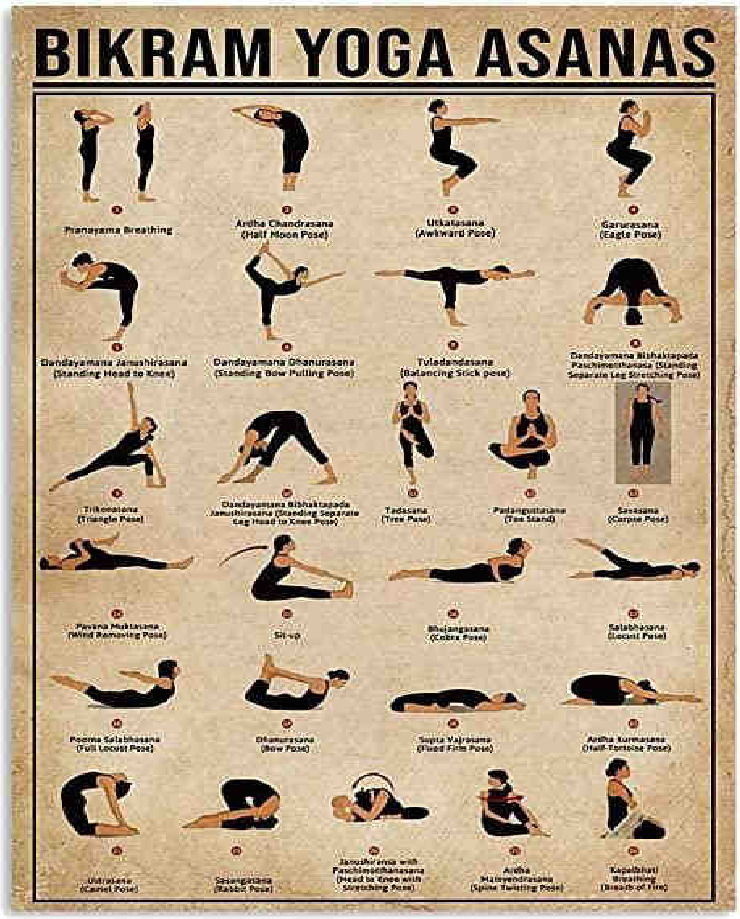
16.6.1 Advantages of Yoga The physical and mental benefits of yoga are varied, from increased flexibility to improving quality of sleep. The mind body interaction makes this especially beneficial.

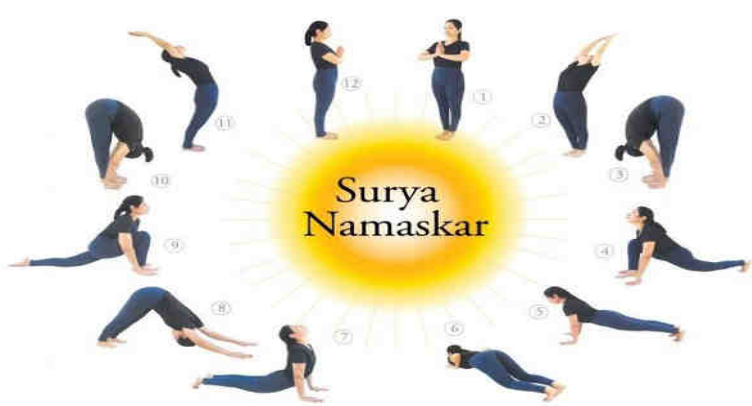
YOGA

- It increases flexibility, stronger muscles and balance. It stops muscles from pulling adversely against the joints
- It has mental health benefits like improving sleep and easing anxiety
- It improves heart health
- It can improve arthritis symptoms
- It can help to lose weight. Calories burnt in one hour of Yoga:

  Power Yoga- 240 calories

  Hatha Yoga-173 calories
- It can ease back and joint pains. Back pain is sometimes due to poor posture. Good posture can keep joints aligned. Yoga improves flexibility and mobility to reduce muscle tension in the back and joint areas.
- It reduces stress and improves well-being.
- It builds strength by using body weight as a form of resistance


BIKRAM YOGA ASANAS
Pranayama Breathing
Ardha Chandrasana
(Half Moon Pose)
Utkatasana
(Awkward Pose)
Garurasana
(Eagle Pose)
Dandayamana Janushirasana
(Standing Head to Knee)
Dandayamana Dhanurasana
(Standing Bow Pulling Pose)
Tuladandasana
(Balancing Stick pose)
Dandayamana Bibhaktapada
Paschimotthanasana (Standing
Separate Leg Stretching Pose)
Trikonasana
(Triangle Pose)
Dandayamana Bibhaktapada
Janushirasana (Standing Separate
Leg Head to Knee Pose)
Tadasana
(Tree Pose)
Padangustasana
(Toe Stand)
Savasana
(Corpse Pose)
Pavana Muktasana
(Wind Removing Pose)
Sit-up
Bhujangasana
(Cobra Pose)
Salabhasana
(Locust Pose)
Poorna Salabhasana
(Full Locust Pose)
Dhanurasana
(Bow Pose)
Supta Vajrasana
(Fixed Firm Pose)
Ardha Kurmasana
(Half-Tortoise Pose)
Ustrasana
(Camel Pose)
Sasangasana
(Rabbit Pose)
Janushirasana with
Paschimotthanasana
(Head to Knee with
Stretching Pose)
Ardha
Matsyendrasana
(Spine Twisting Pose)
Kapalbhati
Breathing
(Breath of Fire)


Surya
Namaskar
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16.7 DISEASES

A disease is a state of disorder or not at ease (dis-ease). It is a condition of the body or the organ where functions are disturbed and away from normal. Any person not at ease physically, mentally or socially is said to be suffering from a disease. Many changes or factors can disrupt this state of ease or harmony.

Health can be affected by insufficient or improper functioning of the organs or the immune system. This may result in a defect in the organ itself or interfere with thousands of biochemical reactions taking place in the body. Such factors are referred to as ***intrinsic factors.*** For example if insulin production is stopped by pancreas, it will lead to ***diabetes.***

Health can be affected by external agents or factors also. For example Diet related deficiencies like lack of vitamins and other essential nutrients. Certain microorganisms are also responsible for causing diseases. Such factors are referred to as ***extrinsic factors.*** Some external factors can be environment related such as pollution, extreme heat or cold.

16.7.1 Communicable & non-Communicable diseases

Diseases can be broadly grouped as communicable and non-communicable diseases

Diseases

Communicable

Diseases which can be transmitted from person to person. e.g., chickenpox; covid-19

Non communicable

Diseases which cannot be transmitted from person to person. e.g., asthma, cancer

16.7.2 Communicable Diseases

Communicable diseases are caused by infectious agents such as bacteria, virus, protozoa and fungus. These microbes are called pathogens as they can cause diseases. They enter the body tissues and start destroying them as they multiply rapidly. They may produce toxic substances as waste causing diseases.

These pathogens can be transmitted in following ways from an infected person to healthy person.

Modes of Transmission of communicable diseases

Through Air- This is also called droplet infection. During sneezing or coughing, tiny droplets of water laden with germs from an infected person remain suspended in air once the water evaporates. These infect a healthy person when he or she inhales the air. e.g., influenza, Covid 19

Sexual Transmission- by sexual activity. e.g. Syphilis, Gonorrhoea, AIDS, Herpes

Indirect Contact- Diseases can be transmitted indirectly by vectors and carriers.

A housefly is a carrier which just carries the germs but does not get infected itself. Diseases like Typhoid and Cholera are transmitted thus.

A female anopheles mosquito is a vector as it gets infected by the pathogen and part of the lifecycle of the microbe is completed in its body. Malaria and dengue are transmitted by vectors.

Through water & Food- Water and food if not prepared and stored hygienically may contain pathogens. e.g., Typhoid, Cholera, Jaundice

Direct Contact- Some diseases like those caused by fungus like ringworm can be caused by direct contact with an infected person.

Communicable diseases can be categorized in the following three ways in accordance to their prevalence:

- Endemic- A low but constant level of infection in the population
- Epidemic-A large number of cases occurring in a short period of time
- Pandemic- A widespread epidemic

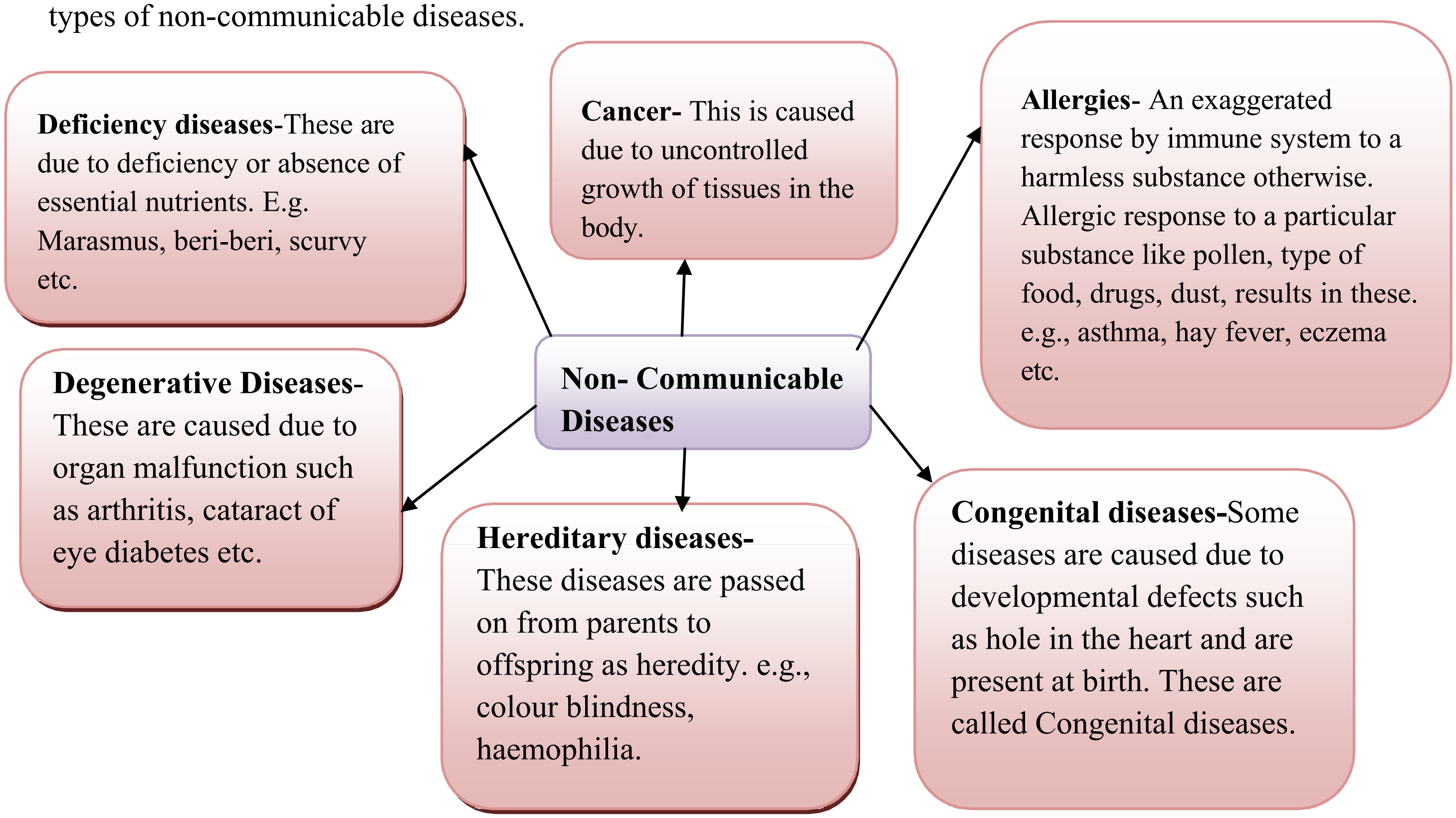
16.7.3 Prevention of Communicable diseases

The following precautions can be taken to prevent Communicable Diseases

- Isolating the patient
- Maintaining proper sanitation conditions
- Fecal matter and urine should be disposed of properly.
- Health education should be given to people
- Vaccination against communicable diseases should be promoted.

16.7.4 Non- Communicable Diseases

These diseases cannot be transmitted from one person to another. The following chart shows the types of non-communicable diseases.



16.7.5 Congenital & Acquired Diseases

Congenital disease is a medical condition present at birth. This may be recognized prenatally (before birth), at birth or many years later. It can be present in the genetic make up of the fertilized egg or may arise sometime during fetal development. e.g., Hole in the heart.

Acquired Disease are those that an individual may acquire during the life time due to external agents, internal factors or the life style of an individual. Most of these can be cured. They can be grouped under communicable and non-communicable diseases. e.g. Typhoid, cancer etc.

16.8 IMMUNITY

A specific immune system helps body defend itself from the diseases. This system produces antibodies which are proteins. These antibodies attack the foreign bodies and pathogens and finish them.
The antibodies then remain in the body and prevent the recurrence of the disease. Thus, a person has developed immunity against that particular disease. For example, if a person suffers from chickenpox, he will most probably never suffer from it again as the body will have developed antibodies after first attack of the disease and these antibodies will remain in the blood to prevent any further attack by chickenpox.
Immunity can be natural when it exists naturally in our body. Often people develop immunity against certain diseases such as measles after having suffered from the disease once.

Acquired immunity is developed through vaccination.

16.9 IMMUNIZATION

Immunity against a particular disease can be induced in the body by introducing dead or weakened germs of the disease. This is called a **vaccine.** A vaccine can be a dose of **dead germs** (cholera or typhoid vaccines), **live microbes** which have been altered so that they are no longer dangerous (polio, measles) or **toxoid** (a harmless form of toxin produced by the pathogen). The body recognizes the antigen and produces antibodies against it. Thus, immunity is achieved. This technique is called **vaccination or immunization.** Some diseases for which vaccination is done are polio, chicken pox, measles, T.B. and Hepatitis.

One can achieve immunity against several diseases by this method. For example, tuberculosis, chickenpox, polio etc. You must be having an immunization chart which keeps a track of all the vaccines that you have been administered since you were born.

Some vaccines are given at intervals in two or three doses to build up more antibodies each time. A booster dose may also be needed after a time to maintain immunity. E.g., Covid -19.

Immunization Schedule Chart

Sn. No.	Vaccine	Due age	Route
1.	BCG	At birth	Intra dermal
2.	Hepatitis B-Birth dose	At birth	Intra muscular
3.	OPV-O	At birth	Oral
4.	OPV 1, 2 & 3	At 6 weeks, 10 weeks & 14 weeks	Oral
5.	Pentavalent 1, 2 & 3 (Diphtheria + Pertuss is + Tetanus + Hepatitis B + Hib)	At 6 weeks, 10 weeks & 14 weeks	Intra muscular
6.	Inactivated polio vaccine	At 6 & 14 weeks	Intra muscular
7.	Rotavirus (where applicable)	At 6 weeks, 10 weeks & 14 weeks	Oral
8.	Pneumococcal conjugate vaccine (where applicable)	At 6 weeks & 14 weeks. At 9 completed months – booster	Intra muscular
9.	Measles/Rubella 1st dose	At 9 completed months – 12 months	Subcutaneous
10.	DPT Booster-1	16–24 months	Intra muscular
11.	Measles/Rubella 2nd dose	16–29 months	Subcutaneous
12.	OPV Booster	16–24 months	Oral
13.	DPT Booster – 2	5–6 years	Intra muscular
14.	TT	10 years & 16 years	Intra muscular

Picture courtesy- Brain Kart

Activity 16.5

1. Create an advertisement or a short skit as a group about ways to keep germs from spreading and present it to the class

2. Choose a communicable disease and create a brochure about fighting the disease and preventing it. Must include:

a) Title

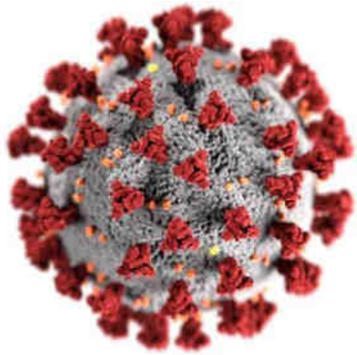
b) Information from the chapter

c) Pictures or drawings

d) Use vocabulary from the chapter

16.10 COVID19

Covid- 19 is caused by the **SARS-CoV-2** virus. It can cause mild to severe respiratory illness, resulting in death. Corona viruses are a family of viruses which derive their name from crown like spikes on the surface of the virus. The new strain of coronavirus-SARS-CoV-2 was first reported in Wuhan, China in December 2019. It has since become pandemic.



Picture Courtsey: WHO

16.11 TRANSMISSION

SARS-CoV-2, the Covid-19 virus is transmitted through droplets suspended in air. They enter the body through nose, mouth or eyes. It attaches to cells in the upper respiratory tract and multiplies rapidly. It then moves into lung tissues. It can spread to other body tissues from there. Covid -19 virus can also spread by close contact such as touching or shaking hands with an infected person and then touching your face.

16.11.1 Symptoms of Covid-19

Covid-19 symptoms vary from person to person. General symptoms include fever, chills, cough, shortness of breath (difficulty in breathing), tiredness, muscle or body ache, diarrhea, loss of taste or smell, sore throat and congestion or runny nose.

16.11.2 Prevention

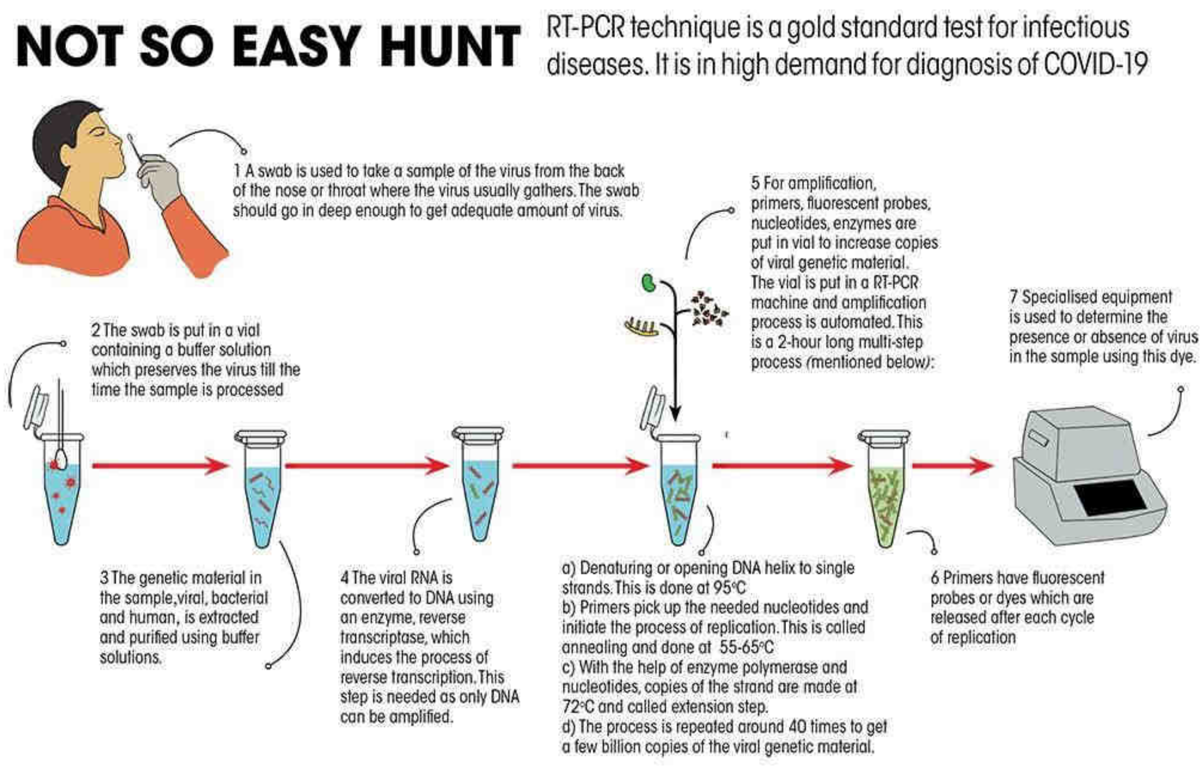
- Stay 6 feet away from others whenever possible
- Wear a cloth mask that covers your mouth and nose when around others
- Wash your hands often. Use a sanitizer that contains at least 60%alcohol.
- Avoid crowded indoor spaces.
- Stay self-isolated at home if you are feeling ill with symptoms that could be Covid-19 or have a positive test.
- Clean and disinfect frequently touched surfaces.

16.11.3 Test forCovid-19

RT-PCR tests were the first to be developed when Covid-19 pandemic began. It is designed to detect viral RNA. A positive result is highly accurate for the presence of viral nucleic acid.

Covid-19 virus is made of RNA rather than DNA. For such viruses the RNA has to be converted into DNA before copying. This process is called reverse transcription. Hence the test is rt PCR= reverse transcription PCR test. It checks for the presence of a pathogen.

A nasal swab is taken from the front or back part of your nasal passage, or from the uppermost part of your nose and throat for the test.



Activity 16.6

Turn to the person next to you.

Inform him or her about Covid -19

Discuss its causes, method of transmission and prevention.

RECAPITULATION POINTS

- Health is defined by WHO ‘as a state of complete physical, mental and social well-being and not merely the absence of disease’.
- Hygiene refers to conditions and practices that help to maintain health and prevent the spread of diseases’
- Physical health is a state wherein the body is able to perform in all areas of physical activities such as sports, occupation and daily chores.
- Mental health refers to cognitive, behavioral and emotional wellbeing.
- Social Health is the ability of an individual to have meaningful interaction with others.
- Personal hygiene entails maintaining cleanliness and grooming of external body.
- Community hygiene is described as collective effort of a community to maintain health and prevent illness in the group.
- Balanced diet is a diet which contains required amount of essential nutrients such as carbohydrates, fats, proteins, vitamins, minerals, roughage and water to keep the body healthy and disease free.
- Community health is defined as the aspect of public health which deals with maintenance, protection and improvement of the health status of the community of people as a whole.
- Yoga is an art and science of healthy living which involves a type of mind-body exercise through different physical postures called ‘Asanas’.
- A disease is a state of disorder or not at ease (dis-ease). It is a condition of the body or the organ where functions are disturbed and away from normal.
- Diseases can be grouped broadly as communicable (can be transmitted from infected person to a healthy person) and non-communicable (cannot be transmitted from person to person).
- Resistance acquired by an individual against the harmful effects of a disease causing pathogen is called immunity.
- Covid- 19 is caused by the SARS-CoV-2virus.
- RT-PCR tests were the first to be developed when Covid-19 pandemic began. It is designed to detect viral RNA. A positive result is highly accurate for the presence of viral nucleic acid.

TERMINAL EXERCISE

1. **Choose the appropriate answer**
    i. Good personal hygiene means
        a. Caring and cleaning our bodies to promote good health
        b. Improving our self-esteem by following some good practices.
        c. Washing our hands
        d. All of the above
    ii. Jaundice is caused by
        a. Deficiency of vitamin A
        b. Drinking contaminated water
        c. Bacterial infection
        d. Air pollution

iii. Covid -19 is caused by
   a. SARS-CoV-2
   b. AIDS virus
   c. H_1N_1virus
   d. Influenza type-A virus

iv. Uncontrolled growth of tissue causes
   a. Cataract
   b. Malaria
   c. Diabetes
   d. Cancer

v. Malaria and Dengue are transmitted by
   a. Vectors
   b. Direct contact
   c. Contaminated food
   d. Sexual contact

vi. Which of the following is not a communicable disease
   a. Malaria
   b. Scurvy
   c. Typhoid
   d. Covid-19

2. Fill in the blanks

i. Antibodies can provide____________against a disease.

ii. Vaccine can be adose of________________,______________________or _____________.

iii. Covid -19virushas_________________instead of DNA.

iv. diseases may be present at birth.

v. test is done to diagnoseCovid-19

3. Differentiate between

i. Endemic, Epidemic and Pandemic diseases.

ii. Congenital and Acquired diseases

iii. Communicable & non communicable diseases

iv. Natural and Acquired immunity

4. Answer briefly

i. How is healthy life of a person useful to the society?
ii. Name two diseases related to heredity.
iii. Define immunization.
iv. Define health and hygiene.
v. What is an allergy? Name two agents that can cause allergy.
vi. What is balanced diet? How can it vary for different people?

5. Long Answer

i. What causes Corona -19? How is it transmitted? What precautions should be taken to prevent its spread?
ii. What is a vaccine? How does it work? Name any two diseases for which vaccines are given?
iii. What is 'Yoga'? List any six advantages of Yoga.
iv. 'Personal hygiene is important for good health'. Do you agree? List some essential personal hygiene practices.
v. How do you know if a person is socially and mentally healthy?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 16.1

1. World Health Organization
2. Physical, Social, Mental
3. According to WHO 'Hygiene refers to conditions and practices that help to maintain health and prevent the spread of diseases.

CHECK YOUR PROGRESS 16.2

Hygiene Habits	Personal	Community	Domestic
Using cleaning agents to mop			✓
Brushing & flossing teeth daily	✓		
Keeping garbage in designated bins		✓	
Bathing or taking shower daily	✓		
Washing & grooming hair regularly	✓		
Trimming nails	✓		
Cleaning bathtub, sink etc			✓
Using toilets rather than open spaces to defecate		✓	
Keeping livestock away from household		✓	

CHECK YOUR PROGRESS 16.3

Q1.
- i. Proteins- egg, meat, milk
- ii. Carbohydrates- Cereals, potato, pulses
- iii. Fats-Oil, Butter, Ghee
- iv. Minerals- Iron, Calcium, Sodium
- v. Vitamins- A, B, D, E, C, K
- vi. Roughage- leafy green vegetables, bran
- vii. Water- juices, potable water

Q2.
- i. Carbohydrates-Give energy to body cells.
- ii. Proteins- are essential for growth, repair and maintenance of body tissues.
- iii. Fats- are needed for energy and warmth
- iv. Minerals-are vital for proper functioning of the body.
- v. Vitamins- help in a number of chemical reactions in the body.
- vi. Roughage- it is required as it gives bulk to the food and regulates bowel movement.
- vii. Water is needed to prevent the body from dehydrating and maintain fluid levels

SUPPLEMENTARY STUDY MATERIAL:

1. NCERT text book- Class 10
2. NCERT text book- Class 6 (components of food)
3. Concise Biology Part II- Selina Publishers, N. Delhi
4. https://www.sciencedirect.com
5. https://www.uniceff.org

17

OUR FOOD RESOURCES AND ANIMAL WEALTH

INTRODUCTION

From the ancient times, activities of man have been centred around his basic need that is food. Ancient man was a nomad, a hunter and food gatherer. With passage of time, man started settling down near river banks where there was availability of water and soil which could produce food plants. Thus, began agriculture. Man, also learnt to make tools which would help him in this. He learnt various steps involved such as irrigation. He realised the importance of collection and storing of seeds. This led to organized agriculture and societies were formed. Agriculture is now considered as an industry

17.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Understand how agriculture started and how did it change progressively over the years.
- Explain Green, Blue & White Revolution
- Understand the Principles and methods of crop production.
- Discuss the role of crop rotation, mixed farming and multi-cropping in increasing the yield and quality of crop.
- Appreciate the improved agricultural practices and organic farming.
- Understand animal husbandry and discuss various aspects like milch animals, poultry and fisheries.
- Discuss the role of Tissue culture and genetic engineering in betterment of crop variety.
- Understand the link between storage, distribution of food and food security.

17.2 DEVELOPMENT OF AGRICULTURE

The word Agriculture is derived from two latin words-*Agre*-field; *Cultura*- Cultivation

Agriculture has been defined as the science of raising plants and animals for food, clothing or other useful products. Agriculture began 10,000 years ago with the cultivation of wheat and barley. It has changed from traditional approach to mechanized farming with technological innovations.

With the knowledge to grow crops, man ceased to be a food gatherer and settled down in Agarian (Farming) communities. Domestication of animals was done to supplement agriculture as well as for a variety of animal products.

Around 19th century there was a steep rise in human population. This accounted for an increase in food requirement. Moreover, food needs to be available throughout the year. Thus there was a need to improvise and intensify farming methodology in order to increase crop yield and animal produce.

In the present times, a large section of society is involved in production of food and connected activities such as fertilizers industry, farm equipment factories, transportation of agricultural produce and implements, storage, distribution, packaging and processing etc. Much of the progress in agriculture has taken place in the last 100 years.

Management of food resources involves coordination between a large number of people from farmers and daily workers to distribution and storage.

17.2.1 Steps for Development of Agriculture

In order to plan progressive agriculture following points are to be considered

- Annual targets for all crops are fixed according to the estimated crop demand and availability of resources.
- Type and amount of irrigation should be estimated in accordance with the type of crop and area under cultivation.
- Demand for fertilizers should be foreseen so that production of fertilizers can be increased in order to fulfil the target.

- Insecticides, pesticides along with spraying implements should be made available on time.
- Building of buffer stock (above the estimated normal demand) should be considered so that if need arises, they can be used in relief operations in areas affected by natural calamities such as floods or famines.

17.3 GREEN, BLUE AND WHITE REVOLUTION

17.3.1 Green Revolution

After the Bengal Famine in 1943, when approximately 4 million people died of hunger, food security was of greatest priority in our future planning in the early post-independence era. Much success was seen in this area only after Green Revolution was initiated by C. Subramanisam, M.S. Swaminathan, and B.P. Pal in 1960s during which agriculture in India adopted technology and was converted into a modern industrial system. Use of high yielding varieties of seeds, mechanized farm tools, irrigation facilities, pesticides & fertilizers etc. started. The revolution lasted from 1967-1978.

Three basic components of green revolution were:

- **More land under Cultivation**-Land under cultivation was increased from 1947, but it had its limitations
- **Practicing double cropping** in existing land-policy to have two crop seasons per year instead of one crop season per year was put into practice. Irrigation was the major problem in having two crops a year as only one monsoon season occurred naturally. Ways to ensure availability of water were looked into. Dams were built to store monsoon water and simple effective ways of irrigation were devised so that two crops per year could be cultivated.
- **Use seeds with improved genes**- To this effect 18000 tonnes of dwarf wheat seeds of Lerma Rojo-64A and Sonara-64 variety were imported in 1966.

17.3.2. White Revolution

Operation Flood, initiated by Dr. Verghese Kurien, was the program that led to the White Revolution in India. He is called Father of the white revolution. This program created a national milk grid which linked producers and consumers in over 700 towns and cities. This ensured that there was no middleman. On one hand the price variation was eliminated and on the other producers got a share in the profit.

17.3.3. Blue Revolution

This program, also known as Neel Kranti Mission, was operational in 1985-1990. The main aim of this revolution was to develop, manage and promote fisheries. This doubled the income of farmers.

17.4 THE PRINCIPLES AND METHODS OF CROP PRODUCTION

Over the years man has learnt that every crop requires specific conditions to grow. For example, rice requires lot of water to grow well whereas wheat does not require as much water. Similarly type of soil or fertilizers may vary according to the crop. Man, also learned that tools and implements such as plough, sickle, harrow, tractors, combine harvesters etc. can improve the efficiency. Knowledge of pest resistant and high-yielding-varieties has also been useful in betterment of produce.

17.4.1 Basic Requirements of Agriculture

There are a few basic requirements which can lead to good agricultural yield:

- An open field where there is plenty of sunlight and air
- Properly aerated and soft loosened soil
- Proper protective fence to ward off grazing animals.
- Proper amount of irrigation.
- Sufficient nutrients (fertilizers) to ensure proper growth of plants.
- Removal of weeds and protection from pests.
- Proper collection and storage of produce.

17.4.2 Methods of Crop Production

Modern agriculture is done in a systematic way. A series of systematic steps are followed which are called agricultural practices.

Agricultural Practices

- Soil Preparation
  - Ploughing
  - Levelling
  - Manuring
- Selection of seeds
- Sowing of seeds
- Irrigation
- Weeding
- Crop protection
- Harvesting & Storage

Fig. 1: Agricultural Practices

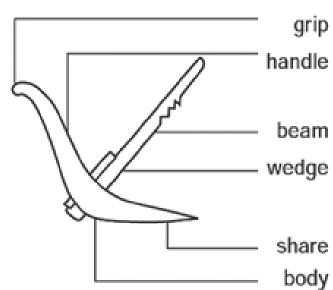
17.4.2.1 Soil Preparation

Soil is the natural medium for cultivating crops. Soil is prepared for cultivation by ploughing, leveling and manuring. This is done so that the seeds can germinate and grow into a healthy plant.

❖ **Ploughing-** The process of loosening and turning of soil is called ploughing or tilling.

Implements used for ploughing-it can be done manually by using a wooden or iron plough. A plough can also be pulled by bullocks or tractor to facilitate the process and save time.

Picture courtesy: You tube



Picture courtesy: Banglapedia

Fig. 2: Ploughing in older time

Fig. 3: Ploughing in modern time

Advantages of ploughing:

The top layer of the soil usually lacks nutrients as they have been used by the previous crops. Ploughing helps to bring up the lower fertile and nutrient rich layers up.

It allows mixing of manure and fertilizers thoroughly.

It allows the roots to penetrate deep into the loosened soil.

This process also aerates the soil which allows the roots to breathe easily.

It helps soil organisms such as earthworms and microbes to grow. These organisms are important for the soil as their waste and decayed bodies helps in manuring the soil.

- **Levelling**- To prevent the loose soil from being eroded by wind or water, it is leveled, the process is called as leveling.

Implements used for leveling- Wooden plank or an iron leveler which can be drawn by bullocks or tractors.

Advantages of Levelling

Ensures that soil is not eroded by water or wind.

It helps in uniform distribution of water and manure.

Fig. 4: Levelling

- **Manuring-** Last step in soil preparation, it provides nutrients for the healthy growth of plants. The most important nutrients are Nitrogen, Potassium and Phosphorus (NPK). Soil gets depleted of nutrients with years of cultivating crops. More so if the same field is being used. These nutrients need to be added to the soil in the form of fertilizers and manures in order to replenish the soil.

Manures are natural fertilizers which are obtained by the decomposition of animal and plant waste by the action of microbes. Manures are not very rich in nutrients but they improve soil texture and water retaining capacity of soil. They are also not nutrient specific which means they cannot supplement the soil with a particular nutrient. The other disadvantage is that they are bulky and thus transportation and storage is a challenge.

Types of Manures

Compost: obtained from decayed animals and plants. These materials are put in a pit in alternating layers with soil. Bacteria and fungi decompose it into compost. If worms are used in composting it is called **vermicompost**

Farmyard Manure: Produced by cattle dung, residues like straw, leaves and branches of crop plants which get decomposed into manure by bacteria and fungi

Green Manure: plants are cultivated and then while ploughing they get mixed and decomposed in soil.

Fig 5: Types of Manures

Chemical fertilizers are man-made synthetic substances which are very rich in nutrients. They are also nutrient specific. They can be absorbed easily. Since they are required in small quantities, it is easy to handle their transport and storage. The disadvantage of using chemical fertilizers is that they harm the soil composition in the long run and are not environment friendly.

CHECK YOUR PROGRESS 17.1

1. Complete the following:

   a. Ploughing: plough:: ______________: leveller
   b. Chemical fertilizers: __________________ :: manures : natural

2. Give one advantage of manures over fertilizers and one advantage of fertilizers over manures

17.4.2.2 Selection of Seeds

To obtain good quality and abundant produce seeds should be selected carefully. The **off-colour, under-sized and chaffy grains** are segregated. Healthy grains are sun dried for two to three days to reduce moisture content. This helps in keeping the microbes away when stored. Well-formed grains are kept aside as seed material for next season's planting.

17.4.2.3 Sowing Seeds

After preparation off soil is now ready for sowing of seeds. Before sowing following precautions should be observed:

- Seeds should be of good quality, healthy, disease resistant, pest free etc.
- Seeds should be sown at proper depth. If they are too deep the plumule cannot come out of the soil and get enough oxygen for respiration. Also if they are on the surface they will be eaten by birds.
- Seeds should be sterilized.
- Seeds should be spaced apart so that competition for space, oxygen, water and nutrients can be avoided.

Methods for Sowing Seeds

Broadcasting-Seeds are scattered on the field manually by hand. After scattering soil is levelled to protect seeds from birds.

This method is not very good as seeds are not sown at proper depth or distance.

Drill Sowing-more efficient implement for sowing. It is a funnel shaped structure attached to many tubes leading to the plough. The seeds are placed in the funnel and they move into the tubes and as the plough moves, one by one seeds are put at a proper depth and distance.

Transplantation-Sometimes as in tomatoes, chillies, rice and brinjal, the seeds are first planted in a seed bed or nursery. When the seedlings are formed, healthy ones are selected and then transferred to the field (Transplanted) ensuring a good crop.

Fig. 6: Methods for Sowing Seeds

Fig. 7 (a): Broadcasting

Fig. 7 (b): Seed Drill

Fig. 7 (c): Transplanting

17.4.2.4 Irrigation

Practice of supplying water to crop fields artificially when required is termed as **irrigation** In India water supply to the crop plants cannot depend on rainfall entirely. Reason is that in some parts it may not rain sufficiently or even if rainfall is high, it may not be at an appropriate time suitable for crops. Irrigation can solve this problem. However, in India only about 18% of cultivable land is under irrigation while 24% is partly irrigated. 58 % still depends on rainfall for water supply to plants.

Sources of water for irrigation are rivers, reservoirs, lakes, ponds, wells and tube wells. The water is channelized into canals or pumped into the fields through pipes.

While irrigating the fields care should be taken that right amount of water is supplied at right time. Fields should also have proper drainage system to avoid **water logging** which reduces oxygen supply to roots by filling up the pores in the soil.

CHECK YOUR PROGRESS 17.2

Q1) Complete the following:

a. Sources of water for irrigation _______,________.

b. Crops that need transplantation _______________,_______________.

c. Crops that are not good for sowing _________________, ______________.

Q2) How is water logging harmful for soil in the long run?

17.4.2.5 Weeding

Some unwanted plants grow alongside the crop plants and spread fast. These plants are harmful as they compete with the crop plants for nutrients, space and water. Such plants are termed as **weeds.** e.g., *Amaranthus, Chenopodium*, Wild oats and grasses. They may also spread pests on to the crop and produce toxic substances which are harmful to the crop. **Weeding** is the removal of these unwanted plants.

Chemical weeding- by spraying weedicides such as 2-4 D, Dalapon and Picloram. Weedicides must be used with care as they are toxic

Manual weeding-by hand or by using trowel, khurpa or harrow.

Methods of Weeding

Biological weeding- by certain organisms which can specifically feed on certain weeds only. Also some crop plants such as barley and soyabean produce toxic substances which prevent the growth of weeds.

Fig. 8: Methods of Weeding

17.4.2.6 Crop Protection

Crop plants can be attacked by pests like fungi, bacteria, viruses, rodents (rats), insects (locusts, weevils etc). Fungi can cause plant diseases such as rust and smut in wheat, blight of potatoes. Bacteria can cause disease called wilt in plants which blocks xylem vessels which affects water transport and the plant dies for want of water. These pests can reduce the crop produce to a large extent. 10% of our crop is destroyed by pests every year. Controlling pests is therefore an essential part of agriculture.

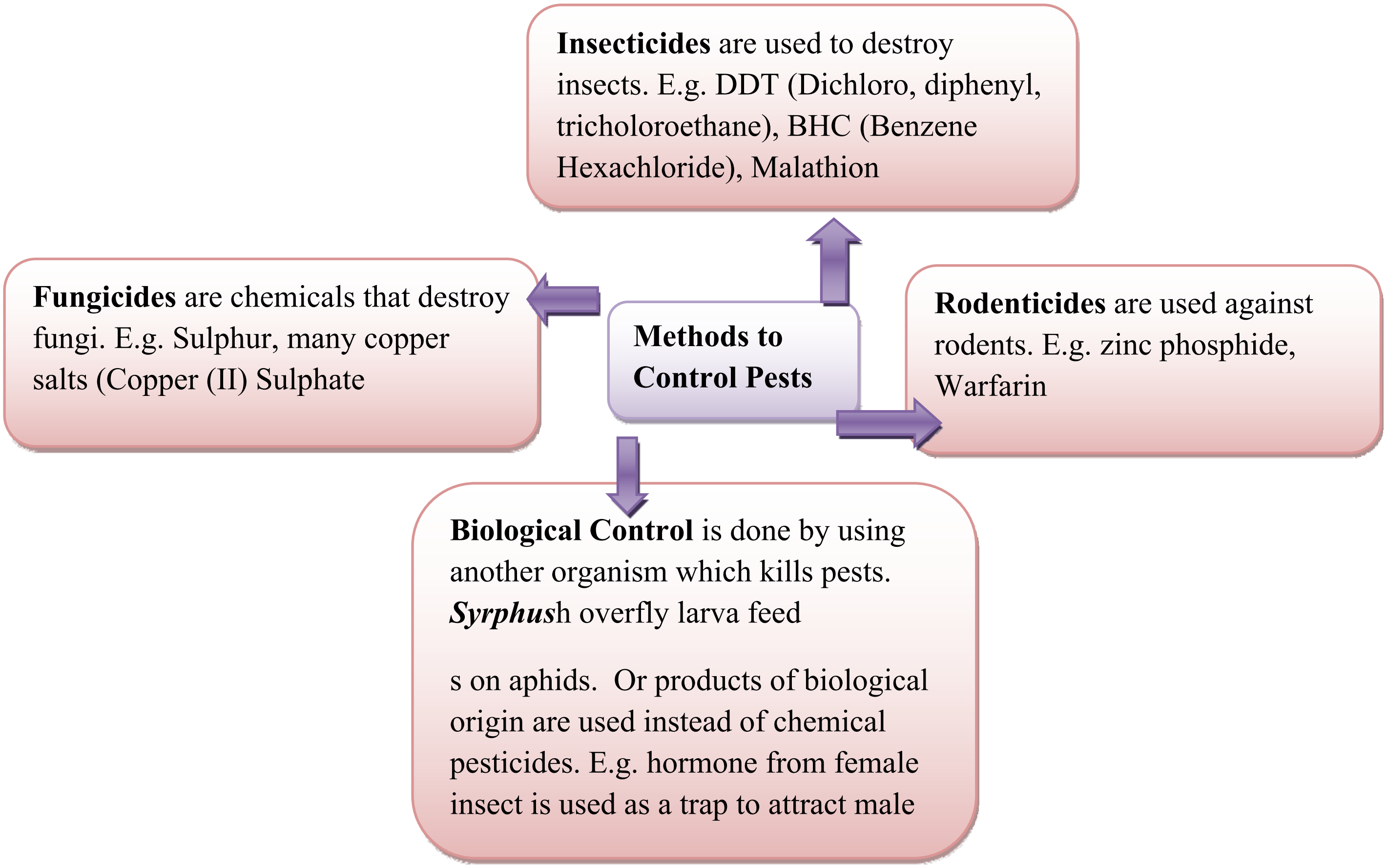


Fig. 8: Methods to Control Pests

Advantages of using pesticides

- They kill pests quickly thereby increasing food production.
- They are easy to store
- A large variety of chemical are available for this purpose.

Disadvantages of using pesticides

- They can remain on fruits, vegetables and grains and may enter our bodies.
- They may enter soil or water bodies and effect life, may also lead to biomagnifications.
- If used repeatedly, pests can develop resistance and pesticides may not be effective.

17.4.2.7 Harvesting

Cutting and gathering of mature crop is termed as **Harvesting.**

Fruits and vegetables need to be harvested manually as they are soft. They are stored in cold storage for future use. However, much of the produce is sold and used immediately.

Cereal grains are harvested twice a year according to the season in India. The two main seasons are Rabi (Winter crop) and Kharif (Monsoon crop).

Rabi	**Kharif**
Sown in the month of Jun/July at the beginning of south west monsoon.	Sowing starts in October and December, beginning of winter.
Harvested in the months of September and October	Harvested in March or April
Needs a lot of water	Does not need standing water
E.g. Rice, maize, ragi, soyabean, pulses etc.	E.g. wheat, barley, oats, mustard etc.

Many a festivals are celebrated in India on the occasion of harvesting. E.g. Bihu, Pongal, Baisakhi, Diwali etc.

Manually by sickle

Methods of Harvesting

Machines such as mechanical harvester or combines. Combines can harvest and thresh (beat the crop to separate chaff) at the same

time.

Fig. 9: Methods of Harvesting

Threshing follows harvesting. It can be done alongside harvesting with the help of combines or separately using threshers. It is the practice of beating the harvested crop to separate grains from chaff. The cut plants can be threshed by beating them on stone or making oxen or buffaloes trample the cut crop. Alternately a **thresher** machine can be used.
After threshing the grains are separated from chaff and hay by the process of **Winnowing.** The mixture of grains and chaff is dropped to the ground from a height under wind current. The seeds fall directly in a heap while chaff and hay being lighter is blown away.

17.5 PROTECTION AND STORAGE OF THE HARVEST

Storage –There is need to store food grain for future use. Also, a **buffer stock** should be maintained to compensate for the shortfall due to failed monsoon or natural calamities like floods, earthquakes or famines.

Grains should be dried properly to prevent the growth of microorganisms. When harvested they have rich moisture content. This moisture content is reduced by drying the grains in direct sun. After drying the grains are packed inn clean and pest free gunny bags before being stored in granaries, go-downs or silos.

Go-downs and granaries should be well ventilated and kept pest free by fumigation.

The temperature should be controlled and regular inspection should be done to check pest infestation.

A modern method for keeping stored grains away from pest infestation is to circulate **nitrogen** continuously through granaries. Lack of oxygen will not allow pests to survive.

CHECK YOUR PROGRESS 17.3

Q1) Unscramble to find the right word according to the definition

a) Unwanted plants that compete with crop plants for nutrition etc. dewes _ _ _
b) An insecticide that is used to kill insects amtihonla _ _ _
c) A machine that does harvesting & threshing together ebmocni _ _ _
d) The stock of grain maintained for emergencies ufefbr _ _ _

e) Crops sown in July and harvested in October fhkrai _ _ _

f) Weeding can be done manually by arrwoh _ _ _

17.6 CROP ROTATION/MIXED/MULTI CROPPING

The land that can be cultivated is limited in India. Same piece of land is cultivated over and over again. This practice depletes the soil of its nutrients. The soil needs to be replenished. We have seen that one way of enriching the soil is by using fertilizers and manures.

Some natural methods of enriching the soil are:

Fallow method-This is the practice of leaving the soil uncultivated (fallow) for a few seasons to replenish the lost nutrients. While the land is left fallow, the decomposed animal and plant waste replenishes the lost nutrients.

Crop Rotation-Some plants like wheat, rice etc. use up large amount of nitrogen from the soil and deplete the soil of this resource. In order to replenish this nitrogen farmers grow a crop of leguminous plants like pea, soyabean etc. These plants have nitrogen fixing bacterium *Rhizobium* in their roots which can utilize atmospheric nitrogen to produce nitrates which are released into the soil. Thus the soil is ready for the next wheat or rice crop. This practice of alternating one crop after the other on the same filed in order to enrich the soil for consumed nutrients is termed as crop rotation.

Mixed/Multiple Cropping-Sometimes two or more crops are grown simultaneously on the same field. The crops are chosen in such a way that their nutrient requirement, time of maturity and harvesting time are different from each other. E.g. cotton, groundnut and chick pea can be grown together at the same time in same field.

17.7 IMPROVED AGRICULTURAL PRACTICES

In order to meet the ever-growing demand for food with increase in population agricultural practices have undergone changes which have helped to increase food production.

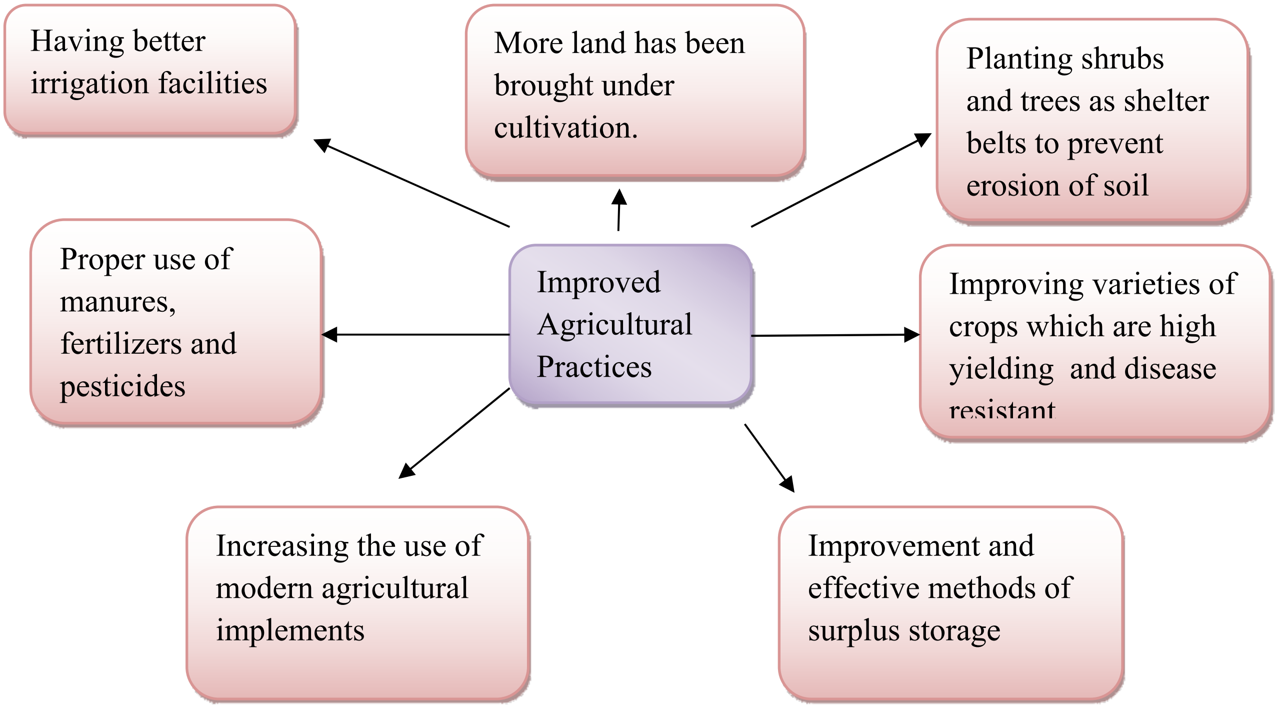


Fig. 10: Improved Agricultural Practices

17.8 BIOFERTILIZERS

Bio-fertilizers are substances which contains microorganisms which enhance the supply of nutrients to the plants, ensuring their proper growth and development. They improve soil fertility and maintain it long term by fixing atmospheric nitrogen. They help in dissolution and mineralization of other plant nutrients like phosphates, better synthesis and availability of hormones, vitamins, auxins and other growth promoting substances that improve plant growth.

Main sources of biofertilizers are bacteria, fungi and cyanobacteria. Some species of microbes used as biofertilizers are: *Azospirullum; Azotobacter, Rhizobium*

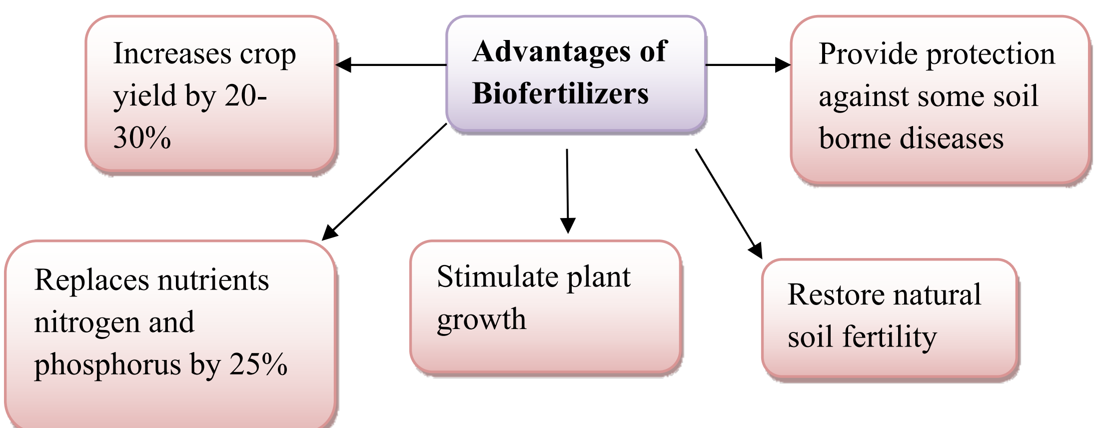


Fig. 11: Advantages of Biofertilizers

17.9 ANIMAL HUSBANDRY

Plants are the main source of food. However, animals are also useful to man in a variety of foods such as milk, meat, eggs, honey etc. that can be obtained. Moreover, other than food, animals are useful in many other ways ranging from giving fiber, leather to working (draught animals) in fields. Man realized the importance of animals very early and started domesticating them. All animals meant for use of man are called **livestock**. The techniques employed for raising livestock are termed as **Animal husbandry.**

Animal Husbandry

Breeding- is the method of producing animals with desired characteristics by crossing two animals with desirable characteristics. **(Hybridization)**

Feeding- Animals require a balanced diet just like us. Type, mode and time of feeding are important.

Weeding-This means eliminating the sick and uneconomical animals from the livestock.

Heeding-Giving proper care to animals and their right management is heeding. This involves cleaning their troughs and eating place, washing and keeping animals clean, providing proper ventilation and giving proper medical care.

Fig. 12: Animal Husbandry

17.9.1 Milch Animals (Cattle)

Cattle comprise of cows, buffaloes and bullocks. This is an important category of livestock.

Cows and buffaloes are also known as milch animals as they provide milk and other dairy products. These are called **dairy** breeds e.g., sahiwal cows; murrah buffalo. Bullocks are used as **draught** animals for ploughing and carrying loads e.g. Siri breeds. Some animals are used for both purposes dairy as well as draught **(dual breeds**) e.g. Sindhi red cows. Cattle droppings form a good source of manures as well.

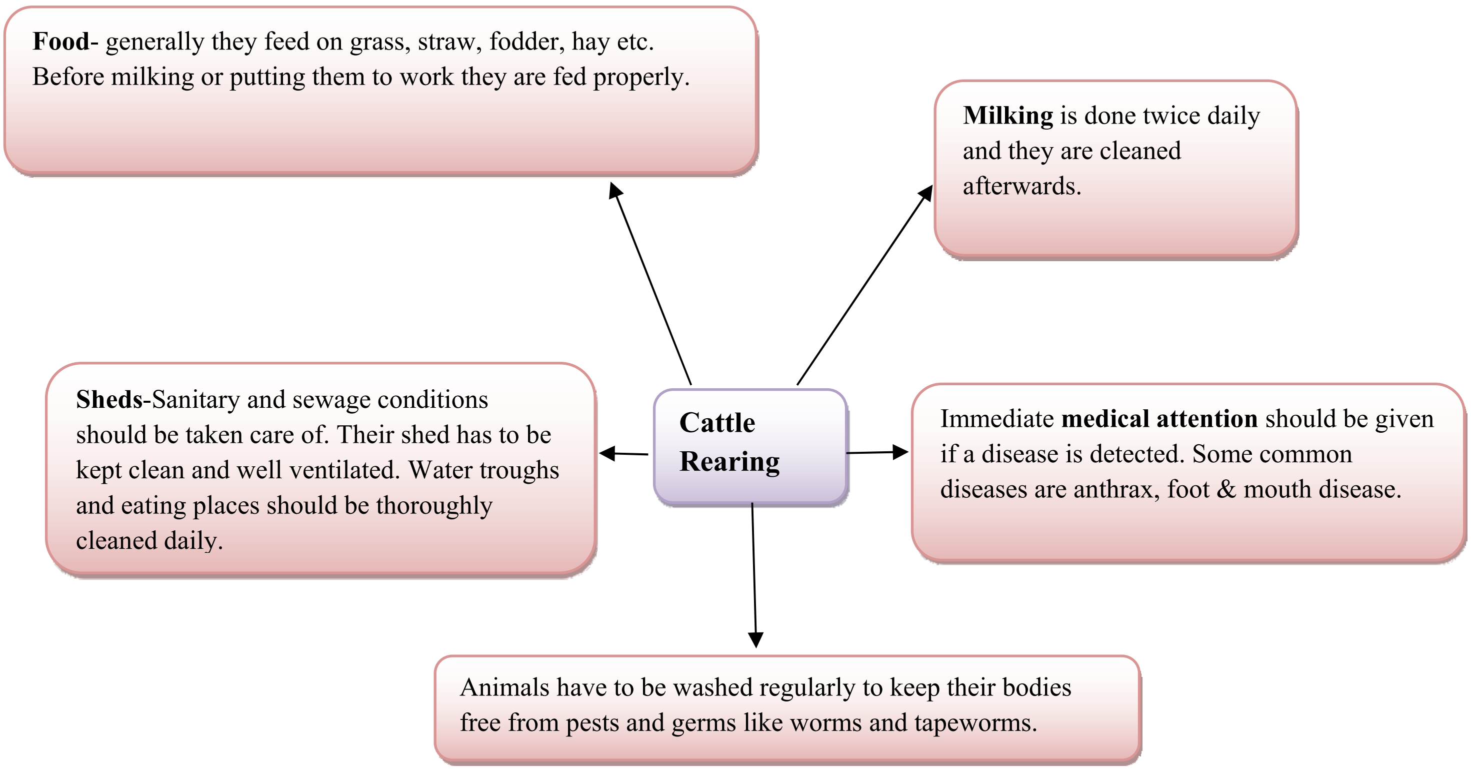


Fig. 13: Cattle Rearing

17.9.2 Poultry

Rearing of birds (chicken, hen and turkey) for eggs and meat is called **poultry** farming. Poultry products are rich in proteins, fats and vitamins. Since birds have a short life span it is easier to breed them.

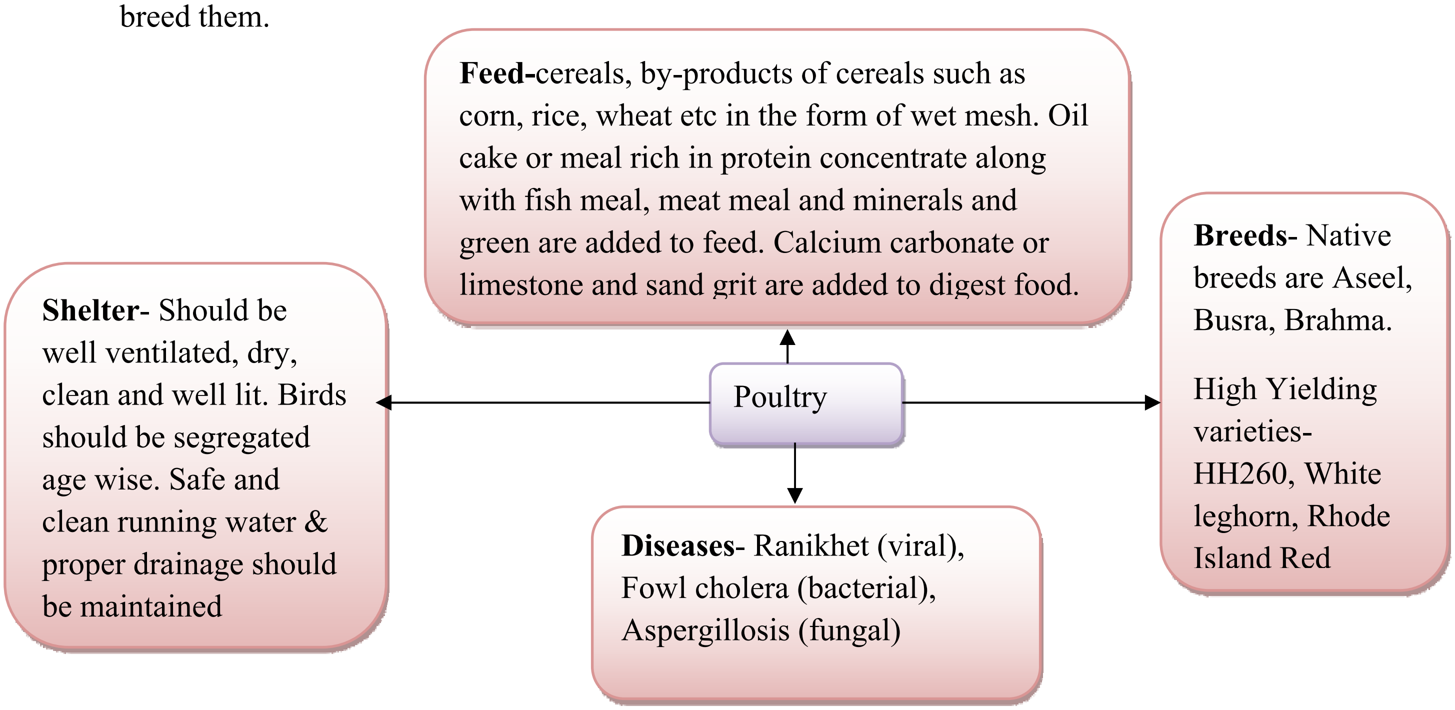


Fig. 14: Poultry

17.9.3 Fishes (Marine and Inland)

India has a long coastline, surrounding it from three sides. People living near sea coast depend largely on fish and other sea food for their protein requirement as well as livelihood. Fish meat is highly nutritious and easy to digest. It is eaten fresh and dried. It can be pickled as well. Fish liver oil from fishes such as cod and shark is also rich in vitamin A and D. Fish leather is also valuable. The practice of culturing fish from seeding, rearing, breeding to harvesting is termed as **pisciculture.**

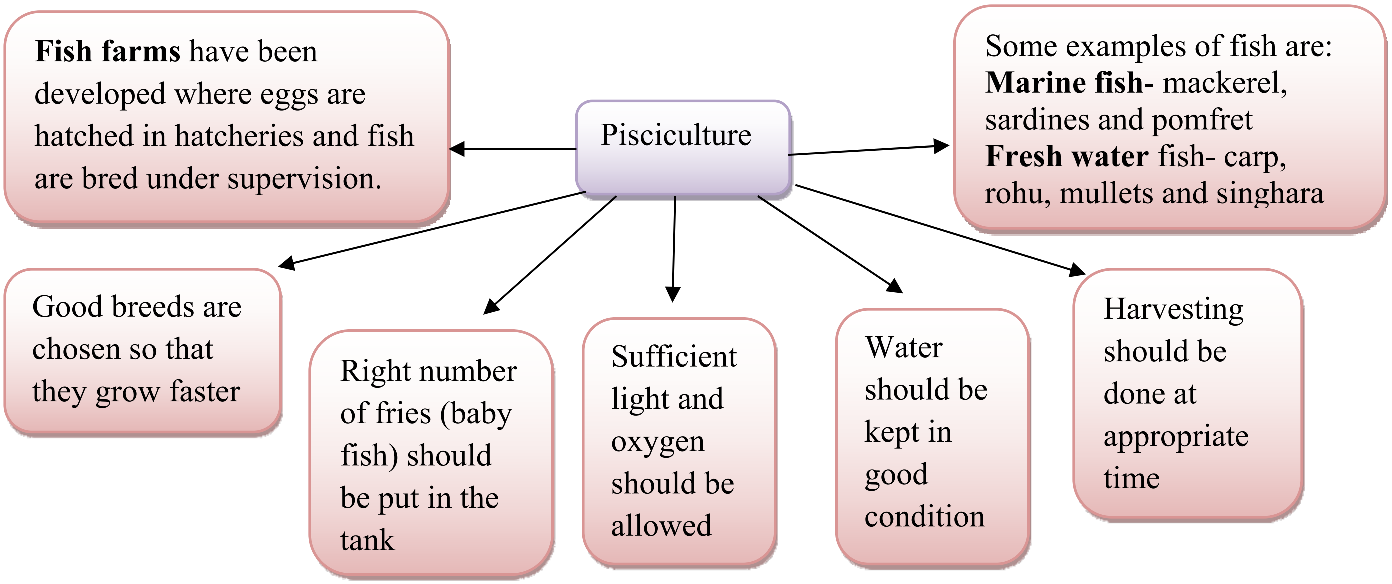


Fig. 15: Pisciculture

17.10 TISSUE CULTURE

Plants can be cloned by cuttings. Cut part of the plant which may be stem or leaf is dipped in hormone rooting powder to stimulate root growth. It is then planted in damp soil.

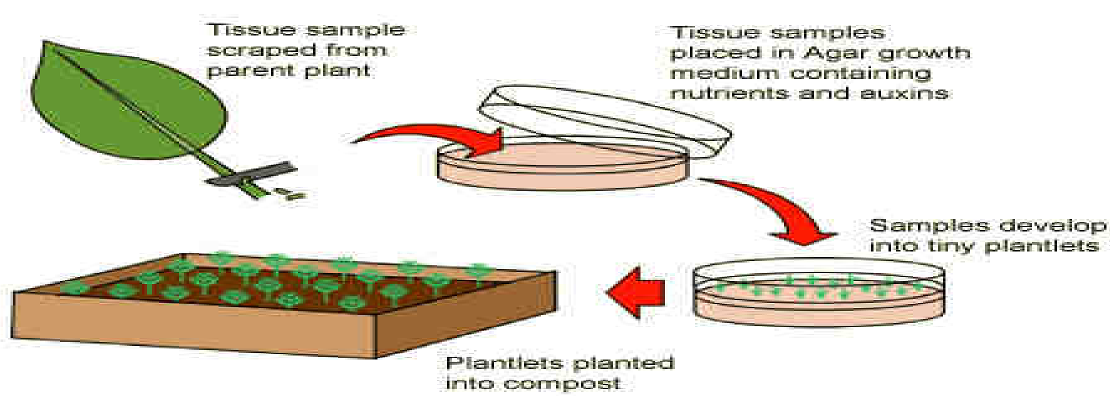


Fig. 16: Tissue Culture

Tissue culture is another way of cloning plants. It is called **micropropagation**. This method makes it possible to grow thousands of new plants from tiny bits of plant tissues. The conditions are kept sterile. Agar gel is used for nutrients. This method is expensive as compared to cuttings.

17.11 GENETIC ENGINEERING

Genetic engineering is a deliberate alteration of genes in an organism. It involves taking a gene from one species and putting it into another species. Such an organism is called GMO (Genetically Modified Organism)

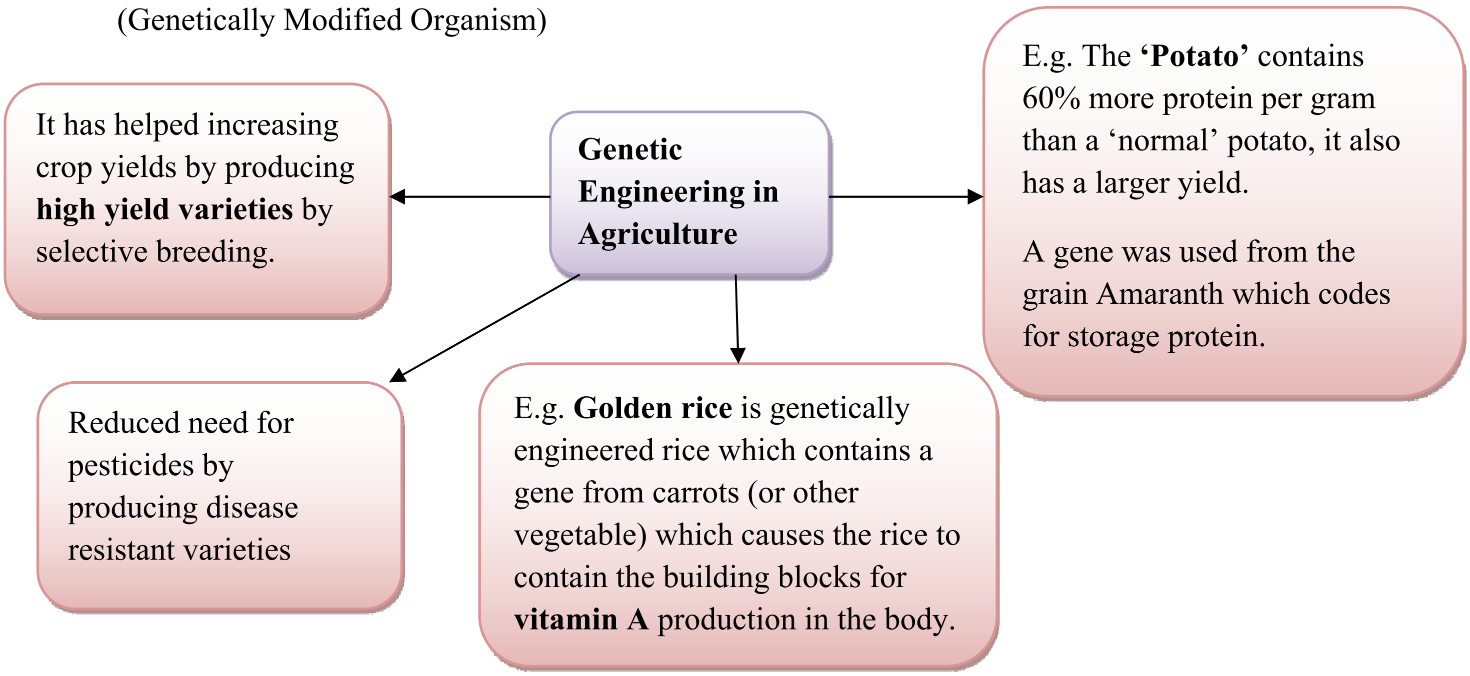


Fig. 17: Genetic Engineering in Agriculture

17.12 FOOD SECURITY

Food security means provision of food to all people at all times not withstanding their economic or physical status. The challenge faced is to make this sustainable. Food security takes a set back due to ever increasing population, changing dietary habits, reduced agricultural land and climate change.

Availability of food depends on production within the country as well as import of food from other countries. It also depends on stock from previous years. Accessibility to food is important for each person. This depends on affordability of the person to buy food. This is done by subsidizing food grains.

Government plays an important role in providing food security by supporting small holder farmers, investing in agriculture, providing training and practical support and reducing environmental impact. With the Green Revolution happening in India, the country has become self-sufficient in food grains in last thirty years because of a variety of crops grown. Moreover buffer stock is procured by **FCI (Food Corporation of India)** and distributed through government controlled ration shops among the poorer section of the nation by **PDS (Public distribution System)**

Cooperatives have been set up in Southern and Western part of the country which set up shops and sell low priced goods to economically backward class.

17.13 ORGANIC FARMING

Organic farming is a farming system which does not use synthetic inputs such as fertilizers, pesticides etc. It instead relies heavily on good farming practices such as crop rotation, using farm manure & bio-fertilizers and biological pest control methods.

Organic farming protects long term fertility of soil. The produce is more healthy, tasty and nutritious. It reduces cost of production for farmers as they do not need to buy costly fertilizers, pesticides etc. Moreover, the health of farmers does not suffer due to the toxic effects of such products. It slows down global warming and is environment friendly. It promotes biodiversity. It prevents pollution of ground water.

While there are many advantages of organic farming, there are certain drawbacks as well. The food produced by organic farming is more expensive as the produce is not as much as in conventional farming. This also means that food production cannot meet the demand of ever growing population.

CHECK YOUR PROGRESS 17.4

Clues

Across

1. The practice of leaving the soil uncultivated (fallow) for a few seasons to replenish the lost nutrients.
2. Substances which contain microorganisms which enhance the supply of nutrients to the plants.
3. Practice of alternating one crop after the other on the same filed in order to enrich the soil.
4. Cows and buffaloes are also known as ______________ animals as they provide milk

5. Fish is a rich source of ______________.
6. Rearing of birds (chicken, hen and turkey) for eggs and meat is called __________.
7. A bacterial disease of cattle_________
8. __________________is another way of cloning plants
9. A gas circulated in store houses to prevent growth of pests.

Down

1. A farming system which does not use synthetic inputs such as fertilizers, pesticides etc.
2. A ________ stock of grains should be maintained to compensate for the shortfall due to failed monsoon or natural calamities.
3. A bacterium that is a good source of bio-fertilizers.
4. The practice of culturing fish from seeding, rearing, breeding to harvesting
5. Another name for tissue culture
6. A leguminous plant which is used in crop rotation.
7. Practice of growing two or more crops simultaneously on the same field.
8. A disease which infects poultry.
9. A breed of buffalo.

RECAPITULATION POINTS

- The word Agriculture is derived from the latin word -Agre-field; Cultura- Cultivation
- Agriculture began 10,000 years ago with the cultivation of wheat and barley.
- Much of the progress in agriculture has taken place in the last 100 years.
- Modern agriculture is done in a systematic way. A series of steps are followed are followed which are called agricultural practices
- Soil Preparation is the first step of Agriculture. Soil is prepared for cultivation by ploughing, leveling and manuring.
- The process of loosening and turning of soil is called ploughing or tilling.
- Levelling is done to prevent the loose soil from being eroded by wind or water.

- Manuring is the last step in soil preparation which provides nutrients for the healthy growth of plants.
- There are three types of manures- Compost, Farmyard and Green manure.
- Before sowing certain precautions should be observed such as quality of the seed, the depth at which the seeds are being sown and the spacing between the seed
- Seeds can be sown by simply scattering them in the field (Broadcasting), by seed drill and transplanting.
- Some unwanted plants grow alongside the crop plants and spread fast. These plants are harmful as they compete with the crop plants for nutrients, space and water. Such plants are termed as **weeds.**
- Weeding is removal of weeds. It can be done manually, chemically or biologically.
- Crop plants can be attacked by pests like fungi, bacteria, viruses, rodents (rats), insects (locusts, weevils etc). These pests can reduce the crop produce to a large extent. 10% of our crop is destroyed by pests every year. Controlling pests is therefore an essential part of agriculture.
- Insecticides, Rodenticides, Fungicides and Biological methods are used to control pests.
- Cutting and gathering of mature crop is termed as **Harvesting.**
- Harvesting can be done manually by sickle or by machines such as harvester & combines.
- Harvesting is followed by threshing & winnowing to separate chaff and hay from seeds.
- There is need to store food grain for future use. Also a buffer stock should be maintained.
- Fallowing, Crop rotation, multi cropping and adding fertilizers & manures are soil enrichment practices.
- In order to meet the ever-growing demand for food with increase in population agricultural practices have undergone changes which have helped to increase food production.
- Bio-fertilizers are substances which contains microorganisms which enhance the supply of nutrients to the plants, ensuring their proper growth and development.

- The techniques employed for raising livestock are termed as **Animal husbandry.** It involves feeding, breeding, weeding and heeding of animals.
- **Tissue culture** is a way of cloning plants. It is called **micropropagation.**
- Genetic engineering is a deliberate alteration of genes in an organism.
- Food security means provision of food to all people at all times not withstanding their economic or physical status.

TERMINAL EXERCISE

1. Choose the correct answer

i. Which of the following includes only weeds?

a. Chenopodium, Rose and wild oats
b. Amaranthus, Chenopodium, Wild oats
c. Paddy, Chenopodium, grasses
d. Amaranthus, grasses, Sunflower

ii. The process of cutting the crops when mature is

a. Winnowing
b. Threshing
c. Levelling
d. Harvesting

iii. Carp and Rohu are examples of

a. Marine fish
b. Freshwater fish
c. Brackish water fish
d. None of these

iv. The disease late blight of potato is caused by

a. Fungus
b. Bacteria
c. Virus
d. Weevil

v. White revolution is related to production of

a. Egg
b. meat
c. milk
d. honey

vi. Organic substances obtained from decomposition of dead plants and animal waste is

a. Manure
b. fertilizer
c. herbicide
d. weedicide

2. Fill in the blanks

a. __________________ results in loosening and aerating the soil.
b. Proper caring and management of animals is known as _____________ _____________.
c. Water logging is the result of ____________________.
d. Operation Flood was initiated by __________________.
e. Seeds can be sown by _____________ or ____________.
f. Cattle raised for milk are ____________ breeds while those reared for work are __________ breeds.

3. Differentiate between

a. Rabi and Kharif crops
b. Tissue culture and cloning by cutting
c. Crop rotation and Multiple cropping
d. Chemical and Biological Weeding.
e. Broadcasting and seed drill
f. Fertilizers and Manures

4. Name the following:

a. Two HYV varieties of Poultry
b. Science of rearing fish
c. Two genetically modified crops

d. Two sources of biofertilizers
e. Two useful fish products.
f. Two insecticides
g. Two rodenticides
h. Two diseases of cattle and poultry

5. Answer briefly

a. Define agriculture. List the various agricultural practices.
b. Why is biological control of pests better than using pesticides?
c. Why should seeds be sown at a correct distance and depth?
d. Define pisciculture. Name two marine and two fresh water fish.
e. What is buffer stock? How is it useful?
f. Why is it important to remove excess water from seeds before storing them?
g. What do you understand by livestock? Give two examples.
h. What is leveling? Why is it done?
i. Define Animal husbandry. State the various practices which are necessary for animal husbandry.
j. Write the full form of FCI and PDS

6. Long Answer

i. Describe how soil is prepared for sowing seeds? Give four advantages of ploughing.
ii. What are the ways by which improvement in agriculture has happened to cope with the increase in population?
iii. What is Food security? Why is it necessary? What is the role of Government in food security?
iv. Write a short note on organic farming? Would you prefer to use produce obtained from organic farming? Why?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 17.1

1 a. Levelling b. inorganic

2. Manures are environmentally friendly and they improve soil texture.
   Fertilizers are nutrient specific and easy to handle

CHECK YOUR PROGRESS 17.2

1. (a) Reservoirs, lakes ponds
   (b) Chilli, paddy, brinjal
   (c) Off-colour, Chaffy, under-sized

2. Water logging reduces oxygen supply to roots by filling up the pores in the soil

CHECK YOUR PROGRESS 17.3

1. (a) Weeds
   (b) Malathion
   (c) Combine
   (d) Buffer
   (e) Kharif
   (f) Harrow

CHECK YOUR PROGRESS 17.4

1.F	A	L	L	2. O	W														
				R		3. B							4. R						
				G		U							H			5. P			
				A		F							I			I			
			6.B	I	O	F	E	R	T	I	L	I	Z	E	R	S			
	7.M			C		E							O			C			
	I			F		R							B			I		8. S	
	C			A					9. M				I			C		O	
10.	R	O	P	R	O	T	A	T	I	O	N		U			U		Y	

C																				
	O			M					X				M			L		A		
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	P				13. M				R			14. P	R	O	T	E	I	N		N
	A				U				O											I
	G				R				15. P	O	U	L	T	R	Y					K
	17. A	N	T	H	R	A	X		P											H
	T				A			17. T	I	S	S	U	E	C	U	L	T	U	R	E
	I				H				N											T
	O								G											
	18. N	I	T	R	O	G	E	N												

18

STRUCTURE OF ATOM

INTRODUCTION

Matter is something that occupies space and has its own mass. It is something that can be felt by us. Some examples of matter are air, water, food, table, pen, gold, sand, fruits, plants, trees, bottle, plastic, stones, oil, fan, chair etc. All these things occupy space and have their own masses. Both, living things and non-living things are matter. The entire universe is composed of matter. Atoms are the basic building blocks of all the matter in the universe. You will learn more about atoms when you read this chapter.

18.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Describe the discovery of electron and proton and neutron
- Explain Dalton's atomic theory and its failure.
- Discuss Thomson's and Rutherford's models of atom and explain their limitations.
- Explain Bohr's model of atom.
- Compare the characteristic properties of proton, electron and neutron;
- Explain various rules for filling of electrons and write the distribution of electrons in different shells.
- Define valency and correlate the electronic configuration of an atom with its valency.
- Define atomic number and mass number of an atom.
- Describe isotopes and isobars.

18.2 ATOMIC STRUCTURE

Structure of matter, especially so the atom has always fascinated people and more so scientists. You had many scientists down the centuries to explore the atomic structure. It starts from ancient India when Sage Kanad proposed the idea of atom to the modern scientists as well. We will start from the discovery of the sub-atomic particles – the electron, proton and the neutron.

18.2.1 SS1 DISCOVERY OF ELECTRONS

The electron was discovered by J.J. Thomson in the year 1897. He took Crooke's tube and arranged the apparatus as shown in figure:

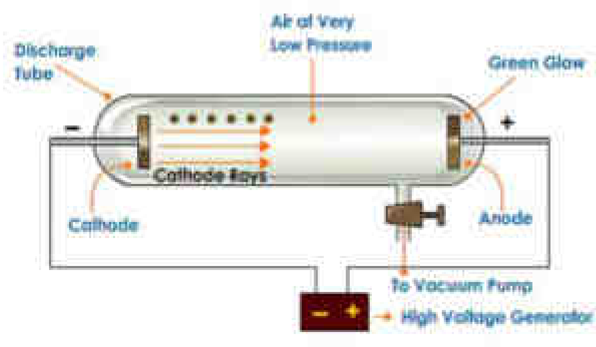


Fig 1: Discovery of Electrons

The following observations were made-

1. When he passed electric current (at high voltage approximately at 10,000volts) through a gas at a pressure of 1 atm, then nothing happened as no changes were seen.
2. When he reduced the pressure to 10-2 atm, the whole tube started glowing with green colour.
3. He further reduced the pressure to 10-4 atm, the whole tube stopped glowing, but a faint green colour was still seen at the anode end.
4. To confirm, a fluorescent screen was placed at the back of the anode and anode was made perforated. When current was passed through it (in the same physical conditions), the Zinc Sulphide (ZnS) screen started glowing which confirmed the following fact.

Conclusion

It proved that at these conditions, some rays were emitted through cathode and were travelling towards anode called cathode rays consisting of negatively charged particles. These particles were later called electrons. This is how the electron was discovered.

18.2.2 DISCOVERY OF PROTONS

Eugen **Goldstein** (in 1886) performed an experiment using a perforated cathode (a cathode having holes in it) in the discharge tube filled with air at a very low pressure. When a high voltage was applied across the electrodes in the discharge tube, a faint red glow was observed behind the perforated cathode.

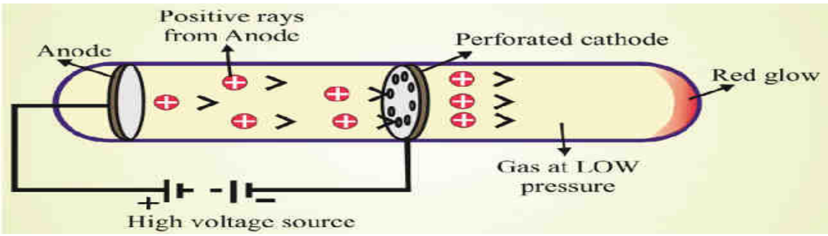


Fig 2: Goldstein's cathode ray tube with perforated cathode

This glow was due to another kind of rays flowing in a direction opposite to that of the cathode rays. These rays were called as **anode rays** or positive rays. These were positively charged and were also called **canal rays** because they passed through the holes or the canals present in the perforated cathode.

The following observations were made-

Like cathode rays, the anode rays also travel in straight lines.

The particles constituting anode rays carry mass and have kinetic energy.

The particles constituting canal rays are much heavier than electrons and carry positive charges

Now after knowing about the atom, different attempts were made to know about its structure. So, various models of different scientists were proposed.

18.2.3 DISCOVERY OF NEUTRONS

It was discovered by Chadwick in the year 1932. It was actually discovered while considering the mass of atomic particles. It was seen that the whole mass of an atom is due to the nucleus and as far we know, the nucleus is positively charged. That means it has only protons in it. But we also know that the mass of an atom is never equal to the number of protons. This shows that the nucleus contains some other particles also that contribute towards mass only and not towards charge. Therefore, the particles were called neutrons (as they possess no charge).

Parameters of Comparison	**Electron**	**Proton**	**Neutron**
Charge	Negative	Positive	Neutral
Symbolised as	e^-	p^+	n^0
Atomic mass	5.45×10^{-4}	1	1
Location	Outside the boundary of the nucleus and moving in different orbits.	Inside the nucleus of the atoms.	Inside the nucleus, exception- hydrogen.

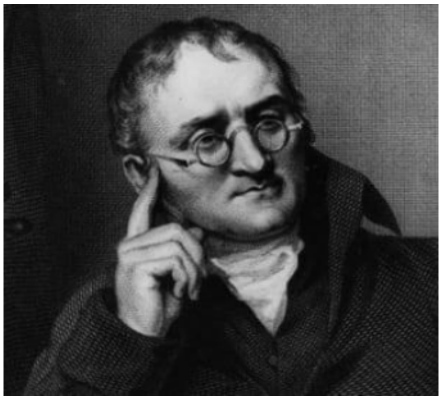
18.3 DIFFERENT MODELS

18.3.1 DALTON'S ATOMIC THEORY

According to this theory, the following observations were made-

1. All matter is made up of small particles called atoms.
2. Atom is invisible.
3. Atom is indivisible.
4. Atoms of an element are alike in all aspects, that is, if we talk about sodium then all the atoms of sodium will be the same in all aspects.
5. Atoms of different elements are different, that is, if we talk about sodium and potassium, then, the atoms of both are going to be different but same among themselves.
6. Atoms of different elements combine in a fixed simple whole number ratio to form compounds.

John Dalton



The scientist, Dalton was the first one to actually formulate all information of an atom in a theoretical form as Dalton's Atomic Theory. He was born in181866 and died in 1844. His theory was published in 1808. His full name was John Dalton.

Atoms can neither be created nor destroyed, that is, the origin of atoms is not known.

18.3.1.1 Drawbacks of Dalton's Atomic Theory

There were certain limitations as observed by other scientists. They observed the following-

1. According to Dalton, an atom was indivisible but later on, it was proved that atom can be subdivided into sub atomic particles called electrons, protons & neutrons.
2. Atoms of the same element can somehow differ from each other. This was proved due to the existence of isotopes in nature.
3. Similarly, atoms of different elements can be the same. This came into notice due to the existence of isobars in nature.
4. According to it, whenever the compound is formed, it is formed as a result of the combination of atoms in a fixed simple ratio. But it has been seen that the ratio might not always be simple. For example, in sucrose that is $C_{12}H_{22}O_{11}$, the ratio is not a simple ratio.

So, these drawbacks led to failure of Dalton's theory of an atom.

Now came the Thomson Model

18.3.2 THOMSON'S MODEL OF AN ATOM (PLUM PUDDING MODEL)

His full name was J.J. Thomson and he was the one who made the first attempt to explain the structure of atoms.

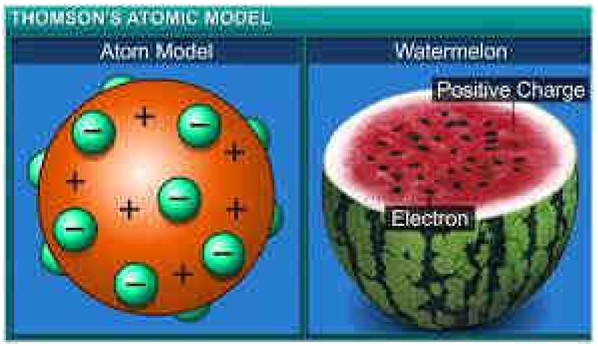


Fig 3: Plum Pudding Model

According to him, an atom is a positively charged sphere in which negative charges are present at certain places like plums in a pudding or cherries in an ice-cream. But this model was rejected as he could not explain the major point observed in his model.

18.3.2.1 DRAWBACK OF THOMSON'S ATOMIC MODEL

He could not explain the distribution of charges and stability of an atom. As we all know that opposite charges attract each other, so, how come it is possible that few negative charges remain scattered in this big positive space. They would have been neutralized. This could not be explained by J.J. Thomson that led to failure of his attempt.

Then, you had Rutherford Model

18.3.3 RUTHERFORD'S SCATTERING EXPERIMENT

In order to understand the structure of an atom, Rutherford performed the scattering experiment. For this, he took a gold foil and passed alpha rays through it. Gold foil actually consists of many gold atoms. So, at an individual level, we are considering the observations through an atom. Alpha rays are actually positively charged rays consisting of Helium nucleus (He).

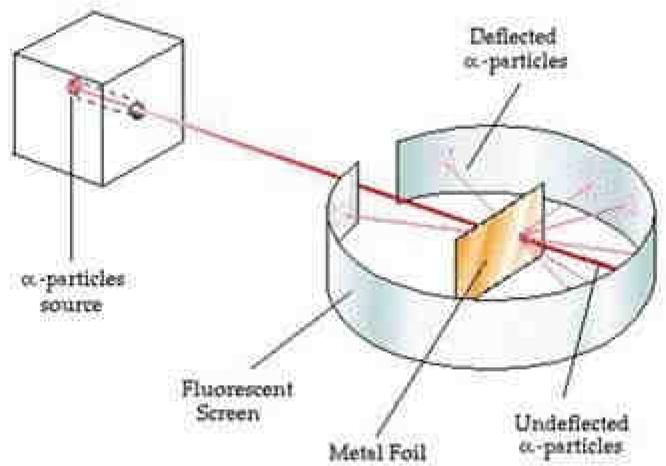


Fig 4: Rutherford's scattering experiment

These rays, when passed through it suffered reflections at different angles and to note that a movable screen made of fluorescent material was placed around it. When the reflected rays strike that screen it causes scintillation. When he passed these rays through gold foil various observations were seen.

Observations were as follows-

- Most of the rays passed straight.
- Some rays were deflected through small & large angles.
- Some rays rebound back.

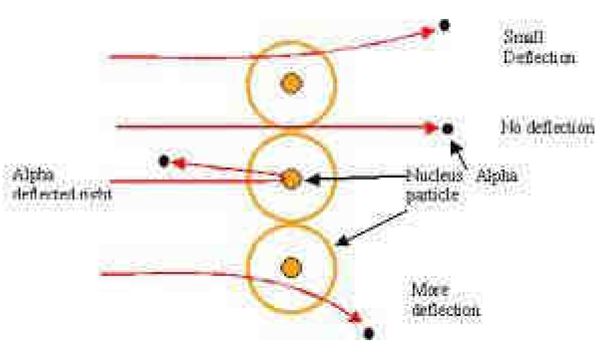


Fig 5: Observations of Rutherford's scattering experiment

The following conclusions were made-

- Most of the space in an atom is empty.
- There is something in the centre of an atom called **nucleus**.
- Nucleus is positively charged.

So, according to Rutherford, the structure of an atom is similar to that of the solar system. He said:

- Atom is electrically neutral.
- Nucleus is in centre in which protons are present.
- Outside nucleus electrons revolve like planets revolve around the Sun.

In this model also few limitations were seen and some questions were left unanswered, which led to its failure.

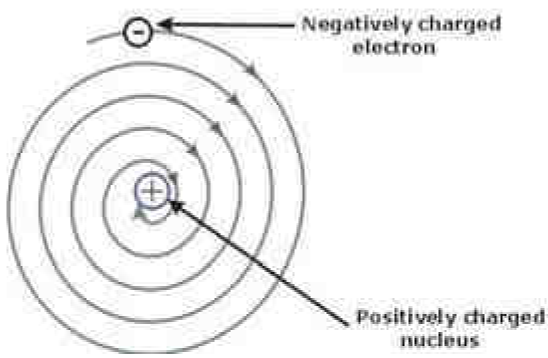


Fig 6: Limitations of Rutherford’s scattering experiment

18.3.3.1 THE DRAWBACK OF RUTHERFORD’S EXPERIMENT

He failed to explain the stability of an atom according to electromagnetic theory: Any charged particle, when revolves in a circular path, continuously emits energy/radiation and shortens its path. As we know, an electron is also a charged particle revolving in a circular path so it should also emit energy, shorten its path and should finally falls into the nucleus and for doing so, it needs time lesser than a fraction of a second. But this doesn’t happen.

18.3.4 BOHR'S THEORY

To overcome the limitations of Rutherford model, the new concept and picture of atom was given by Neil Bohr which made a great contribution in knowing the structure of an atom. According to it:

- Atom is electrically neutral i.e. number of Protons = number of Electrons.
- In the centre of an atom, nucleus is present which is positively charged.
- In the nucleus, protons and neutrons are present.

Protons possess = positive

Neutron possess = no charge.

- Outside the nucleus, shells or energy levels designated as K,L,M,N and so on are present.

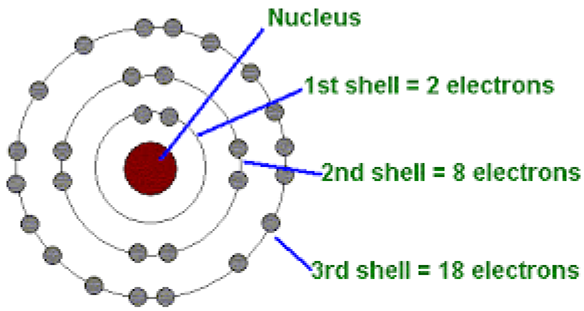


Fig 7: Distributions of Electrons in different shells

- In shells, electrons revolve.
- Electrons are negatively charged.
- Each shell has a fixed amount of energy. So, as long as an electron remains in the same shell, it never loses or gains energy.
- Number of electrons in each shell is determined by Bohr Bury rule i.e. $2n^2$.

1. The formula ***$2n^2$*** gives the accommodation of the maximum number of electrons in each shell, **n=1, 2, 3, 4 for K=2, L=8, M=18, N=32**.
2. The outermost orbit can hold a maximum of **8 electrons**.
3. The electrons fill the inner levels first as they follow the stepwise filling of orbitals

Number of electrons in **K-shell: n = 1**

$2n^2 = 2 \times 1^2 = 2$

Maximum number of electrons in **K-shell, first shell = 2**

Number of electrons in **L-shell, n = 2,**

$2n^2 = 2 \times 2^2 = 8$

Maximum number of electrons in L-shell, **second shell = 8**

Using the formula **2n^2** number of electrons in any shell can be calculated.

1. K Shell 2 x (1) 2 = 2 electrons

2. L Shell 2 x (2) 2 = 8 electrons

3. M shell 2 x (3) 2 = 18 electrons

4. N shell 2 x (4) 2 = 32 electrons

The outermost shell of an atom cannot accommodate more than 8 electrons, even if it has a capacity to accommodate more electrons. This is a very important rule and is also called the **octet rule**. The presence of 8 electrons in the outermost shell makes the atom very stable.

The shells are occupied in the increasing order of their energies.

Electrons are not accommodated in a given shell, unless the inner shells are completely filled.

The arrangement of electrons in the various shells or orbits of an atom of the element is known as electronic configuration.

18.3.4.1 RULES OF WRITING ELECTRONIC CONFIGURATION

The rules to write the electronic configuration of an atom is as follows.

1) Maximum number of electrons in an orbit is calculated by the formula $2n^2$, where 'n' is the number of orbits 1, 2, 3, 4 denoted by shells K, L, M, N.

2) Electrons occupy the next orbit only after filling up the inner orbit completely

3) Maximum number of electrons in the outermost orbit will not be more than 8 electrons according to the **octet rule**.

Now writing down the electronic configuration of some elements:

(a) Hydrogen

Atomic number Z = 1

So, number of electrons = 1

Maximum number of electrons in K-shell or 1st shell = 2

Electronic configuration is K or 1

1

(b) Helium

Z = 2

So, number of electrons = 2

Maximum number of electrons in K-shell or 1st shell = 2

Electronic configuration is K or 2

2

(3) Lithium

Z= 3

K-shell or 1st shell can have only 2 electrons

But Lithium has 3 electrons

So, it will first fill up the K-shell with 2 electrons

Next electron will move to the 2nd shell or L-shell

Electronic configuration is K L or 2,1

2 1

(4) Beryllium

Z = 4

Electronic configuration K L or 2, 2

2 2

(5) Boron

Z = 5

Electronic configuration K L or 2, 3

2 3

(6) Carbon

Z = 6

Electronic configuration K L or 2, 4

2 4

(7) Neon

Z = 10

Electronic configuration K L or 2, 8

2 8

Since both these 1st and 2nd shells (K , L shells) have been filled

So, the electron will jump to the 3rd shell (M – shell)

(8) Sodium

Z = 11

Electronic configuration K L M or 2,8,1

2 8 1

(9) Chorine

Z = 17

Electronic configuration K L M or 2,8, 7

2 8 7

(10) Argon

Z = 18

Electronic configuration K L M or 2, 8, 8

2 8 8

This is how, we write the electronic configuration of elements

CHECK YOUR PROGRESS 18.1

1 Which sub-atomic particles were discovered by the following scientists?

A) Chadwick

B) Thomson

C) Goldstein

2. Give evidence of existence of nucleus of atom.

3. Why is atom neutral?

4. How is proton different from electron?

5. Name the particles used by Rutherford in his scattering experiment.

6. What is meant by electronic configuration?

7. Draw Bohr model.

18.4 SOME USEFUL CONCEPTS AND DEFINITIONS

ATOMIC NUMBER and MASS NUMBER

(a) Atomic Number (Z)

The nucleus of an atom consists of *Protons*, and the atomic number is equal to the number of protons present in one atom of an element. As the atom is electrically neutral, the number of protons and electrons are the same. The notation ***Z*** denotes an Atomic number. The atomic number of Hydrogen is one as it has only one proton.

Grasping the essential points

Number of Protons present in an atom = **Atomic number (Z)**

Number of Electrons present in an atom= **Atomic number (Z)**

(b)Mass Number (A)

The mass number is the measure of the total **number of protons and neutrons** in the atom. The notation ***A*** indicates the **Mass number**.

Mass Number = Atomic Number + Number of Neutrons in the Nucleus

$\boldsymbol{A = Z + n°}$

Mass Number is also called Nucleon number.

Summarizing it

Atomic number (z): Is defined as "Number of protons in atom". Mass number (A): Is defined as "sum of protons and neutrons present in the atom."

So, to calculate; the number of neutrons

Neutrons = Mass number – Atomic number
= A - Z

Atomic number Z = A - n

18.4.1 VALENCY CONCEPTS

A few terms

Valency Shell is the outermost shell of the atom.

Valency Electrons are the number of electrons present in the valency shell (outermost shell)

Examples

Hydrogen (Z is 1). Z is atomic number of the element

Valency shell is 1 electron

Valency electrons = 1

Electronic configuration is 1

Helium (Z is 2)

Valency shell is 2 electrons

Valency electrons = 2

Electronic configuration is 2

Lithium (Z is 3)

Valency shell is 1 electron

Valency electrons = 1

Electronic configuration is 2, 1

Beryllium (Z is 4)

Valency shell is 2 electrons

Valency electrons = 2

Electronic configuration is 2, 2

Boron (Z is 5)

Valency shell is 3 electrons

Valency electrons = 3

Electronic configuration is 2, 3

Carbon (Z is 6)

Valency shell is 4; electron

Valency electrons = 4

Electronic configuration is 2, 4

Nitrogen (Z is 7)

Valency shell is 5

Valency electrons = 5

Electronic configuration is 2, 5

Oxygen (Z is 8)

Valency shell is 6

Valency electrons = 6

Electronic configuration is 2, 6

Fluorine (Z is 9)

Valency shell is 7

Valency electrons = 7

Electronic configuration is 2, 7

Neon (Z is 10)

Valency shell is 8

Valency electrons = 8

Electronic configuration is 2, 8

Sodium (Z is 11)

Valency shell is 1

Valency electrons = 1

Electronic configuration is 2, 8, 1

Phosphorus (Z is 15)

Valency shell is 5

Valency electrons = 5

Electronic configuration is 2, 8, 5

Chlorine (Z is 17)

Valency shell is 7

Valency electrons = 7

Electronic configuration is 2, 8, 7

Argon (Z is 18)

Valency shell is 8

Valency electrons = 8

Electronic configuration is 2, 8, 7

Same method is used and now it is clear that

Whatever electrons are carried in the valency shell (outermost shell)

So, are the number of valency electrons.

Some more Valency definitions

What is Valency?

What are the rules of calculations for Valency?

18.5 VALENCY

The concept of valency arises from the study of inert elements. Inert elements are also called noble gases. They have 8 valence electrons (octet) in their outermost orbit/shell or valence shell except helium which has 2 electrons (duplet). Apart from these elements, all other elements have less than 8 electrons in their valence shell. To attain stability, these atoms lose, gain or share electrons with other atoms to complete their octet. Thus, valency of the atom of an element can be defined as follows:

"The combining capacity of the atoms of an element is known as valency."

Or

"The number of electrons gained, lost or shared by atom of an element in order to complete its octet (or duplet) or to attain stable configuration is known as the valency of the element"

18.5.1 RULES OF CALCULATION OF VALENCY

To calculate the valency of an element, the electronic configuration of the element must be written first and then the valency is calculated. The valency of an element can be calculated as follows:

- Elements having 1, 2, 3 and 4 electrons respectively in their valence shell: For these elements valency is equal to the number of electrons present in their valence shell.
- Elements having more than 4 electrons in their valency shell: For these elements having more than 4 electrons in their valence shell, valency can be calculated as follows:

Valency = 8 – Number of valency electrons

Valency given for some Elements as per Rules of Calculation

Z= Atomic Number. p= Protons. n= Neutrons. e= Electrons.

Element	**Symbol**	**Z**	**No p**	**No n**	**No e**	**Distribution of Electrons** K	L	M	N	**Valency**
Hydrogen	H	1	1	–	1	1	–	–	–	1
Helium	He	2	2	2	2	2	–	–	–	0 (2 – 2)
Lithium	Li	3	3	4	3	2	1	–	–	1
Beryllium	Be	4	4	5	4	2	2	–	–	2
Boron	B	5	5	6	5	2	3	–	–	3
Carbon	C	6	6	6	6	2	4	–	–	4
Nitrogen	N	7	7	7	7	2	5	–	–	3 (8-5)
Oxygen	O	8	8	8	8	2	6	–	–	2 (8 -6)
Fluorine	F	9	9	10	9	2	7	–	–	1 (8 – 7)
Neon	Ne	10	10	10	10	2	8	–	–	0 (8 – 8)

Sodium	Na	11	11	12	11	2	8	1	–	1
Magnesium	Mg	12	12	12	12	2	8	2	–	2
Aluminium	Al	13	13	14	13	2	8	3	–	3
Silicon	Si	14	14	14	14	2	8	4	–	4
Phosphorus	P	15	15	16	15	2	8	5	–	3 (8 – 5)
Sulphur	S	16	16	16	16	2	8	6	–	2 (8 – 6)
Chlorine	Cl	17	17	18	17	2	8	7	–	1(8 – 7)
Argon	Ar	18	18	22	18	2	8	8	–	0 (8 – 8)

Isotopes

- The atoms of an element can exist in several forms having similar atomic numbers but varying mass numbers.
- Isotopes are pure substances.
- Isotopes have a similar chemical nature.
- Isotopes have distinct physical characteristics.

The three isotopes of Hydrogen

$^{1}_{1}H$ Hydrogen $\quad$ $^{2}_{1}H$ Deuterium $\quad$ $^{3}_{1}H$ Tritium

Fig 8: Isotopes of Hydrogen

Example: Consider two atomic species namely U and V. Are they isotopes?

	U	**V**
Protons	5	5

Neutrons	5	6
Mass Number	5 + 5 = 10	5 + 6 = 11
Atomic Number	5	5

From the above example, we can infer that U and V are isotopes because their atomic number is the same.

Element	**Number of protons**	**Number of Neutrons**	**Mass number**	**Atomic number**
Carbon (^{12}C)	6	6	12	6
Carbon (^{13}C)	6	7	13	6
Carbon (^{14}C)	6	8	14	6
Hydrogen (^{1}H)	1	no neutron	1	1
Hydrogen (^{2}H)	1	1	2	1
Hydrogen (^{3}H)	1	2	3	1

Where can we use Isotopes?

1. The fuel of Nuclear Reactor – Isotope of Uranium

2. Treatment of Cancer – Isotope of Cobalt

3. Treatment of Goitre – Isotope of Iodine

Isobars:

Suppose there are two or more elements which have different atomic number but their mass number is same then these elements are known as Isobars.

Example:

Argon and Calcium are Isobars as both have same mass number and atomic number is different.

Element	Number of protons	Number of neutrons	Mass Number	Atomic Number
Argon	18	22	40	18
Calcium	20	20	40	20

Applications of Isobars:

- Isobars are used in the medical field to treat tumours and blood clots.
- Thyroid disorders can be treated using isobars of iodine.
- Blood cancer can be treated using isobar of phosphorus.

CHECK YOUR PROGRESS 18.2

1. Give two examples of isotopes.

2. Tell the electronic configuration of Neon and Chlorine.

3. If the number of electrons in an atom is 6 and the number of protons is also 6
Find
   a) Atomic number.
   b) Charge of the atom.

4. What is Valency? Find the valency of Carbon, Phosphorus and Argon

5. Define isotopes with one example.

6. Give two uses of Isobars.

TERMINAL EXERCISE

1. Difference between Isotopes and Isobars.

2. Give main points of Bohr Theory.

3. Describe Rutherford's scattering experiment with diagrams.

4. Why did Dalton's Atomic Theory fail?

5. Define Atomic number and mass number with examples.

6. What is electronic configuration and give suitable examples. Describe any five elements giving their electronic configuration, shell wise.

7. Tell about valency electrons, valency shells and give the concept of Valency with three examples.

RECAPITULATION POINTS

- JJ Thomson discovered the electrons using the Crooke's tube experiment.
- Earnest Rutherford discovered the nucleus of the atom by the scattering experiment using gold foil.

- Goldstein discovered the proton by use of Cathode Ray tube.
- Chadwick discovered the neutron.
- The different atomic models are
  a) Dalton's atomic theory
  b) Thomson (plum pudding model)
  c) Rutherford's model is based upon the scattering experiment of gold foil
  d) Neil Bohr model
- Maximum number of electrons in an orbit is calculated by the formula 2n2, where 'n' is the number of orbits 1, 2, 3, 4 denoted by shells K, L, M, N.
- The atomic number is equal to the number of protons present in one atom of an element.
- Mass Number = Atomic Number + Number of Neutrons in the Nucleus
- Valency Shell is the outermost shell of the atom.
- Valency Electrons are the number of electrons present in the valency shell (outermost shell)
- Inert elements are also called noble gases.
- The combining capacity of the atoms of an element is known as valency.
- Isotopes are element can exist in several forms having similar atomic numbers but varying mass numbers.
- Isobars are elements which have different atomic number but same mass number.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 18.1

1. a) Neutron

b) Electron

c) Proton

2. The evidence of the nucleus was found in Rutherford's scattering experiment when alpha particles were bombarded on the gold foil and rays which returned back, confirmed the presence of the nucleus.

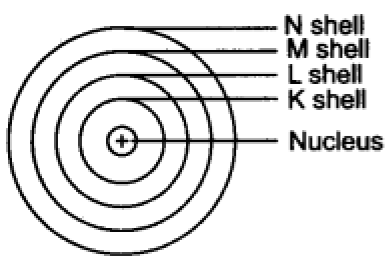
3. Atom consists of equal number of protons and electrons, so the charge is neutral.

4. Proton is positively charged whereas the electrons are negatively charged. Also the proton is heavier than the electron.

5. The particles used were alpha particles in Rutherford's scattering experiment.

6. The arrangement of electrons in various shells of the atom is known as electronic configuration.

7. Bohr model drawing.



Bohr's Model

CHECK YOUR PROGRESS 18.2

1. The two uses of isotopes

a) Are in the treatment of cancer.

b) Used as a nuclear fuel.

2. The electronic configuration of Neon and Chlorine are

Neon

Atomic number Z = 10

Electronic configuration is 2, 8 Shell wise K L

2 8

Chlorine

Atomic number Z = 18

Electronic configuration is 2, 8, 7 Shell wise K L M

2 8 7

3. Atomic number = number of protons = 6

And number of protons = number of electrons

6 = 6

So, the charge on the atom is neutral

4. Valency is combining capacity of the atom.

Carbon

Atomic number Z is 6

Electronic configuration is 2, 4

Valency electronar4

Valency = 4

Phosphorus

Atomic number Z is 15

Electronic configuration is 2, 8, 5

Valency electrons is 5

Rule:

Valency = 8 – valency electrons

= 8 – 5

= 3

So, valency is 3

Argon

Atomic number Z is 18

Electronic configuration is 2, 8, 8

Valency electrons is 8

Rule:

Valency = 8 – valency electrons

= 8 – 8

= 0

So, valency is zero 0

5. Isotopes are forms of the same element with the same atomic number but different mass numbers because of the presence of additional neutrons

MASS NUMBER (A) = ATOMIC NUMBER (Z) + NO. OF NEUTRONS

Take this example

Hydrogen has 3 Isotopes

1st Isotope which is Hydrogen, also called Protium

Atomic number Z = 1

Number of neutrons = 0

A = Z + n

= 1 + 0

= 1

Mass number is 1

2nd Isotope is Deuterium

MASS NUMBER (A) = ATOMIC NUMBER (Z) + NO. OF NEUTRONS

A = Z + n

= 1 + 1

= 2

Mass number is 2

3rd Isotope is Tritium

MASS NUMBER (A) = ATOMIC NUMBER (Z) + NO. OF NEUTRONS

$A = Z + n$

$= 1 + 2$

$= 3$

Mass number is 3

These are the three isotopes of Hydrogen.

6. Two uses of Isobars

   - Thyroid disorders
   - Tumours

19 MATTER IN OUR SURROUNDINGS

INTRODUCTION

We have already learned about matter – its composition, various theories etc; but here, we will learn about, how matter is present in nature and our surroundings. Interestingly, matter exists in different forms both physically and chemically and they are inter-convert able. Used in many ways and we can know, its processes and procedures.

19.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Learn about matter and its characteristics
- Gain knowledge about Molecular Theory of Matter.
- Explain about Physical characteristics of matter.
- Develop understanding about chemical characteristics of matter.
- Learn about properties of Metals, Nonmetals and Metalloids
- Explain about inter conversion of matter.

19.2 MATTER AND ITS CHARACTERISTICS

Matter is anything which occupies space and has mass is called matter. Air and water, sugar and sand, hydrogen and oxygen etc. the matter is made up of very small tiny particles. The particles of matter are constantly moving (they are in motion). The particles which make up matter are atoms and molecules. Particles of matter have space between them and they attract each other.

Classification-

1) On the basis of physical properties, matter is classified as solids, liquids and gases.
2) On the basis of chemical properties, matter is classified as elements, compounds and mixtures.

19.2.1 Characteristics of Matter

Matter is made up of small particles called atoms.

- These particles are too small to be observed with naked eye.
- These particles are constantly moving constantly.
- These particles have spaces between them.
- Particles of matter attract have the force of attraction amongst themselves.

Theory of molecular structure of matter

It states -

▪ Matter is made up of small particles called molecules.

▪ They are in a state of continuous motion. Due to this, we can say that they possess kinetic energy (K.E)

▪ K.E. Increases with rise in temperature.

▪ K.E. Is maximum in gases and least in solids.

▪ The space between molecules is called intermolecular space which is found to be least in solids and maximum in gases.

▪ There is a force that exists between particles of matter and is called intermolecular force.

19.2.2 PHYSICAL CLASSIFICATION 0F MATTER

This classification is done on the basis of physical properties of matter, that is the properties that can be seen or felt by touching, looking etc.

According to it, matter is divided into 3 types:

1) Solids
2) Liquids
3) Gases

19.2.3 SOLIDS

If you take any solid let's say we consider wood, what properties can you find in it by looking at it.

▪ First property that we can make out is: That it has fixed shape and volume: we realize this because when wood is kept on the floor or any surface, it occupies definite space.

▪ Another property that we notice is it is not compressible, if we try to squeeze it or change its shape, we cannot do so. This is probably due to the reason that there is no space between solid particles and in order to compress it, there should be space between particles. This is because when we apply force, the particles fill those empty spaces and come closer.

▪ Another property: They don't need container to hold them: we don't have to put an almirah or any other solid in a container. It can be kept as such on the surface.

▪ They do not flow: This is because when wood is kept in a place, it remains at the same place. It doesn't flow or move on its own.

▪ Their diffusion tendency is nil: it is seen that wood doesn't move from one side of room to another side of room on its own as the particles do not have that much energy that they keep on moving.

Explanation of Solids on the basis of Molecular Structure:

If we see any solid, we observe that particles are tightly packed in solid. They are very closely packed due to which there is hardly any space between particles or we can say that intermolecular spaces are very less and when particles are closer, that means the intermolecular forces of attraction are stronger. As a result, solids have fixed shape, volume and can't be compressed because of high density.

19.2.4 LIQUIDS

We observe -

▪ It has neither fixed shape nor volume.

▪ It can be compressed more than an almirah.

▪ It can flow in all directions.

▪ It can fill the entire space of a container.

▪ It can easily diffuse that is more than solids.

▪ It has lesser density than solids.

Explanation of Molecular Structure of Liquids:

In liquids, the particles are not as closer to each other as in solids due to which the intermolecular space is comparatively more, which results in a lesser attraction between the particles. So, intermolecular force is comparatively les as compared to solids.

19.2.4.1 GASES

Let's sum up the properties of gases in comparison to solids and liquids:

▪ They have neither a fixed shape nor fixed volume.

▪ They are highly compressible.

▪ They can flow, and diffuse to great extent.

▪ They have very low density.

▪ They can fill the entire space.

Explanation of gases on the basis of molecular structure:

In gases, the particles are very far apart. Due to this, they have high kinetic energy and keep on moving randomly. As a result, the intermolecular spaces are very large and intermolecular forces are almost nil.

Let us, take an example of water existing in three different forms.

A) 25°C, B) 0°C, C) 100°C?

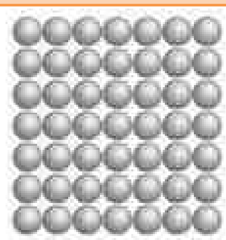
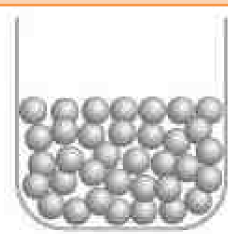
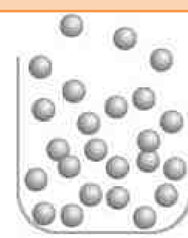
Answer: The physical state of water is as follows -

A) 25°C – water (liquid)

B) 0°C – ice (solid)

C) 100°C – water vapour (gas)

19.4 STATES OF MATTER

Solid State	Liquid State	Gaseous State
		
The space between the particles is very less.	The space between the particles is slightly more as compared to solids, but still very less as compared to gases. The particles of a liquid can slip and slide over each other.	The particles are much farther apart from one another as compared to solids and liquids. They have a very disorderly arrangement of particles compared to the solids and liquids.

The force of attraction between the particles is strong. Thus, particles in a solid are closely packed.	The force of attraction between the particles is strong enough to hold the particles together but not strong enough to hold the particles in a fixed position.	The force of attraction between the particles is negligible, hence particles of a gas move freely in all the directions. Gases thus can mix or diffuse into other gases.
The kinetic energy of the particles is very less and so solids have an orderly arrangement of the particles. Therefore, solids have a fixed shape and volume.	The kinetic energy of the particles is more than that of solids. Thus, liquids have a disorderly arrangement of particles compared to solids.	The particles of a gas have maximum kinetic energy. They move with high speed in all directions and can exert pressure on the walls of its container.
Solids maintain their shape even when they are subjected to external force i.e. they are rigid.	Liquids do not have a fixed shape but have a fixed volume. Liquids take up the shape of the container in which they are poured.	Gases neither have a definite shape nor a definite volume. They fill up the container completely.
Solids cannot be compressed.	Liquids cannot be compressed much. The compressibility of liquids is almost negligible.	Gases can be compressed easily. Example: the LPG cylinders used at home and the CNG cylinders used in vehicles.

19.5 BROWNIAN MOTION OF PARTICLES (BY ROBERT BROWN)

The random or zig-zag movement of microscopic particles in a fluid, as a result of continuous bombardment from molecules of the surrounding medium, is known as Brownian motion.

For example, dust moves randomly because the random moving particles of air collide with dust particles.

19.5.1 TEMPERATURE

Temperature is the degree of hotness or coldness of body or we can also say that temperature measures the extent of motion of atoms. It is measured with the help of thermometer.

There are different scales on which temperature can be recorded:

Commonly used scales are Celsius / Centigrade (°C) and Kelvin (K)

Celsius Scale (°C)

▪ It is written as °C.

▪ On it the lower fixed point (at which ice melts) is O °C.

▪ The upper fixed point on it (at which water boils) is 100 °C.

Kelvin scale (K)

▪ The lower fixed point is- 273K

▪ The upper fixed point is 373 K

▪ Kelvin scale is called as absolute zero scale of temperature because on it the lowest possible temperature is zero.

Absolute zero

This is the theoretical temperature at which particles have the least amount of energy and the slowest movement. It occurs at -273.15 °C, or 0 Kelvin on the scientific temperature scale. Scientists have not been able to cool down any substance to this temperature but have come very close. It used to be thought that particles would stop moving at absolute zero but experiments have shown that this isn't the case.

19.5.1.1 RELATIONSHIP BETWEEN KELVIN (K) AND CELSIUS (°C)

These scales are inter-convert able by using the well-defined relations like 0 °C = 273 K.

So, K = °C+ 273

Or

°C = K -273

For example, if we need to convert 15 °C to K then, we need to add 273 to it and it comes out to be 288K (15 + 273 = 288 K)

Convert the following temperatures to the Kelvin scale.

(a) 25°C (b) 373°C.

Rule: K = °C+ 273

Answer: (a) 25 Degree Celsius = 25+273=298K

(b) 373 Degree Celsius =373+273=646K

Convert 300K and 573 k in to Celsius?

Rule: °C= K -273

Answer: 300K-273=27Degree Celsius

573K -273 = 300 Degree Celsius

19.6 CHEMICAL CLASSIFICATION OF MATTER

As said above, on the basis of chemical properties, matter is classified as elements, compounds and mixtures.

Element: A pure substance which is made up of only one kind of atom and cannot be broken into two or simpler substances by physical or chemical means is referred to as an element.

Characteristics of elements are:

- An element is homogeneous in nature; it is a pure substance, made up of only one kind of atom. For example, iron and silver are made of only iron and silver atoms.

- An element cannot be broken down into simpler substances by any physical or chemical methods such as heat, light electricity, or chemical reactions with other substances. For example, if you were to smash a piece of iron into smaller pieces or heat it, the piece still remains as the element iron.
- An atom is the smallest unit that shows all the properties of an element. For example, an atom of iron shows all the properties of that metal.
- Elements have sharp melting and boiling points.

Elements are classified as metals, non-metals and metalloids.

19.6.1 METALS: Metals are the elements that readily loose an electron to form a positive ion or cation.

Example: Gold, silver, copper, iron, potassium etc.

19.6.1.1 PROPERTIES OF METALS

- Metals have lustre. When freshly cut, they show metallic lustre. Example: Gold.
- Metals are good conductors of heat and electricity. As metals have free electrons in them, they are able to conduct heat and electricity. Example: Copper.
- Metals are malleable, meaning they can be hammered into thin sheets. Example: Aluminium.
- Metals are ductile, which means they can be drawn into wires.
- Metals are sonorous. They give a ringing sound when they are hit by a hard iron rod. Example: copper.
- Almost all metals are solids at room temperature.

Exceptions:

- Sodium and potassium are soft metals.
- Mercury is liquid at room temperature.
- Zinc is brittle in nature; it is non-ductile and non-malleable.
- Tungsten is a poor conductor of electricity.

19.6.2 NON - METALS: Non - metals are those elements that readily gain an electron(s) to form a negative ion or anion.

Example: Hydrogen, Oxygen, Iodine etc.

19.6.2.1 PROPERTIES OF NON-METALS

- Non-metals exist as solids, liquids and gases.
- Example: Silicon and carbon are solids; bromine is a liquid; chlorine, fluorine and oxygen are gases.
- Non-metals are non-lustrous, that is, they have a dull appearance.
- Example: The surfaces of sulphur and phosphorus do not shine.
- Most non-metals have very low density.
- Example: Oxygen and nitrogen are lighter than air.
- The exception is diamond, a form of carbon. Diamond is one of the strongest known substances.
- Non-metals are not malleable.
- Example: Sulphur and iodine cannot be hammered into sheets.
- Non-metals, except for carbon fibers, are not ductile.
- Example: Phosphorous and Bromine cannot be drawn into wires.
- Non-metals are bad conductors of heat and electricity.
- Example: Nitrogen and Oxygen cannot conduct electricity.
- The exception is graphite, a form of carbon which is a good conductor of electricity.
- Non-metals have low melting and boiling points.
- Example: Sulphur and Phosphorus have

19.6.3 METALLOIDS: The elements which have intermediate properties between those of metals and non-metals are called metalloids.

- They are amphoteric in nature.

- Metalloids react both with acids and bases.
- For example, boron, silicon and germanium.

Noble Gases are helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), radon (Rn), and oganesson (Og). The noble gases are colourless, odourless, tasteless, non-flammable gases. They traditionally have been labelled Group 0 in the periodic table because for decades after their discovery it was believed that they could not bond to other atoms; that is, that their atoms could not combine with those of other elements to form chemical compounds.

19.6.4 COMPOUND: A pure substance composed of two or more elements that are chemically combined in a fixed proportion is called a compound.

Example: Water (H_2O), which is made from the elements hydrogen and oxygen, and table salt (NaCl), which is made from the elements sodium and chloride

19.6.4.1 PROPERTIES OF A COMPOUND

- A compound is homogeneous in nature, made up of the same type of molecules. For example, water contains only molecules of water.
- The components of a compound cannot be separated by physical methods but they can be separated by chemical and electrochemical methods. For example, water can be broken into constituent elements hydrogen and oxygen by the process of electrolysis.
- A compound has a fixed composition. For example, a water molecule is always composed of two hydrogen atoms and one oxygen atom.
- A compound has a distinct set of properties which is not similar with the properties of its constituent elements. For example, sodium chloride table salt is a harmless substance which is a white crystalline solid. On the other hand, its constituents sodium is a greyish white solid and chlorine is are a greenish yellow gas that is potentially dangerous.
- A compound has a sharp melting and boiling point. For example, water has a boiling point of 100°C, and a melting point of 0 °C

19.6.5 MIXTURES: Matter that consists of two or more substances which may be elements, compounds, or both mixed together physically in any proportion, but not chemically combined.

19.6.5.1 PROPERTIES OF MIXTURE

- There is no definite proportion in which the constituents of a mixture combine. For example, the mixture of salt and sand can be in any ratio.
- The parts of a mixture can be separated by physical means. For example, a mixture of iron filings and sulphur can be separated by using a magnet.
- When a mixture is created, no new substance is formed; each part of a mixture retains its own properties. For example, we could mix various proportions of hydrogen and oxygen gas, as long as you do not ignite the mixture, the combination will form a mixture that can be separated.
- Energy is neither given out nor absorbed in the preparation of a mixture. For example, no heat or light energy is liberated or absorbed when iron filings and sulphur are mixed together.
- A mixture does not have a sharp melting or boiling point. For example, sugar solution does not boil at a fixed temperature.

Table …...Difference Between Compound and Mixture.

Sl. No.	Differentiating Property	Compound	Mixture
1	Definition	Compound are substances which can be formed by chemically combining two or more elements.	Mixtures are substances that are formed by physically mixing two or more substances.
2	Types	Compounds can be of three types, which are: covalent compounds, metallic	Mixtures are mainly of two types i.e. homogenous mixtures and

		compounds and ionic compounds.	heterogeneous mixtures.
3	Substance Category	Compounds fall under pure substances.	Mixtures can be categorized as impure substances.
4	Composition Details	The chemical composition of compounds is always fixed.	A mixture can have a variable composition of the substances forming it.
5	Nature	Compounds are always homogeneous in nature	Mixtures can either be homogeneous or heterogeneous in nature.
6	Separation of Constituents	The constituents of a compound can only be separated by either chemical or electrochemical methods (like extraction).	Mixtures can be separated into their constituents via physical separation methods such as filtration. Thus, the separation of mixtures is relatively easier than the separation of chemical compounds.
7	Properties	The properties of compounds are unique to themselves and need not necessarily reflect the properties of the constituent elements.	The constituents of a mixture do not lose their properties and so, the properties of a mixture are generally the sum of the properties of its constituents.
8	New Substance	A new substance is formed after the constituents are chemically combined. So, a	No new substances are formed in mixtures and their properties are dependent on the properties of their

		compound has different properties from its constituents.	respective constituents.
9	Melting and Boiling Points	The melting and boiling points of a compound are always defined.	The melting and boiling points of a mixture are not defined.
10	Example	Water, salt, baking soda, etc.	Oil and water, sand and water, smog (smoke + fog), etc.

Mixture: Classification

Mixtures are classified into homogeneous and heterogeneous types.

A) Homogeneous Mixture

1. Those mixtures, in which the substances are completely mixed together and are indistinguishable from one another, are called homogeneous mixtures. For example: - All homogeneous mixtures are solutions. Example: - Soda water, Soft drinks, lemonade etc.
2. A Mixture of sugar in water (called sugar solution).

Lemonade

Further examples

- Air
- Sugar water
- Steel (alloy)

You can't pick out components of a homogeneous mixture or use simple mechanical means to separate them. You can't see individual chemicals or ingredients in this type of mixture. Only one phase of matter is present in a homogeneous mixture.

B) Heterogeneous Mixture

1. Those mixtures in which the substances remain separate and one substance is spread throughout the other substance as small particles, droplets or bubbles are called heterogeneous mixtures.
2. The suspensions of solids in liquids are also heterogeneous mixtures.
3. A mixture containing two (or more).
4. All the suspensions and colloids are heterogeneous mixtures. For Example: - Sugar and sand mixture, muddy river water, soap solution.

Mixture of Oil and water Further examples are

- Cereal in milk
- Blood (removed by spinning in a centrifuge)
- Gravel
- Soil
- Iron fillings and sand (removed by magnet)

Usually, it's possible to physically separate components of a heterogeneous mixture. For example, you can centrifuge (spin out) solid blood cells to separate them from the plasma of blood.

Heterogeneous versus Homogeneous comparison chart

	Heterogeneous	Homogeneous
Uniform	No	Yes
You can see the parts	Yes	No
Can be separated physically	Yes	No
Examples	Soil, blood, sand and iron filings	Air , sugar water
Chemically bonded	No	No

Difference between Homogeneous and Heterogeneous Mixture

Homogeneous mixture	Heterogeneous mixture
It has a uniform composition	It has a non-uniform composition
It has only one phase	There are two or more phases
It can't be separated out physically	It can be separated out physically
'homo' means the same	'hetero' means different
Example: a mixture of alcohol and water	**Example:** a mixture of sodium chloride and sand

These are various parts of both, the physical and chemical characteristics of matter. Next, matter can be interconverted from one form to another form like for example water (liquid form) can be frozen to ice (solid form) and water (liquid form) can be boiled to water vapour (gas form) and vice versa. This is called "interconversion of matter"

CHECK YOUR PROGRESS 19.1

1. What are Noble gases?

2. Discuss briefly about Metalloids.

3. What do you mean by Brownian movement?

4. Name the two scales of temperature.

5. What is absolute zero?

19.7 INTER–CONVERSION OF MATTER

1) Change of State of Matter:

Physical states of matter can be interconverted into each other in following two ways:

(a) By changing the temperature.

(b) By changing the pressure.

2) Effect of Change of Temperature:

Solid to liquid:

- On increasing the temperature of solids, the kinetic energy of the particles increases which overcomes the forces of attraction between the particles thereby solid gets converted to a liquid.

- **Melting:** The Change in solid state of a substance into liquid is called melting.
- **Melting point:** The temperature at which solid melts to become a liquid at the atmospheric pressure is called its melting point.
- Melting point of ice is 0 °C

Liquid to gas:

- On heating a liquid like water, the kinetic energy of its particles increases as high as in a gas, thus causing the liquid to change to a gas.

- **Boiling:** The change of a liquid substance into gas on heating is called boiling.
- **Boiling point:** The temperature at which a liquid boils and changes rapidly into a gas at the atmospheric pressure is called its boiling point.
- Boiling point of water is 100°C.

Gas to liquid:

- On cooling a gas like steam (or water vapour), the kinetic energy of its particles is lowered down, causing them to move slowly and bringing them closer, forming a liquid.

- **Condensation:** The process, in which a gas, on cooling, turns into a liquid at a specific temperature is called condensation or liquefaction.

Liquid to solid:

- When a liquid is cooled down by lowering its temperature, its particles lose the kinetic energy and come to a stationary position, causing the liquid to turn to solid.

- **Freezing:** The change of a liquid substance into solid by lowering its temperature is called freezing.
- **Freezing point:** The temperature at which the state of a substance changes from a liquid to a solid is called the freezing point of that substance.

3) Effect of Change of Pressure (Gas to liquid)

- Gases can be liquefied by applying pressure and reducing the temperature.
- When a high pressure is applied to a gas, it gets compressed and if the temperature is lowered, the gas is liquefied.

4) Evaporation:

The process of conversion of a substance from the liquid state to the gaseous state at any temperature below its boiling point is called evaporation or vaporisation.

Factors affecting the rate of evaporation:

- Surface area: The rate of evaporation increases on increasing the surface area of the liquid.

- Temperature: The rate of evaporation increases with an increase in temperature.

- Humidity: Decrease in the humidity increases the rate of evaporation.

- Wind speed: An increase in the wind speed increases the rate of evaporation.

Evaporation	**Boiling**
It is a surface phenomenon.	It is a bulk phenomenon.
It is a slow process.	It is a rapid process.

It takes place at all temperatures but below the boiling point.	It takes place at a definite and constant temperature.

Table: Difference between Evaporation and Boiling.

19.8 SOME IMPORTANT TERMS

1) Fusion: The process of melting, that is, change of a solid state into liquid state is also known as fusion.

2) Latent heat: The heat energy that is required to change the state of a substance without causing any rise in the temperature of the substance is called latent heat. Since, the heat energy is hidden in the bulk of the matter, it is called latent heat.The hidden heat which breaks the force of attraction between the molecules during a change of state.

Fusion	Vaporisation
Heat energy required to change 1kg of solid into liquid.	Heat energy required to change 1kg of liquid to gas at atmospheric pressure at its boiling point.

3) Latent heat of fusion: The heat energy required to convert 1 kilogram of a solid into liquid at atmospheric pressure, at its melting point, is known as the latent heat of fusion

4) Latent heat of vaporisation: The heat energy required to convert 1 kilogram of liquid into gas, at atmospheric pressure, at its boiling point, is known as the latent heat of vaporisation

5) Diffusion

- Intermixing of particles of two different types of matter on their own is called diffusion.
- The rate of diffusion increases on increasing the temperature of the diffusing substance (by heating).

  Examples of diffusion in gases:
- The aroma of food being cooked in the kitchen reaches us even from a considerable distance due to diffusion.
- The fragrance of a burning incense stick spreads all around due to diffusion.
- The fragrance of a perfume spreads due to the diffusion of the perfume particles into air.

Examples of diffusion in liquids:

- Colour of potassium permanganate is acquired by water, on its own, due to the diffusion of potassium permanganate particles in water.
- The spreading of ink in water, on its own, is due to the diffusion of ink particles in the water.

Examples of diffusion in solids:

- If two metal blocks are bound together tightly and kept undisturbed for a few years, then the particles of one metal are found to have diffused into the other metal.
- If we write something on a blackboard and leave it undisturbed for at least 10 to 15 days, we will find that it becomes quite difficult to clean the blackboard afterwards. This is due to the fact that some of the particles of chalk have diffused into the surface of the blackboard.

6) Sublimation: The change of state of a substance directly from a solid to gas or gas to solid, without changing into the liquid state, is called sublimation. The changing of a solid directly into vapours on heating and of vapours into solid on cooling, is known as sublimation.

CHECK YOUR PROGRESS 19.2

1. Explain melting and boiling points.

2. What is the effect of pressure on gases?

3. How are liquids changed to solids freezing point)?

4. Define evaporation.

5. Give two main differences between boiling and evaporation.

RECAPITULATION POINTS

- Matter is anything which occupies space and has mass.
- Molecular Theory of Matter states that matter is made up of small particles called atoms and they are always in motion.
- Physical classification of matter is in the form of solids, liquids and gases.
- Temperature, its different scales of measurement and relationship between them.
- Chemical classification of matter is in the form of elements, compounds and mixtures.
- A pure substance composed of two or more elements that are chemically combined in a fixed proportion is called a compound.

- Matter that consists of two or more substances which may be elements, compounds, or both mixed together physically in any proportion, but not chemically combined.
- Those mixtures, in which the substances are completely mixed together and are indistinguishable from one another, are called homogeneous mixtures.
- Those mixtures in which the substances remain separate and one substance is spread throughout the other substance as small particles, droplets or bubbles are called heterogeneous mixtures.
- Physical states of matter can be interconverted into each other by changing the temperature and pressure
- Fusion is the process of melting, that is, change of a solid state into liquid state.
- Latent heat is the heat energy that is required to change the state of a substance without causing any rise in the temperature of the substance
- Latent heat of fusion is the heat energy required to convert 1 kilogram of a solid into liquid at atmospheric pressure, at its melting point.
- Latent heat of vaporisation is the heat energy required to convert 1 kilogram of liquid into gas, at atmospheric pressure, at its boiling point.
- Diffusion is intermixing of particles of two different types of matter on their own

TERMINAL EXERCISE

1. What are compounds and mixtures? Tell their differences also.

2. How can temperature control the various states of matter? Answer in details.

3. Define homogeneous and heterogeneous mixtures. Tell their differences.

4. Explain latent heat. What is latent heat of fusion and latent heat of vaporisation?

5. What is evaporation. Explain various factors involving evaporation.

6. Define the various scales of measurement of temperature. Tell their mathematical relationship.

7. Give detailed tabular differences between solids, liquids and gases.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 19.1

1. Noble Gases are helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), radon (Rn), and oganess on (Og). The noble gases are colourless, odourless, tasteless, non-flammable gases.
2.Metalloids: The elements which have intermediate properties between those of metals and non-metals are called metalloids. They are amphoteric in nature, reacts with both with acids and bases. For example, boron, silicon and germanium.
3. The random or zig-zag movement of microscopic particles in a fluid, as a result of continuous bombardment from molecules of the surrounding medium, is known as Brownian motion. For example, dust moves randomly because the random moving particles of air collide with dust particles.
4. Temperature is the degree of hotness or coldness of a body. There are different scales on which temperature can be measured. Commonly used scales are Celsius / Centigrade (°C) and Kelvin K)

5. Absolute zero is the theoretical temperature at which particles have the least amount of energy and the slowest movement. It occurs at -273.15 °C, or 0 Kelvin on the scientific temperature scale.

CHECK YOUR PROGRESS 19.2

1.Melting point: The temperature at which a solid melt to become a liquid at the atmospheric pressure is called its melting point. Boiling point: The temperature at which a liquid boils and changes rapidly into a gas at the atmospheric pressure is called its boiling point.

2. Gases can be liquefied by applying pressure and reducing the temperature.

When a high pressure is applied to a gas, it gets compressed and if the temperature is lowered, the gas is liquefied, meaning it is changed into liquid like LPG or CNG
3.Freezing point: The temperature at which the state of a substance changes from a liquid to a solid is called the freezing point of that substance.
4. The process of conversion of a substance from the liquid state to the gaseous state at any temperature below its boiling point is called evaporation or vaporisation. Factors affecting the rate of evaporation are Surface area, Temperature, Humidity, Wind speed.
5. Refer to the text

20 CLASSIFICATION OF ELEMENTS

INTRODUCTION

Classification is of vital importance not only in research, but also in our daily lives. It makes things easier. Let's look at a simple example to see how this works. You've probably been to a library. A huge library has thousands of books. Regardless, if you ask for a certain book, the library personnel will be able to locate it quickly. Because the books are divided into many categories and subcategories, this is possible. They are placed on shelves in the appropriate order. As a result, finding books is simple. Use the same logic in chemistry. Compounds make up the majority of the stuff we see, touch, and feel. There are millions of such compounds on the market right now. You'll be pleasantly surprised.

Compounds are generated as a result of diverse permutations and combinations of only approximately 118 odd elements, which may surprise you. Individually studying the characteristics of these elements and their compounds is a huge undertaking.

Scientists felt it was necessary to put components with similar qualities together in order to examine all of these elements' qualities independently. As a result, the elements have been grouped into a few groups, with elements in the same group having similar features. In this lesson, we will look at numerous attempts to classify elements over time, and moment, and then we'll look at the current element classification.

20.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Gain knowledge about the classification of elements.
- Explain the postulates and constraints of Doberenier Triads, the Newland Law of Octaves, and Mendeleev's Periodic Table.
- Understand that the contemporary periodic table creates order from chaos.
- Know about the positions of elements in the Modern Periodic Table.
- Recognize current periodic table trends in terms of

(i)valence,

(ii) atomic size, and

(iii) metallic and non-metallic characteristics.

20.2 KANAD'S PREDICTIONS

Indian and Greek philosophers were perplexed by the nature of matter in ancient times. There are a few basic elements that have emerged. Earth, fire, air, and sky are the four elements that make up the universe. Gradually, the idea that all matter Earth, fire, air, and sky were regarded to be the five primary elements in ancient times. However, we now understand that an element is a pure material made up of only one type of atom and possessing a specific set of qualities.

Kanad was a prominent philosopher from India (600 B.C). Matter, he claimed, was made up of indestructible particles known as paramanus (param means ultimate and anu means particle) (now called atoms). A paramanu does not exist in its natural condition; instead, it joins with other paramonus to form the anu, a larger particle (now known as molecules).

20.3 TRIADS OF DOBEREINER

A German scientist named Johann Wolfgang Doberiener attempted to organise elements with similar properties into three-element groups in the year 1817. He referred to these individuals as traids. The middle element's atomic mass was about the average of the other two elements' atomic masses, and the three elements in a traid were placed in order of increasing atomic mass.

Elements	**Cl Br I**	**Li Na K**	**Ca Sr Ba**
Atomic mass	**35.5 80 127**	**7 23 39**	**40 88 137**
Average atomic mass of first and third elements	**35.5 +127÷2=81.25**	**7+39÷2=23**	**40+137÷2=88.5**

20.3.1 Importance

It has a great significance in forecasting the middle element's atomic mass and characteristics. Even now-a-days, these elements resemble in their properties.

20.3.2 Limitations

All the elements discovered at that time could not be classified into traids. He could identify only three traids. [Cl, Br, I; Li, Na, K; Ca, Sr, Ba]

20.4 NEWLAND'S LAW OF OCTAVES

In 1886, an English chemist named John Newland organized Starting with hydrogen and ending with thorium, the known elements are listed in sequence of increasing atomic weights. (56th element). In terms of properties, every eighth element is the same as the first. He likened it to the octaves used in music.,i.e., Sa, re, ga, ma, pa, da, ni and in the west, they use the nations— do, re, mi, fa, so, la, ti. Therefore, his finding is known as the Law of Octaves.

20.4.1 Newland's Octaves

sa (do)	re (re)	ga (mi)	ma (fa)	pa (so)	da (la)	ni (ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ca and La	Zr	—	—

20.4.2 Limitations

1. Newland's Octaves Law was only valid up to calcium.

After calcium, none of the other elements had properties that were comparable to the first.

2. No further elements would be discovered in the future, according to Newlands. However, several more elements were discovered afterwards that did not fit into the Octave law.

3. Newland's rearranged two pieces in the same slot and grouped some dissimilar elements together.

Only the lighter parts functioned well with Newland's law of Octaves.

20.5 MENDELEEV'S PERIODIC TABLE: SHORTCOMINGS AND LIMITATIONS

A Russian chemist Dmitri Ivanovich Mendeleev, gave the principle to the early establishment of a periodic table of elements, in which the elements were listed in the order in which they were discovered.

According to their fundamental feature, atomic mass, as well as chemical properties that were similar. At the time, there were only 63 elements known at that time. He studied at the relationship between an element's atomic number and its atomic weight. It was also discovered that on a regular basis, elements with comparable physical and chemical properties reappear.

He considered done of the fundamental aspects of a element is the formulae of the hydride and oxides shaped by it.one of the essential properties of a element for the order. He then organized 63 components in the rising request of their nuclear masses and observed that the properties of elements are the occasional capacity of their nuclear masses.

20.5.1 Mendeleev's Periodic Table (Published in a German journal in 1872)

The letter 'R' is used to indicate any of the elements in their group in the formula of oxides and hydrides at the top of the columns.

Group	I	II	III	IV	V	VI	VII	VIII
Oxide Hydride	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods ↓	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series:	K 39.102	Ca 40.08	Sc 44.96	Ti 47.90	V 50.94	Cr 50.20	Mn 54.94	Fe Co Ni 55.85 58.93 58.71
Second series:	Cu 63.54	Zn 65.37	Ga 69.72	Ge 72.59	As 74.92	Se 78.96	Br 79.909	
5 First series:	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 99	Ru Rh Pd 101.07 102.91 106.4
Second series:	Ag 107.87	Cd 112.40	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.90	
6 First series:	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.85		Os Ir Pt 190.2 192.2 195.0
Second series:	Au 196.97	Hg 200.59	Tl 204.37	Pb 207.19	Bi 208.98			

20.5.2 Highlights of Mendeleev's Periodic Table

(i) The table contains 8 vertical segments, called columns and 6 even rows, called periods.

(ii) In his table, Mendeleev left holes for the elements not found around then. He named such elements by prefixing a Sanskrit numeral Eka (one), divi (two), tri (three) and so on.

(iii) He additionally anticipated the nuclear masses and properties of a few components that were not known around then. elements like scandium, gallium and germanium have properties like those anticipated by Mendeleev.

(iv)In request to gather the components having comparable properties, at certain spots: Mendeleev needed to put a component with a marginally more noteworthy nuclear mass before a component with a somewhat lower nuclear mass.

(v) Noble gases such as helium (He), neon (Ne), argon (Ar), and others were discovered relatively late because to their severe dormancy and low fixation in our environment. When these gases were found, one of the advantages of Mendeleev's occasional table was that they could be transported to a separate gathering without disrupting the previous one. one.

20.5.3 Limitations of Mendeleev's Periodic Table:

Albeit this table was significantly useful for the investigation of components however a couple things could not be made sense of based on this table. These oddities are:

(i) Position of Hydrogen:

The electronic setup of hydrogen looks like with antacid metals. Besides, it joins with halogen, oxygen, and sulfur give kind of mixtures as given by antacid metals. for example (HCl, NaCl), (H2O, Na2O) and (H2S, NO2S).

(ii) Position of Isotopes

Isotopes of an element have chemical properties that are comparable yet have distinct atomic masses. These elements were not included in Mendeleev's periodic table. For example, the element chlorine has two isotopes with weights of 35 and 37, respectively.

(iii) Atomic Mass Uncertainty: Another issue was that atomic masses did not rise in a predictable manner from one element to the next.

(iv) Heavier Elements Are Placed Before Lighter Elements: Elements having a higher atomic mass are placed first, followed by elements with a lower atomic mass. Argon (39.9) and nickel, for example (58.7).

CHECK YOUR PROGRESS 20.1

1. Fill in the blank:
   (a) Element having similar chemical properties but different atomic masses in known as __________.

2. State True and False for the following statement.
   The characteristics of elements are a periodic function of their atomic masses, according to Mendeleev's periodic law.
3. Answer the following:
   (a) State Dobereiner's law of traids.
   (b) What is Newlands law of Octaves? Why is it called so?
   (c) On what basis, Mendeleev classify the elements?

20.6 MODERN PERIODIC TABLE PERIODIC TABLE

In the Modern Era Moseley demonstrated in 1913 that a component's nuclear number is a more important feature. On the basis of this, he updated Mendeleev's Periodic Law to read, "Physical and compound properties of the components are an occasional capacity of their nuclear number."
Modern Periodic Law is the term for this.

20.6.1 Highlights of Modern Periodic Table

There are 18 vertical columns labelled groups and seven horizontal rows labelled periods in this table. The Group's Characteristics The following are some of the most important qualities of elements found in groups: There are no sub-groups in the groupings.

A collection of elements all have the same number of valence electrons.

As we progress through the group, the number of shells grows.

The chemical characteristics of the elements in a group are the same.

5. Physical properties of elements in a group vary, such as melting point, boiling temperature, and density.

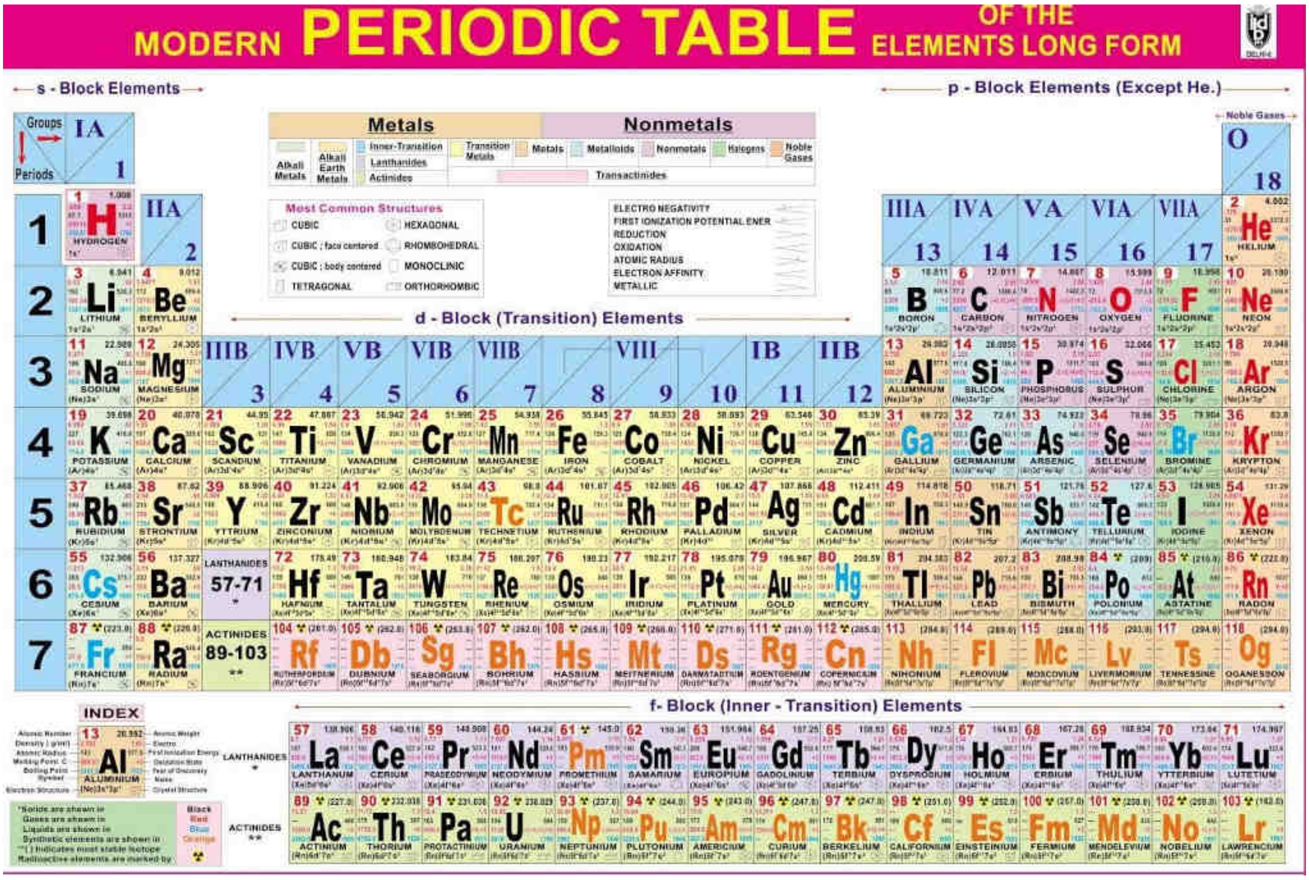


Fig 1: Modern Periodic Table

20.6.2 Features of Periods:

The following are the main characteristics of the elements in a period:

• Periodic elements have the same number of orbits, but not the same number of valence electrons.

• The number of valence shell electrons rises by one unit as the atomic number increases by one unit while moving from left to right in a period. As a consequence, atoms having the same number of orbits from the same element are clustered together in the same period.

• The chemical characteristics of electrons are affected by the number of valence shell electrons, which can be explained by the filling of electrons into various shells.

• The number of electrons in different periods varies, which can be explained by the loading of electrons into different shells.

• The formula $2n^2$ gives the maximum number of electrons that can be accommodated in a shell.

Where n is the number of shells from the nucleus, for example.

As a result of the K-shell– 2 $*(1)^2$ = the initial period has two electrons and is referred to as a very short period.

Because L-shell – 2 $* (2)^2 = 8$, the period has 8 electrons and is referred to as a short period.

M-shell – 2 * $(3)^2$ = 18, yet only 8 electrons can be found in the outermost shell. There are eight elements in this period as well. As a result, it is often known as a brief period.

The long periods, which have 32 elements, are the sixth and seventh periods.

20.6.3 POSITION OF THE ELEMENTS IN THE MODERN PERIODIC TABLE

- To find an element's position in the periodic table, write down its electronic configuration first, and then look it up in the table. use the following formula to determine its period and group number:
- An element's period number equals the number of electron shells in its atom.
- Two elements belonging to the same period of the periodic table have the same number of valence shells. For example, if an element's atom has two electron shells (K and L), it belongs to the second period. The number of valence electrons is equal to the group number of an element with up to two valence electrons, e.g. If an element has one valence electron, it is classified as group 1, and if it has two valence electrons, it is classified as group 2. An element with more than 2 valence electrons has a group number equal to the number of valence electrons (n) plus 10, therefore its group number is n+10.
- When two (or more) elements have the same number of valence electrons, they are classified as belonging to the same periodic table group.

20.6.4 EXPLANATION OF THE MENDELEEV'S PERIODIC TABLE ANOMALIES

The key reason for current occasional table is nuclear number not nuclear mass, consequently it is more exact.

- Since, the table depends on nuclear number and isotopes have same nuclear number and substance properties, so they can be put at one spot in a similar gathering of the occasional table.
- In this occasional table, a special position has been given to hydrogen. It is kept at upper left corner due to its novel qualities.
- The place of Cobalt and Nickel is legitimate itself on the grounds that nuclear number of Cobalt is not exactly nuclear number of Nickel.

20.7 PATTERNS IN THE MODERN PERIODIC TABLE:

In this table a few properties show a customary pattern when we move along a period from left to right or in a gathering through. These properties are:

Valency:

It is the joining limit of a element to obtain respectable gas design. It relies on the quantity of valence electron present in the peripheral shell of its atoms. For the elements of gathering 1,2,13, and 14, valency= number of valence electrons, though for the elements of gathering 15 onwards, valency = 8-valence electrons Thus, the valences of elements of various gathering are as per the following:

Valency of gathering 1 element is 1

Valency of gathering 2 element is 2

Valency of gathering 13 element is 3

Valency of gathering 14 element is 4

Valency of gathering 15 element is 3

Valency of gathering 16 element is 2

Valency of gathering 17 element is 1

Valency of gathering 18 element is 0

Valency along a gathering:

In a gathering, external electronic design is same for every one of the components so all have similar number of valence electrons and the valency. E.g. every one of the components of gathering 1 have valency=1

20.8 VARIATION ALONG A PERIOD:

The valency increases from 1 to 4 and then decreases to zero from group 15 to 18

Group	1	2	13	14	15	16	17	18
Valency	1	2	3	4	3	2	1	0

Atomic Size:

The radius of an atom is referred to as atomic size. The distance between the nucleus's centre and the outermost shell of an isolated atom can be observed. It is measured in picometers, for example, the hydrogen atom's atomic radius is 37pm.

20.8.1 Variation along a Group

The atomic size grows as you progress through the group. This is due to the fact that as we progress through the group, more shells are added. This increases the distance between the nucleus and the outermost electrons. As a result, despite the rise in nuclear charge, the atomic size increases.

20.8.2 Variation along a Group

Moving from left to right along a period reduces the atomic radius. This is due to an increase in nuclear charge, which causes the valence electrons to pull closer to the nucleus, shrinking the atom's size.

Third period element	Na	Mg	Al	Si	P	S	Cl
Atomic radius (pm)	186	160	143	118	110	104	99

20.8.3 Metallic and Non – metallic Properties:

Metals have a tendency to lose one or more electrons, resulting in positive ions. These can be found on both the left and right sides of the periodic table. Metals lose electrons and generate positive ions, which gives them their metallic properties. These elements are also known as electropositive elements because they produce positive ions.

Non-metals are elements that have a proclivity for gaining one or more electrons in order to produce negative ions. As a result, these elements are electronegative. In the periodic table, they can be seen on the right side. The element's non-metallic nature is owing to their electron accepting inclination.

Some elements share characteristics with both metals and non-metals. They're referred to as metalloids.

Metalloids or semi-metals are the borderline elements boron, silicon, germanium, arsenic, antimony, tellurium, and polonium, which have intermediate characteristics.

20.8.4 Variation along a Period and a Group

A Period and a Group: As the effective nuclear charge acting on the valence shell electrons grows with time, the tendency to lose electrons diminishes.

Because the outermost electrons are far away from the nucleus, the effective nuclear charge experienced by valence electrons diminishes as they move down the group. As a result, they are easily misplaced. As a result, metallic character decreases over time and down a group.

E.g., in case of elements of third period, metallic and non-metallic character vary in the following manner.

Third period element	Na	Mg	Al	Si	P	S	Cl
	Metals			Metalloid	Non- metal		

However, in groups, the order of variation of metallic and non-metallic character is as follows:

Lithium	Li	Least metallic element	
Sodium	Na	↓	
Potassium	K	↓	Metallic character
Rubidium	Rb	↓	
Caesium	Cs	↓	
Francium	Fr	Most metallic element	

Nature of Oxides:

Oxides of the metals are of basic in nature while those of non-metals are acidic. This means that along a period, the basic character of the oxides of the elements decreases while their acidic character increases. Nature of Oxides

e.g.

Oxide	Name	Nature
Na_2O	Sodium Oxide	Strongly basic
MgO	Magnesium Oxide	Basic
Al_2O_3	Aluminium Oxide	Amphoteric
SiO_2	Silicon dioxide	Weakly acidic

20.8.5 Electronegativity

It may be defined as the relative electron attracting tendency of an atom for a shared electron pair in a covalent bond with another atom.

Variation along a period and a group

The electronegativity of the elements increases along a period because of the increment in the non-metallic character. Similarly, it decreases down the group since the non-metallic character decreases.

Fluorine	F	Most electronegative
Chlorine	Cl	
Bromine	Br	
Iodine	I	Least electronegative

Example 1. Below is a list of elements from the periodic table. Boron, aluminium, gallium, indium, and thallium are all elements that can be found in nature (boron is the first member and thallium is the last).

In respect to the aforementioned group of items, respond to the following question.

a) Which of the elements below has the most metallic properties?

b) Which elements do you think would have the highest electronegativity?

d) Will the elements to the right of this boron group be more metallic or less metallic than the ones to the left?

Sol. (i) Thallium is the metalloid with the most metallic properties. In a group, the metallic character grows stronger.

(ii) Boron has the highest electronegativity, which falls as the group number lowers.

(iii) Less metallic in nature as time passes since metallic nature lessens as time passes.

CHECK YOUR PROGRESS 20.2

1. Fill in the blanks.

   A) The number of group and periods present in the modern periodic table is __________ and ________.

2. State True or False for the following statement.

   (a) If two (or more) elements have the same number of valence electrons, they belong to the same periodic table group.

3. What is the primary distinction between Mendeleev's periodic law and modern periodic law?
4. In which period and group would you place the elements with the electronic configurations 2, 8 and 2, 5.
5. How does atomic size of the elements vary along a period?

RECAPITULATION POINTS

- Elements are classified based on how similar their properties are. The two primary classes of elements are metals and non-metals. Dobereiner classified the elements into traids.
- When the three elements in a trait were placed in order of increasing atomic mass, Dobereiner discovered that the atomic mass of the middle element was roughly equal to the average of the atomic masses of the other two elements.
- According to Newland's Law of Octaves, the elements are organised in increasing order of their atomic weights and chemical characteristics.
- Mendeleev had to alter a few elements with slightly higher atomic masses before they could be placed together with similar qualities.
- According to the Periodic Law of the Modern Era, Mendeleev also predicted that other elements will exist (yet to be identified). "Physical and chemical properties of elements are a periodic function of atomic number."
- The elements are organised into 18 vertical columns called groups in the Modern Periodic Table.
- Periodicity is defined as the regular repetition of elements with similar properties at regular intervals.
- Valency depends on the number of electrons in the outer most shell. If the number is 1, 2, 3, 4 then valency is same as 1,2,3,4 but if the electrons present in the outer shell are 5,6,7,8 then valency is 8-5=3, 8-6=2, 8-7=1, 8-8=0 respectively. Similar trend is seen in atomic size.
- As you progress through the groups, the metallic character becomes stronger, then weaker. While non-metallic character decreases as you go through the groups and grows over time, metallic character increases. Metal oxides are basic, whereas non-metal oxides are acidic.
- From left to right, the acidic character of oxides increases, then diminishes as you move down a group.
- Electronegativity is the tendency of an atom to attract electrons in a shared electron pair in a covalent bond with another atom. It rises from left to right during the course of a period and then drops as you progress down a group.

TERMINAL EXERCISE

(1) Multiple Choice Questions

A) Which element was proved to be applicable to the law of Octaves?

Oxygen (a), calcium (b), cobalt (c), and (d) potassium

B) Mendeleev's periodic rule was used to organise the elements in the periodic table.

(a) Increasing the number of atoms in a molecule

(b) Decreasing the number of atoms in a molecule

(c) Increasing the number of atomic masses in a molecule

(d) Atomic masses are decreasing.

C) Which statement regarding the contemporary periodic table is correct?

(a) It consists of 18 horizontal rows known as periods.

(b) It consists of seven vertical rows known as groups.

(c) There are 18 vertical columns referred to as groups in it.

(d) It's broken down into 18 sections.

D) In the current periodic table, where would you locate the element having electrical configuration 2,8?

a) Group 8

b) Group 2

c) Group 18

d) Group 10

E) The element with the greatest valence electrons is

a) Na

b) Al

c) Si

d) P

(2) Fill in the blanks

(a) Dobereiner could only recognise __ traids from the elements available at the time.

(b) In 1913, ___ demonstrated that an element's atomic number is a more fundamental property.

(c) The distance between the centre of ____ and the shell of an isolated atom is called the atomic radius.

(d) The relative electron attracting tendency of an atom for a shared pair of electrons in a covalent bond with another atom is called its____.

(3) True or False

(a) Mendeleev's periodic table contains vertical column called periods.

(b) Metals make up the majority of the periodic table.

(c) An element with up to two valence electrons has a group number equal to the number of valence electrons.

(d) SiO_2 is less acidic as compared to MgO.

(4) Match the property given in Column A with the Column B

(a) Smallest atom	1. Francium
(b) Metalloid	2. So_2
(c) Strong acidic	3. Silicon
(d) Most metallic	4. Iodine
(c) Least electronegative	5. Lithium

5. Very Short Type Questions:

(a) What does periodicity in element properties mean in terms of the periodic table?

(b) Group 18 elements are referred to as monovalent? If so, how would you go about doing it?

(c) The electrical configurations of the two elements X and Y are 2,8,2 and 2,8,6 correspondingly.

Which of the two elements, X or Y, has the greater atomic radius?

Identify the elements X and Y by their atomic numbers.

6. Short Answer Type Question:

(a) Briefly describe Mendeleev's method for determining element categorization. How did he come up with the periodic law?

(b) Using the number 11 as the atom number, write the name, symbol, and electrical configuration of the element X.

(c) An element's valence shell has six electrons and three shells in total.

(i) What will the atomic number of this element be?

(ii) When will you encounter this component?

(iii)Select a different element from the same group as this one.

7. Long Answer Type Questions:

(A) Mendeleev predicted the occurrence of previously undiscovered elements, naming two of them Eka-silicon and Eka-aluminum.

(i)Recognize the elements that have taken their position.

(ii) In the modern periodic table, mention the element's group and time.

(iii)Recognize the differences between metals, non-metals, and metalloids.

(iv)How many valence electrons are there in each of them?

(B) In the modern periodic table, what does the term "group" mean? When travelling from the top to the bottom of a group, how do the following changes occur?

(C) A basic oxide is formed when an element in the periodic table's second group and third period burns in the presence of oxygen.

(i)Identify the component

(ii) Make a note of the electrical configuration.

(iii)Write a balanced equation when this oxide is dissolved in water.

(iv)Draw the electron dot structure for the formation of this oxide.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 20.1

1. (a) Isotopes

2. Mendeleev arranged the elements on the basis of their atomic mass and similarity in chemical properties.

3. (a) When elements are organised in order of increasing mass, Dobereiner's Law of Traids asserts that groups of three elements (known as traids) with comparable chemical properties are formed. The middle element's atomic mass is the average of the atomic masses of the other two elements.

(b)In Newland's Law of Octaves. He organised the elements according to their atomic weights in ascending order. He discovered that every eighth element had the same physical and chemical properties as the first element using these criteria.

(c) It is known as the laws of Octaves because it matched with the characteristics as that of the Octaves in music. In music, the 1st note matches with that of the 8thnote.Similarly, the properties of the 8th element matched with the properties of the 1st element.

CHECK YOUR PROGRESS 20.2

1 (a) 18 and 7

2 (a) True

(3)

Mendeleev's Periodic Table	Modern Periodic Table
a) Mendeleev's periodic table is based on atomic mass	The modern periodic table is based on the atomic number
b) In Mendeleev's periodic table noble gases were not placed	In the modern periodic table noble gases are in a separate group named group 18

4) 2,8- electronic configuration. So, the element neon has an atomic number of ten.

Neon is in group <u>18</u> and in period <u>third</u>

2,5 electronic configurations

So atomic number is- 7

Therefore, element is nitrogen

Nitrogen is in group <u>15</u> and in period <u>7th</u>

5)Atomic size falls from left to right across a periodic table because the number of shells remains constant but nuclear charge increases, increasing the nucleus's attractive Valence electrons are attracted to each other. As a result, the atomic size decreases.,

SUPPLEMENTARY STUDY MATERIAL

a) NCERT, Science, class 10^{th}
b) S Chand chemistry written by Manjit Kaur
c) Chemistry, Arihant publications
d) http://www.nios.ac.in

21 MATTER: MIXTURES AND SOLUTIONS

INTRODUCTION

In the early chapters you have studied about matter. Matter is anything that occupies volume and has mass. Elements, compounds, and mixtures are all matter.

In our daily lives, we come across a lot of mixtures and solutions. The air we breathe, the food and drink we consume, and the clothing we wear are all examples. Students will get a better understanding of how matter is organised at the atomic level by studying how chemists identify pure substances from mixtures and solutions. We may modify matter using this understanding to improve our health and quality of life.

Can you look around and find mixtures around you?

21.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Define a mixture.
- Distinguish between different types of mixtures.
- Give examples of mixtures from daily life.
- Distinguish between true solutions, suspensions and colloids.
- List the properties of true solutions, suspensions and colloids.
- Prepare a true solution, suspension and colloid.
- Calculate a solution's concentration in terms ofm/m%, m/v% and v/v%.
- Suggest suitable purification techniques to obtain a given product.
- Differentiate between physical changes and chemical changes.
- Cite examples of physical changes and chemical changes.

21.2 WHAT IS A MIXTURE?

Mixture is a form of matter made up by mixing two or more pure forms of matter physically. For example, sugar can be mixed in water just by stirring. This sugar solution thus formed may be physically divided into sugar and water by the process of evaporation. However, sugar cannot be broken down into its essential parts just by heating.

21.3 IS IT POSSIBLE TO MAKE A MIXTURE?

A mixture may be formed by:
Combining two or more elements, like a mixture of Sulphur powder and iron fillings
Combining two or more compounds, like a mixture of salt and sugar
Combining two or more elements and compounds, like a mixture of iron fillings and salt

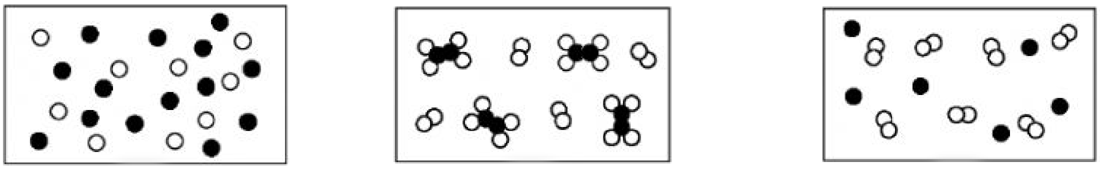


Fig 1 (a) Mixture of elements (b) Mixture of compounds (c) Mixture of an element and a compound

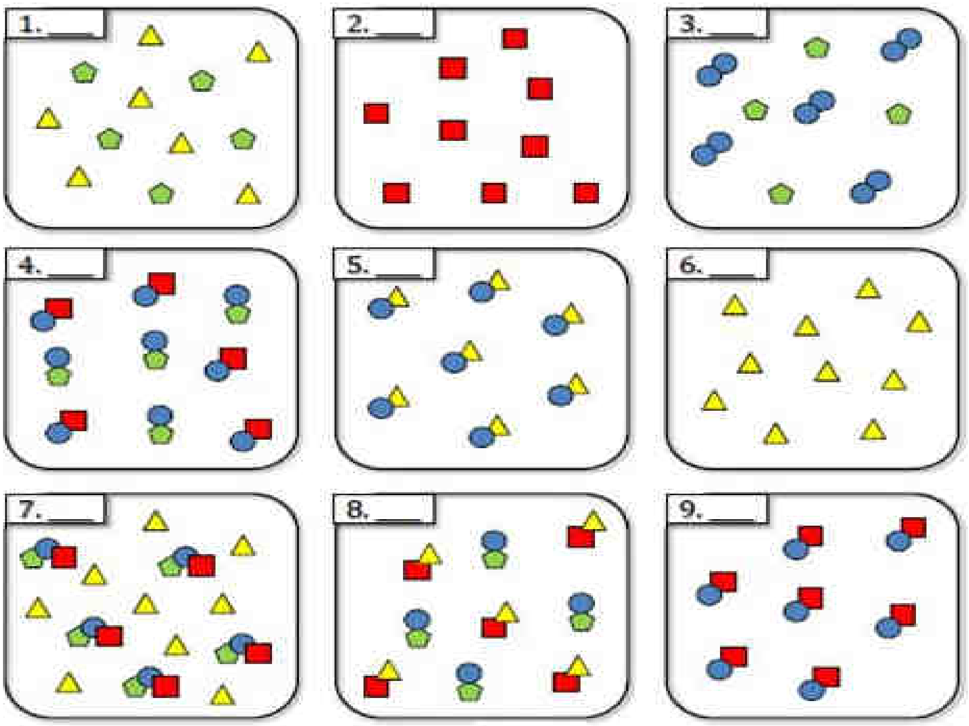
21.4 WHAT ARE THE DIFFERENT TYPES OF MIXTURES?

A mixture may be classified into two types based on their composition.
Homogeneous mixture – A mixture that has a consistent composition throughout. The boundary between the constituent particles cannot be differentiated. For example – lemonade, salt and water, etc.
Heterogeneous mixture – A mixture with a non-uniform composition is referred to as a heterogeneous mixture. Boundaries of constituent particles can be identified. For example – Soil and sugar, Sulphur powder and Iron fillings, etc.

CHECK YOUR PROGRESS 21.1

1. Identify the following as:
   - Element
   - Compound
   - Mixture of elements
   - Mixture of element and compound
   - Mixture of compounds

   Direction: Label each image correctly to reflect what it represents. Remember that each shape represents a different element. When two or more elements are joined, the object represents a compound.



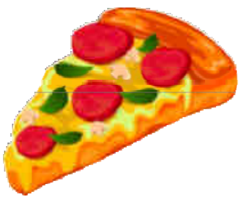
2. Identify the following mixtures as homogeneous or heterogeneous.

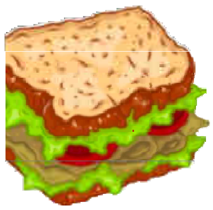

Choco chip cookies

Vinegar


Oxygen gas cylinder


Air


A slice of pizza


Sandwich


Cold drink with ice


Wine

21.5 WHAT ARE THE CHARACTERISTICS OF A MIXTURE?

A mixture possesses the following properties.

- The qualities of the components in a mixture are retained.
- The composition of a mixture may or may not be uniform throughout.
- Physical methods can be used to separate components of a mixture.
- The percentage of components in a mixture is variable.

ORGANIZATION OF MATTER

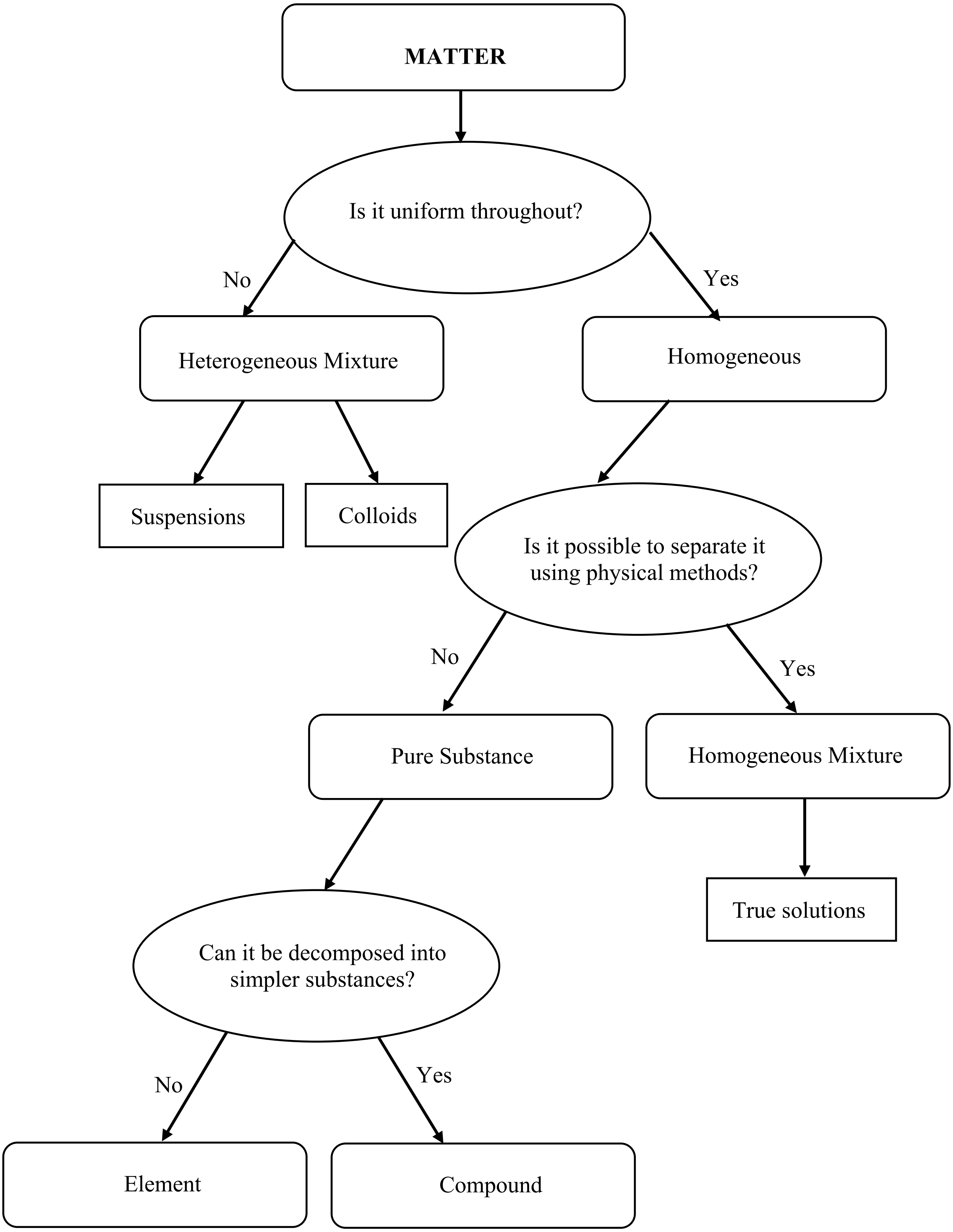


Fig 2: Organization of Matter

21.6 HOMOGENEOUS MIXTURES

A homogeneous mixture is one in which the constituents are evenly distributed throughout. A true solution or simply a solution is a homogenous mixture in which one component, the solute, entirely dissolves in another substance, the solvent. The solvent is usually a liquid, although the solute might be a liquid, solid, or gas. A solution may also have one than one solute present in it. In a solution, the solute particles are evenly distributed among the solvent particles.
Mixing of alcohol and water, for example, produces a solution where alcohol is the solute and the solvent is water.
Hence, Solution = Solute + Solvent
In most cases, the solute is present in lesser quantities while the solvent is present in excess.

Given below are some examples of true solutions.

Name of the solution	Solute	Solvent
Sugar solution	Sugar	Water
Tincture of iodine	Iodine	Alcohol
Aerated drinks	Carbon dioxide gas	Water
Air	Oxygen and other gases	Nitrogen

21.6.1 Characteristics of a true solution

- It is a completely uniform mixture.
- The properties and composition of a true solution are same throughout.
- The solute particles are of the order of about 10^{-10} m in size.
- It is clear and transparent.
- The solute particles do not scatter light.
- A true solution is stable, i.e., the solute particles do not settle and cannot be separated from the solvent using the method of filtration.

Did you know?

A homogeneous mixture created by a combination of two or more metals or a metal and non-metal is called an alloy. Alloys can be made from a combination of metals and additional elements. Alloys have a variety of qualities which are usually different from their constituents. Alloys outperform pure metals in terms of strength and hardness. They are also called solid solutions.

For example, in the automotive industry, alloy wheels are made from an alloy of aluminium or magnesium.

(Source: momo.com/en-gb)

21.6.2 Concentration of a solution

The quantity of solute (mass or volume) presents in a given amount of solution (mass or volume) is known as the concentration of a solution.

Let us do a simple activity to understand the concentration of a solution.

Activity 1

- Take 2 glasses containing the same volume of water.
- Label them as A and B.
- Add two spoons of salt in glass A and dissolve it completely.
- Add one spoon of salt in glass B and dissolve it completely.
- Taste the two solutions.

Which solution is saltier?
The solution in glass A is saltier as it contains more amount of salt (solute).

In the activity above, what we get is a qualitative idea of concentration. The concentration of a solution can be expressed in a variety of ways quantitatively. Let us look at them one by one.

- Mass by mass percent (m/m %)

$$\text{m/m \%} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100$$

- Mass by volume percent (m/v %)

$$\text{m/v \%} = \frac{\text{mass of solute (g)}}{\text{volume of solution (mL)}} \times 100$$

- Volume by volume percent (v/v %)

$$\text{v/v \%} = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 100$$

Solved Examples:

1. A solution is made up of 10 g of sugar and 100 g of water. Calculate the solution's m/m %.

Mass of solute (sugar) = 10 g
Mass of solution = Mass of solute + Mass of solvent
= 10 + 100 = 110 g

$$\text{m/m \%} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100$$

$$= \frac{10}{110} \times 100$$

$= 9.09\ \%$

2. 35 g of glucose is dissolved in water to make 350 mL of glucose drink. Calculate m/v % of this solution.

Mass of solute (glucose) = 35 g
Volume of solution = 350 mL

$$\text{m/v}\ \% = \frac{\text{mass of solute (g)}}{\text{volume of solution (mL)}} \times 100$$

$$= \frac{35}{350} \times 100$$

$$= 10\ \%$$

21.7 HETEROGENEOUS MIXTURES

A heterogeneous mixture is one in which the components are not evenly distributed throughout. They may be classified as colloids or suspensions. Let us understand each of them separately.

21.7.1 Suspensions

A suspension is a heterogeneous mixture in which some particles settle out after a period of time. Because the particles in a suspension are larger than those in a solution, gravity can pull them down out of the solution. Particles of a suspension are visible with the naked eye. For instance, sand in water, chalk powder in water, and so forth.

Properties of a suspension

- It's a blend that's heterogeneous.
- The properties and composition of a true solution are non-uniform.
- The solute particle size is over 1000 nm.
- It is opaque or translucent.
- The solute particles usually block light but may scatter light when the particles are suspended. This scattering of light is called Tyndall effect.
- When left undisturbed, the solute particles settle down and can be separated from the solvent by filtration.

Did you know?

Some days are clear, while others are not. The sea is clear and smooth on a calm day. Fish and under water plant life is clearly visible without any obstruction. On a stormy day, the seabed is agitated. The water gets cloudy and murky and nothing is clearly visible in water. The sand forms a suspension in water. As the storm settles, the water clears up slowly and the sea gain appears clear.

(Source: U.S.Navy)

21.7.2 Colloids

Colloids are mixtures in which the particles are larger than are small enough that they do not settle out while standi cheese, etc.

Dispersed phase and dispersion medium are two compon component is known as the dispersed phase which is suspended in solvent like component called the dispersion medium.
Hence, colloid = Dispersed phase + Dispersion medium

A colloid may be classified into different types based on the dispersion medium's and dispersed particles' physical states.

Dispersion Medium	Dispersed Phase	Type of Colloid	Example
Solid	Solid	Solid Sol	Gemstones, coloured glasses
Solid	Liquid	Solid emulsion/ Gel	Cheese, Jellies
Solid	Gas	Solid foam	Pumice stone, Sponge
Liquid	Solid	Sol	Starch in water, Paints
Liquid	Liquid	Emulsion	Milk, hair cream
Liquid	Gas	Foam	Whipped cream, Soap lather
Gas	Solid	Aerosol	Smoke, Dust in air
Gas	Liquid	Aerosol	Fog, mist

Properties of a colloid

- It is a heterogeneous mixture but appears homogeneous.
- The properties and composition of a true solution are same throughout.
- The solute particles range between 1 – 1000 nm in diameter.
- It is opaque or translucent.
- The dispersed phase particles scatter the beam of light and make the path of a light beam visible.
- A colloid is stable, i.e., the dispersed phase particles do not settle down as they continuously move in zig-zag motion. This is called Brownian motion.

- The components cannot be removed from the colloid by filtration as it is stable. However, a unique separation technique known as centrifugation is employed.

21.7.3 Tyndall effect

The scattering of visible light by colloidal particles is known as the Tyndall effect. It is named after John Tyndall, an Irish physicist. When a beam of light passes through a colloidal solution with constituent particles of equal size to the wavelength of the light beam, the beam is scattered in such a way that its route or trajectory is visible.

Tyndall effect is observed in colloidal solutions and some suspensions in a fine state. The more the interaction between the particles and the light beam, the greater the light scattering and the greater the chance of seeing the Tyndall effect. Here are some examples of the Tyndall effect:

- The path of the light is visible as the sunlight hits the dust particles.
- During foggy conditions, the light rays emitted by an automobile's headlight strike the fog particles and scatter, causing the path of the light visible.
- When laser light is shone through a container filled with milk and water, the course of the light is clearly evident.
- When the sun shines on the particles of gases like oxygen and nitrogen, it causes them to vibrate. Colours with shorter wavelengths, such as blue and violet, scatter much more.

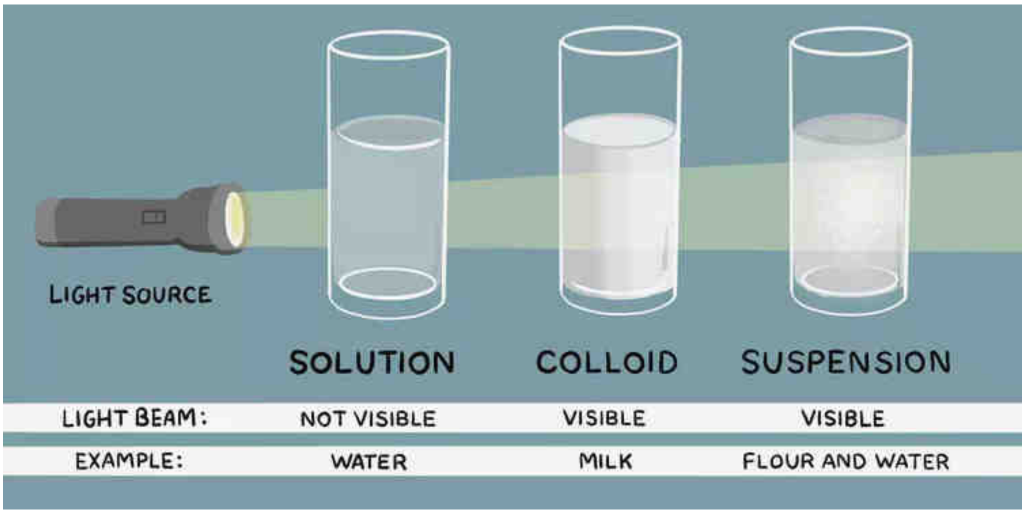


Fig 3: Difference between Colloid and Suspension

Activity 2

- Take a transparent colourless glass containing 100 mL water.
- Add 2 spoons of flour to it.
- Mix it well.

What do you observe?
Flour is typically off-white in colour (slightly yellow). Because blue light scatters more than red light, the mixture appears slightly blue.

21.7.4 Brownian motion

Brownian motion is the random motion of particles suspended in a fluid (a liquid or a gas) caused by collisions with the gas or liquid's fast-moving atoms or molecules. The particles move in a zig-zag fashion and do not settle down. This is the reason for the stability of colloidal particles. With the help of this motion, a true solution may be differentiated from a colloid. The following are some examples of Brownian motion:

- The motion of pollen grains on still water
- Diffusion of pollutants in the air
- Diffusion of calcium through bones

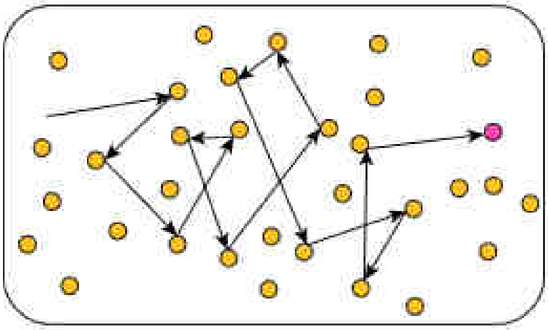


Fig 4: Brownian motion

Know the Scientist!

Robert Brown (1773 – 1858)

(Source: https://www.britannica.com)

In 1827, a Scottish botanist Robert Brown, for the first time, observed a chaotic motion of small particles discharged from pollen seeds suspended in water. By colliding with much smaller water molecules, pollen particles (also known as Brownian particles) are able to move. When the acting force is larger in one direction, the water molecules accelerate the particle in that direction, and everything then repeats in a new position. As a result, the motion is disorganised and abrupt. Brownian motion is one of the experimental proofs that matter particles move in a disorganised manner all of the time.

CHECK YOUR PROGRESS 21.2

1. The solvent and solute present in the tincture of iodine are:
   (a) Water and alcohol
   (b) Alcohol and iodine
   (c) Water and iodine
   (d) Water and salt

2. Sol and Gel are examples of
   (a) Solid-solid colloids
   (b) Sol is a solid-liquid colloid and Gel is liquid-solid colloid
   (c) Sol is a solid-solid colloid and Gel is a solid-liquid colloid
   (d) Sol is a liquid-solid colloid and Gel is a solid-liquid colloid

3. The correct order which describes the true solution, colloidal solution and suspension in the order of their increasing particle size is:
   (a) Suspension < Colloidal solution < true solution
   (b) Colloidal solution < true solution <Suspension
   (c) True solution < Colloidal solution < Suspension
   (d) Colloidal solution < Suspension < True solution

4. Fill in the blanks:
   When solid particles (the __________) split up and nestle between the particles of a liquid (the solvent), a solution is formed. There are only so many ___________ that the solute particles can fit onto. When these gaps are full, the solute particles drop to the bottom, like the last delicious taste you find at the bottom of a mug after you have poured too much ___________ in your tea.

5. A student was handed three powdered items in three packets, including sugar, earth, and starch powder, and she failed to identify them. He didn't want to eat them because he knew it would be dangerous. He filled three beakers with boiling water and began to add these items to the beakers. He pours a small amount of package I's contents into beaker I, packet II's contents into beaker II, and packet III's contents into beaker III. Each beaker's contents were swirled. He left the beakers undisturbed and saw that beaker I produced a translucent solution, beaker II produced a transparent solution, and beaker III produced an opaque solution. Which of the following conclusions do you think you'll come to?

Option	Packet I	Packet II	Packet III
(a)	Sugar	Soil	Starch Powder
(b)	Starch Powder	Sugar	Soil
(c)	Soil	Starch Powder	Sugar
(d)	None of the above		

21.8 SEPARATION OF MIXTURES

Most of the substances that we see around us are mixtures. Mixtures need to be separated into their constituents to get the useful substances from a mixture or to get a particular substance from the mixture or to identify substances present in a mixture.

Physical methods can be used to separate mixtures. Different separation techniques are employed to segregate different kind of mixtures. The method used is based on the properties of constituent particles like, size, density, viscosity, solubility in a solvent, boiling points, etc.

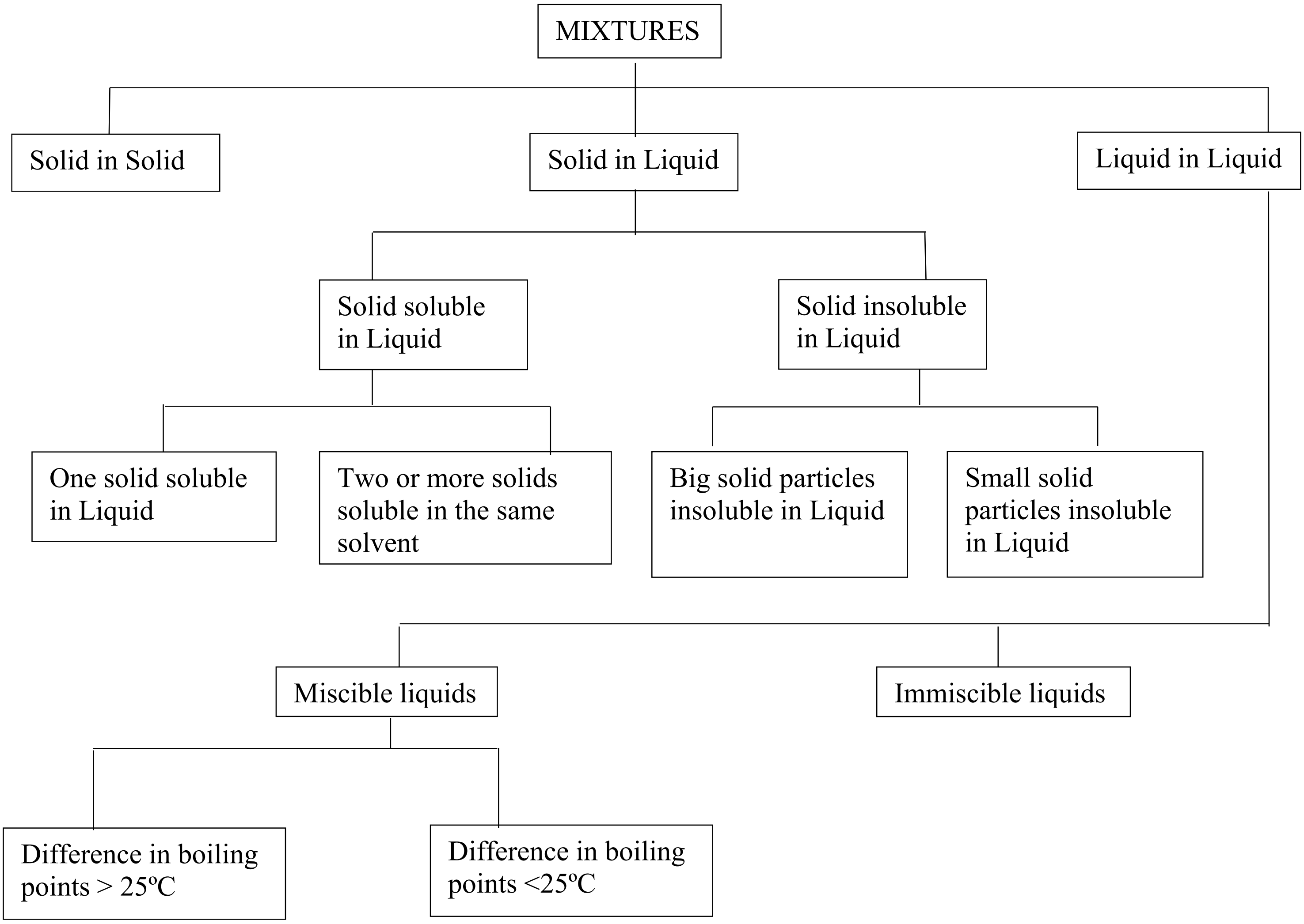


Fig 5: Mixtures

21.8.1 Solid in Solid mixtures

Solid components of a mixture can be separated by the following methods.

- **Handpicking**
  Principle–Itis used to separate combinations in which one of the ingredients is in a small amount.

Examples – separation of stones from rice or pulses, separating chana – rajma mixture, etc.

Fig 6: Handpicking

- **Magnetic separation**
  Principle -It is used to separate mixtures in which one of the components possesses magnetic properties.
  Examples – separation of iron fillings from sulphur powder, etc.

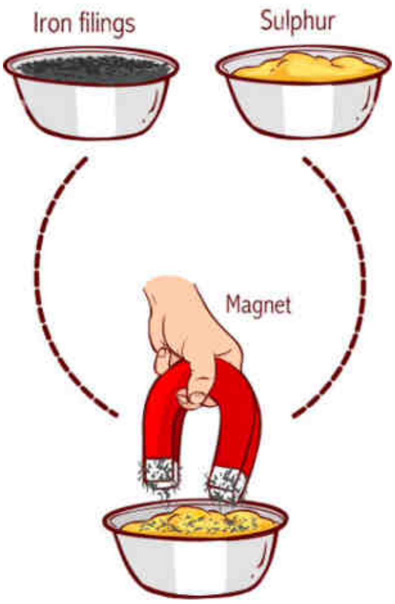


Fig 7: Magnetic separation

- **Sieving**
  Principle – Itis used if there is a difference in the size of the solid particles.
  Examples– separation of coarse gravel from fine gravel, etc.

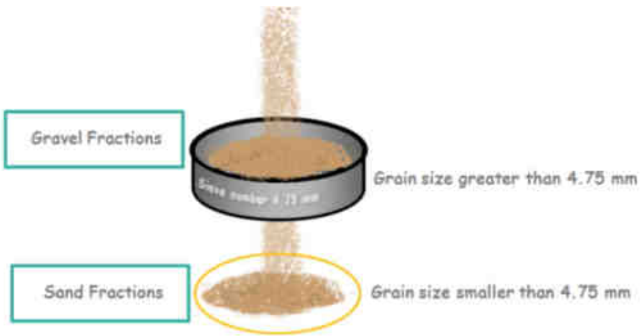


Fig 8: Sieving

- **Sublimation**
  Principle **–**It is used if there is a difference between the sublimable and non-sublimable nature of solids.
  Example – separation of ammonium chloride from salt, separation of camphor from sugar, etc.

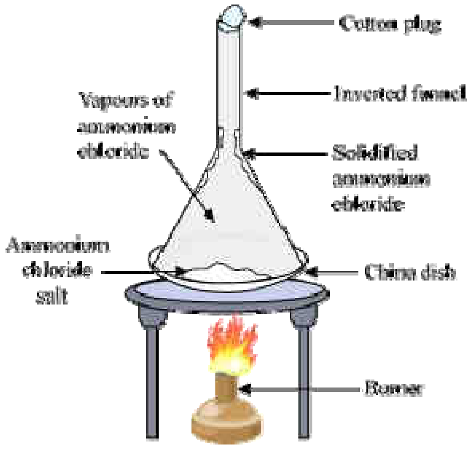


Fig 9: Sublimation

21.8.2 Solid soluble in Liquid mixtures

- **One solid soluble in liquid**

The following methods can be used to separate soluble solids from liquids:

(i) **Evaporation to dryness**
Principle – It is used to separate the soluble solid from the solvent as solids do not vapourise easily but liquids do.
When you heat a solution, the solvent evaporates, leaving the dissolved particles behind as residue.
Examples – separating salt from water, separating ammonium chloride from water, etc.
This method is not suitable to separate sugar and water as sugar decomposes on heating.

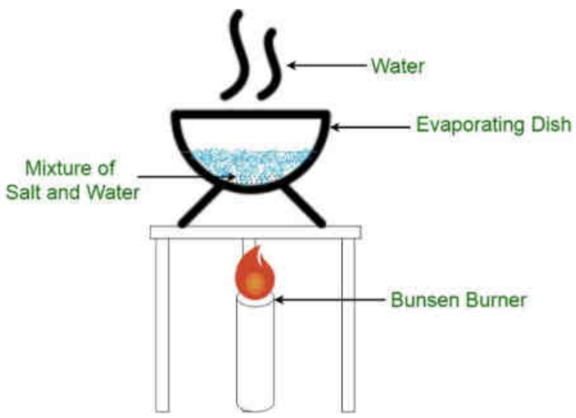


Fig 10: Evaporation

(ii) Crystallisation

Principle – It is used to separate solute from the solid in pure crystalline form. The concentrated solution is heated till the volume reduces to half and is left to cool. The pure solid crystallises out.

Examples – Obtaining pure salt from salt solution, obtaining pure copper sulphate from copper sulphate solution, etc.

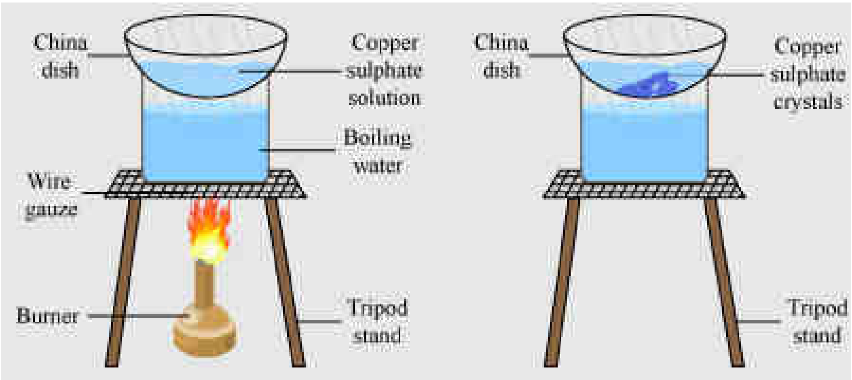


Fig 11: Crystallisation

(iii)Simple distillation

Principle – This method is used if the solvent has a much lower boiling point than the solute.

This is the process of converting a liquid into a vapour, which is then condensed back into a liquid. The liquid is collected as the distillate. *Example* – Separation of salt from water. Salt is left behind. Both solute and solvent can be obtained by this method.

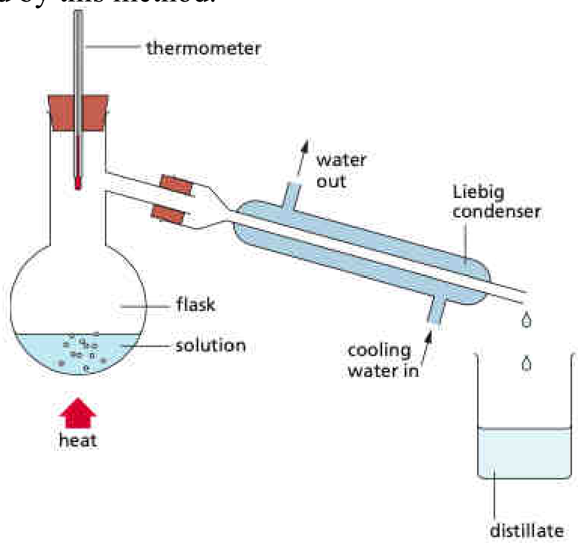


Fig 12: Simple distillation

- **Two or more solids soluble in the same solvent**

If there are two or more solids that are soluble in the same solvent, **chromatography** can be used to separate them. The term 'chromatography' comes from the Greek word *Kroma* which means colour. Because this technique was first employed to separate colours, it was given this name.

Principle –The components of the mixture separate themselves based on their solubilities in the same solvent.
A filter paper is used to transport the solvent. Near one end of the paper, a drop of mixed solution is spotted and dried. The end of the paper, closer the spot, is then dipped into the solvent without drowning the spot itself. Various components of the mixture get separated at different levels on the filter paper.
Examples – Separation of black ink into its constituent dyes, separation of colourful components present in leaf, etc.

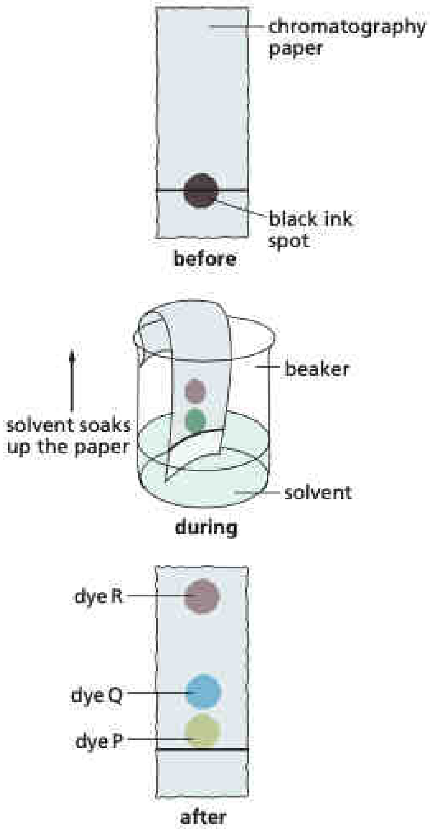


Fig 13: Chromatography

21.8.3 Solid insoluble in Liquid mixtures

- **Big solid particles insoluble in liquid**

The following methods can be used to separate big solid particles insoluble in liquids.

(i) Sedimentation and decantation
Principle –It is used to separate mixtures where the solid component which is insoluble in the mixture and is heavier than the liquid settles down due to gravity. The supernatant liquid, that is, the clear liquid that lies above the solid residue after sedimentation is decanted off.
Examples –This approach can be used to separates and water, chalk powder and water, etc.

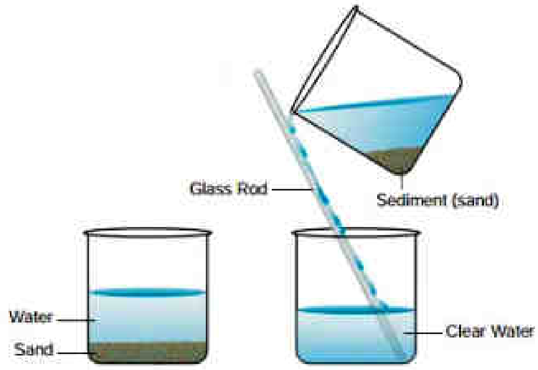


Fig 14: Sedimentation & Decantation

(ii) Filtration

Principle **–**Itis used to separate mixtures where the solute particles are insoluble in the solvent.

In this process, the suspended solid matter is suspended from a liquid, by passing the solution through a filter paper. The liquid obtained after filtration is known as the filtrate, while the solid left on the filter paper is known as the residue.

Examples **–** While making tea, a sieve (filter) is used to separate tea leaves from the liquid, separation of sand and water, etc.

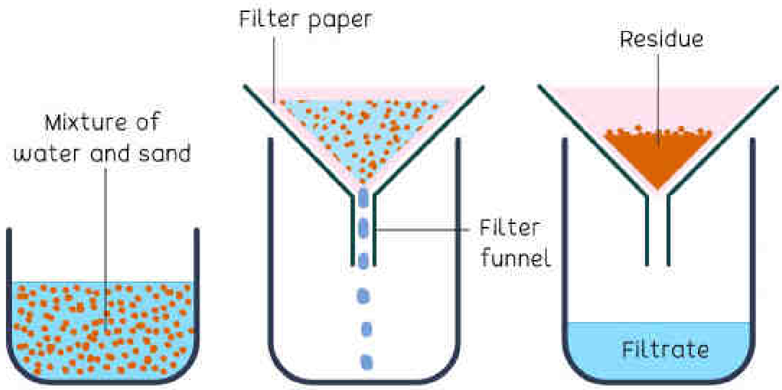


Fig 15: Filtration

- **Small solid particles insoluble in liquid**

Small solid particles that are insoluble in liquid can be removed from the liquid using **centrifugation.**

Principle **–**This method is used if the insoluble solid is very light and does not settle under the influence of gravity.

When the particles are spun quickly, the denser particles are driven to the bottom while the lighter particles remain at the top. Centrifugation is generally carried out in a centrifuge, a device that can rapidly spin, just like a mixer grinder or a washing machine.

Examples **–** it is used to take butter out of cream, squeeze water from clothes, etc.

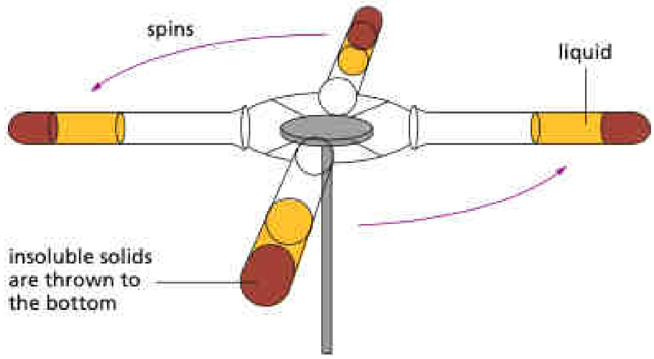


Fig 16: Centrifugation

21.8.4 Separating miscible liquids

The technique employed for separation if miscible liquids is predicated on the boiling temperatures of the constituents being different. They can be distinguished by the following methods.

- ***Simple distillation***
  Principle –Fortwo miscible liquids with difference in boiling points > 25°C, the method of simple distillation can be used.
  The most volatile component vaporises at the lowest temperature when the mixture is heated. The vapour goes through a condenser and condenses back into liquid form. Distillate is the condensate that is collected.
  Examples –Simple distillation can separate a mixture of acetone and water.
  Acetone being more volatile vapourizes at 56°C and is collected as distillate. Water is left behind.

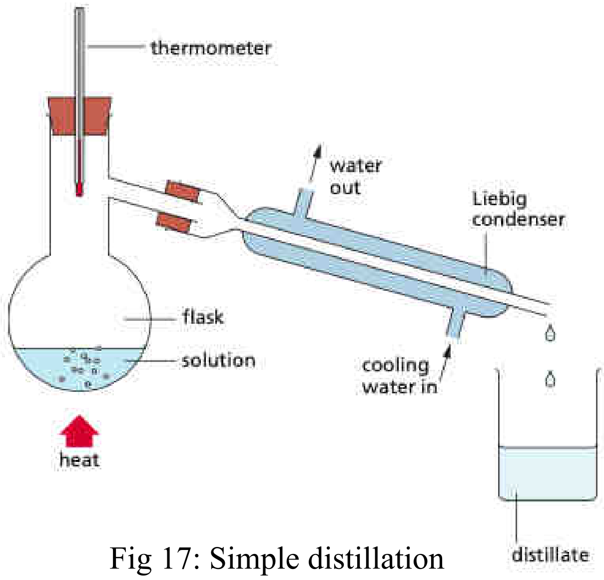


Fig 17: Simple distillation

- **Fractional distillation**
  Principle –For liquids that are miscible but have a difference in boiling points < 25°C, the method of fractional distillation can be used.

The sole difference is that between the distillation flask and the condenser is a fractionating column. A tube filled with glass beads serves as the fractionating column. Vapours might cool and condense on the surface of the beads continuously. Quick cooling of vapours is required as the components of the mixture have less difference in their boiling points.

Examples –separation of air components, separation of petroleum into its constituents, separation of ethanol and water, etc.

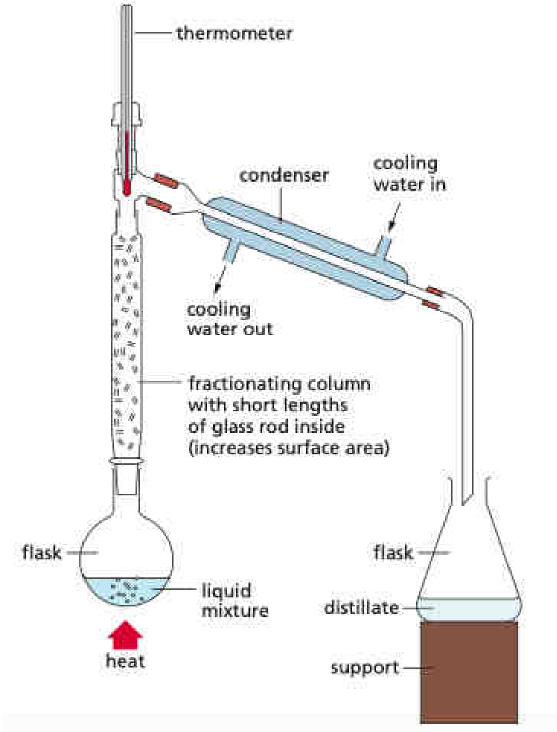


Fig 18: Fractional distillation

21.8.5 Separating immiscible liquids

A **separating funnel** can be used to separate a mixture of two immiscible liquids.

Principle –Based on their densities, immiscible liquids divide into layers.

The mixture is poured into the separating funnel and the layers are allowed to separate. The heavier one sinks to the bottom, while the lighter one floats to the top. The denser layer is drained out by turning on the stopcock at the bottom of the funnel.

Examples – Separation of oil and water, etc.

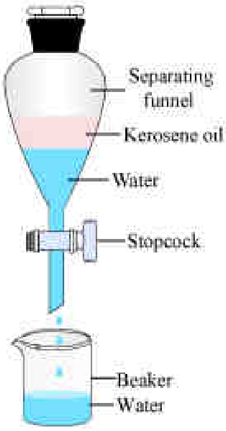


Fig 19: Separation using separating funnel

CHECK YOUR PROGRESS 21.2

1. What is the best method to separate water from aqueous copper sulphate solution?
2. Hexane and octane are liquids that differ slightly in their boiling points. Suggest a method to separate these two components.
3. What is the most feasible way to separate the different components of blood?
4. Dye A and dye B have different solubilities in water. What is the best technique to separate these two?
5. What criteria can be used to determine a substance's purity?
6. Name the method used to carry out the following separations:
    a. Butter from milk   b. Oil from water

    Also, mention the principle of the technique used.
7. Liquids P and Q are immiscible and have boiling points 200 K and 250 K respectively. Which method will you use to separate liquids P from liquid Q?

21.9 PHYSICAL AND CHEMICAL CHANGES

Changes in matter occur due to change in kinetic energy of molecules. When a substance absorbs enough energy, then its atoms or molecules move around rapidly. They collide frequently with each other and the state of matter changes. This results in a physical change.

However, if different sorts of molecules or atoms exist, they may collide with each other on increasing energy. As a result, a new material is formed. Such a change is a chemical change.

Listed below are the characteristic differences between physical and chemical changes.

Physical Change	Chemical Change
No new substance is formed, i.e, the chemical nature and makeup of the substance remains the same.	A new substance is formed, i.e., the chemical nature and makeup of the substance changes.
They are generally reversible.	They are generally irreversible.
Example –Boiling of water, melting of popsicle, breaking of glass, etc.	Example – Growing of tree, burning of leaves, cooking food, etc.

In some cases, both chemical and physical changes occur together. For example, when a candle is lit, the wax melts, resulting in a physical change and the wick of the candle burns which is a chemical change.

21.10 RECAPITULATION

- Most of the matter around us in the form of mixtures. Mixtures contain more than one component, combined physically in any proportion.
- The characteristics of the components in a mixture are retained.
- Mixtures may be differentiated as homogeneous or heterogeneous. The composition of homogeneous mixtures is uniform, but the composition of heterogeneous mixtures is non-uniform.
- A mixture may have two or more elements, two or more compounds or two or more elements and compounds.
- A true solution is a homogeneous mixture. The solvent is the primary component of a true solution, whereas the solute is the small component.
- A solution's concentration is defined as the mass of solute present per unit mass or volume of the solution.
- Colloids are heterogeneous mixtures with a homogenous appearance. Colloids have particle sizes that are too tiny to be seen with the human eye. The dispersion medium is the major component of a colloid, whereas the dispersed phase is the minor component.
- Suspensions are heterogeneous in nature. Suspension particles are large enough to be seen with the naked eye.
- Mixtures can be separated into their components on the basis of the properties of the constituent particles like size, density, viscosity, boiling points, melting points, etc.
- Changes around us may be physical or chemical in nature. Physical changes do not result in the formation of new substances. However, chemical reactions result in the formation of new compounds.

TERMINAL EXERCISES

1. Which of the following will show Brownian motion?
   (a) Salt solution
   (b) Milk
   (c) Copper sulphate solution
   (d) Starch solution

2. A mixture of sulphur and iron fillings is
   (a) heterogeneous and shows Tyndall effect
   (b) homogeneous and shows Tyndall effect
   (c) heterogeneous and does not show Tyndall effect
   (d) homogeneous and does not show Tyndall effect

3. In milk, the dispersed phase and dispersion medium are
   (a) Liquid, Solid

(b) Solid, Liquid
(c) Liquid, Liquid
(d) Solid, Gas

4. The correct sequence for separating a mixture of sand, salt and iodine is
   (a) Filtration → Sublimation → Evaporation
   (b) Sublimation → Filtration → Evaporation
   (c) Sublimation → Evaporation → Filtration
   (d) Filtration → Evaporation → Sublimation

5. Which of the following is not a mixture?
   (a) Soap solution
   (b) Blood
   (c) Oxygen
   (d) Coal

6. The size of particles of true solutions is
   (a) < 1 nm
   (b) Between 1 nm to 100 nm
   (c) > 100 nm
   (d) > 1000 nm

7. Petrol is obtained from petroleum by
   (a) distillation
   (b) fractional distillation
   (c) steam distillation
   (d) distillation under reduced pressure

8. Cream is obtained from milk
   (a) Filtration as milk is liquid and hence it can be filtered out
   (b) Filtration as cream is solid and hence it can be easily filtered out
   (c) Centrifugation, as cream and milk have difference in chemical formula
   (d) Centrifugation as particles of cream and milk have difference in their density

9. Classify the following as physical and/or chemical change:
   (a) Burning of a candle
   (b) Boiling of water
   (c) Fading of colour on clothes
   (d) Mixing Iron filings and sulphur

10. Suggest a separation technique for the following mixtures:
   (a) Blue dye in water
   (b) Cream from milk
   (c) RBCs in blood
   (d) Two miscible liquids with large difference in boiling points
   (e) Air

11. In each of the questions given below (11-16), there are two statements marked as Assertion and Reason. Mark your answer as per the codes provided below:
   (a) A is true but R is false

(b) Both A and R are true and R is the correct explanation of A
(c) A is false but R is true
(d) Both A and R are true but R is not the correct explanation of A
(e) Both A and R are false

12. Assertion: Mixture of peanuts, puffed rice, potatoes and salt is homogeneous.
Reason: The components are distributed uniformly throughout the mixture.

13. Assertion: Mixture of salt and sugar is a mixture of compounds.
Reason: Both salt and sugar are compounds.

14. Assertion: A mixture of clay and water is separated by centrifugation.
Reason: Clay particles are big in size and settle at the bottom.

15. Assertion: To obtain both water and sugar from the mixture, filtration is used.
Reason: Water is more volatile than sugar.

16. Assertion: Cutting of tree is a physical change.
Reason: No new substance is formed when a tree is cut.

17. Assertion: Alcohol mixed with water can be separated using a separating funnel.
Reason: A separating funnel is used to separate two immiscible liquids.

18. Crystallization is better technique than simple evaporation technique. Justify.

19. Rashmi has a mixture of salt, sand and water. She wants to separate this mixture and obtain all the three back. Explain the different separation techniques she should use.

20. Asolidmeltsbetween234–240°C.Isthis solid pure or impure? Give a reason for your answer.

21. Sea water can be considered both a homogeneous and heterogeneous mixture. Comment.

22. Tincture of Iodine is a mixture of X and Y. X is a liquid and Y is a solid which vaporises on heating by a process called P?
(a) What is substance X?
(b) What is substance Y?
(c) Describe and name the process P

23. A solution is prepared by dissolving 5g of salt and 8g of sugar in 77g of water. Calculate the mass percent of each component of the solution.

24. 350g of 10% (m/m) sugar solution is mixed with 150 g of 20% (m/m) salt solution. Calculate the m/m percent of the new solution.

25. Liquid A has a boiling point of 74°C. Liquid B has a boiling point of 49°C. Describe with the aid of a diagram how you would obtain purified samples of liquid A and B from a mixture of liquids A and B.

26. Case Study

If a homogeneous solution placed in dark is observed in the direction of light, it appears clear and, if it is observed from a direction at right angles to the direction of light beam, it appears perfectly dark. Colloidal solutions viewed in the same way may also appear reasonably clear or translucent by the transmitted light but they show a mild to strong opalescence, when viewed at right angles to the passage of light, i.e., the path of the beam is illuminated by a bluish light. This effect was first observed by Faraday and later studied in detail by Tyndall and is termed as Tyndall effect. The Tyndall effect is due to the fact that colloidal particles scatter light in all directions in space. This scattering of light illuminates the path of beam in the colloidal dispersion. ***(Source: Chemistry for Grade XII, NCERT)***

(i) A solution is observed from a direction at right angles to the direction of light beam. It appeared to be perfectly dark. The solution could be
(a) Starch solution
(b) Egg albumin in water
(c) Chalk powder in water
(d) Salt in water

(ii) A solution showed opalescence when viewed at right angles to the beam of light. The solution could be
(a) Salt solution
(b) Sugar solution
(c) Milk
(d) Tincture of iodine

(iii) The size of particles that show tynd all effect is
(a) < 1 nm
(b) Between 1 nm to 100 nm
(c) > 100 nm
(d) > 1000 nm

(iv) Tyndall effect is not shown by
(a) Air
(b) Whipped cream
(c) Cheese
(d) Fog

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 21.1

1. 1. Mixture of elements

   2. Element

   3. Mixture of element and compound

   4. Mixture of compounds

5. Compound
6. Element
7. Mixture of element and compound
8. Mixture of compounds
9. Compound

2. Choco chip cookies – Heterogeneous

   Vinegar – Homogeneous

   Oxygen gas cylinder – Homogeneous

   Air – Homogeneous

   A slice of pizza – Heterogeneous

   Sandwich – Heterogeneous

   Cold drink with ice – Heterogeneous

   Wine – Homogeneous

CHECK YOUR PROGRESS 21.2

1. (b) Alcohol and iodine
2. (d) Sol is a liquid-solid colloid and Gel is a solid-liquid colloid
3. (c) True solution < Colloidal solution < Suspension
4. Solute, spaces, sugar
5. (b) Packet I - Starch Powder, Packet II – Sugar, Packet III – Soil

CHECK YOUR PROGRESS 21.3

1. Crystallization
2. Fractional distillation
3. Centrifugation
4. Chromatography
5. Boiling point or Melting point
6. a. Butter from milk – Centrifugation

   This method is used if the insoluble solid is very light and does not settle under the influence of gravity.

   b. Oil from water – Using a separating funnel

   Immiscible liquids divide into layers based on their densities
7. Separation using separating funnel

22 BASICS OF CHEMICAL COMBINATION

INTRODUCTION

In the previous units, we have studied about elements and mixtures. We have seen how elements combine physically and retain their properties to form mixtures. Have you ever wondered,

What will happen if the elements combine chemically?

Why will the elements combine chemically?

How will the elements combine chemically?

We shall be seeking answers to these questions in this unit.

With the development of ideas on atoms and elements, chemists started investigating how and why the substances react? Whenever the elements combine chemically, it is the electron that takes part in a chemical reaction. This interaction between atoms may include combinations that can occur in a variety of ways. This variety of combinations is what gives rise to a large number of chemical reactions and compounds. All these combinations are governed by certain principles, called the laws of chemical combination. These guiding concepts serve as a foundation for analysing chemical interactions. With the supplied initial conditions, they provide a mathematical formulation and predictability. They serve as a springboard for the creation of a wide range of chemicals and reactions. And, while chemistry remains tough and enigmatic, we can make some progress with the laws of chemical combination on our side.

22.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Understand the law of mass conservation.
- Gain knowledge about the law of definite proportion/ constant composition.
- Recognize the significance of these laws in chemical reactions.
- Make chemical formulae.
- Write the names of compounds if the chemical formula is given.

- Calculate the molecular mass
- Carry out calculations based on mole concept.

22.2 LAWS OF CHEMICAL COMBINATION

22.2.1 Law of Conservation of Mass/ Law of Indestructibility of Matter

The Law of Matter's Indestructibility "Nothing arises from nothing" is a key concept in ancient Greek philosophy, arguing that what exists now has always existed, since no new matter can create where none previously existed.
This was later restated as 'The Law of Conservation of Mass', coined by Antoine Lavoisier, which holds that mass cannot be generated or destroyed in a chemical reaction. To put it another way, during a chemical reaction, the total mass of reactants and products does not change, or the total mass of reactants and products is equal in a chemical change.
Burning wood, for example, is a chemical change. It may seem that burning destroys matter, but the mass of matter before and after burning remains the same. When wood burns, that is, when wood reacts with oxygen, it produces ash, carbon dioxide, and water vapour. In this change, if the mass of wood, amount of oxygen required to burn the wood, the amounts of carbon dioxide and water produced are known to us, we shall be able to find the total mass of products and reactants and verify the Law of Mass Conservation.
Let's do it mathematically. Suppose 500g of wood burns in 100g of Oxygen to produce 450g of ash, 90 g of Carbon dioxide and 60 g of water vapour,
then the mass of reactants = mass of wood + mass of Oxygen = 500 + 100 = 600 g
mass of products = mass of ash + mass of Carbon dioxide + mass of water vapour = 450 + 90 + 60 = 600 g
As the mass of reactants = mass of products, therefore, the law of mass conservation is verified.
Link to the video: https://www.youtube.com/watch?v=Wwmsy4huZQ0&t=10s

Know the Scientist!

Antoine-Laurent Lavoisier

Antoine-Laurent Lavoisier, an experimenter, revolutionized chemistry. Among his many contributions, he created the rule of conservation of mass, discovered that combustion and respiration are driven by chemical interactions with what he called "oxygen," and contributed to the systematisation of chemical nomenclature.

22.2.2 Law of Constant Composition/ Law of Definite Proportion

The *Law of Definite Proportions* (also known as Proust's Law) was developed by Joseph Proust (1754-1826). This law asserts that regardless of the original substance's quantity or source, *when a compound is broken down into its elements, the masses of the elements will always be in the same proportions*. This means that the total number of atoms of each element in a compound are always in the same proportion.

This law was based mostly on Joseph Proust's tests with basic Copper carbonate.

This can also be understood by taking another example, like that of water. Water taken from any source, be it pond, lake, river or tap will always have the formula H_2O, that is,in water the Hydrogen atoms to Oxygen atoms ratio is 2:1 irrespective of the source.

The mass of Hydrogen in water is 2u and that of Oxygen is 16u.

Therefore, the ratio of masses of Hydrogen and Oxygen are 2:16 = 1:8

Let us take another example.

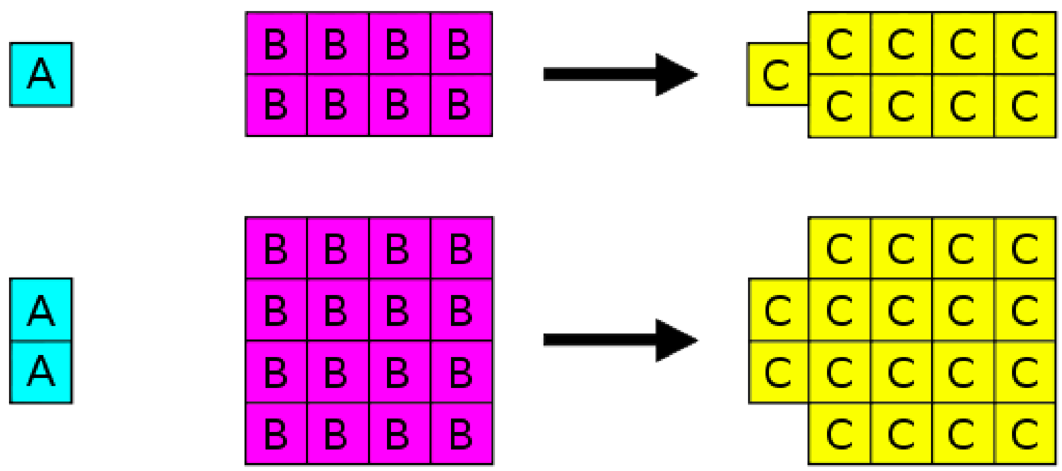


Figure 1: Elements react according to Law of Definite Proportions

In the figure, If 1g of A reacts with 8g of B, then 2 g of A must react with 16 g of B according to the Law of Definite Proportions. If 1 g of A reacts with 8 g of B, they must produce 9 g of C according to the Law of Conservation of Mass. Similarly, when 2 g of A react with 16 of B, 18 g of C must be produced.

When elements react together to generate the same product, the Law of Definite Proportions applies. While the Law of Definite Proportions can be used to compare two experiments in which hydrogen and oxygen react to form water, it cannot be used to compare one experiment in which hydrogen and oxygen react to form water with another experiment in which hydrogen and oxygen react to form hydrogen peroxide.

Link to the video https://www.youtube.com/watch?v=4-SjNzqFb5U

Know the Scientist

Joseph Proust

Joseph L. Proust was born on September 26, 1754 in Angers, France. In a paper titled "Researches on Prussian Blue," Proust established the law of definite proportions, or Proust's law, as it is currently known. Before Proust, it was widely assumed that two elements might combine in any number of ways, so that if you were building iron sulphide and had a lot of iron, the compound would be iron-rich, and if iron was scarce, the combination would be Sulphur-rich. It was speculated that there could be a wide spectrum of Iron sulphide. Proust demonstrated that iron could combine with Sulphur or Oxygen only in two ways, both with fixed and repeatable quantities, and that no intermediate compounds existed.

(Source: weebly.com)

CHECK YOUR PROGRESS 22.1

1. The ratio of carbon and oxygen in a compound is 3: 8 by mass. If the mass of Carbon is 12 u, and that of Oxygen is 16 u, what is the atomic ratio in which Carbon and Oxygen combine? Name the compound formed.
2. Nitrogen and Hydrogen combine in the ratio of 14:3 to form NH_3. Using this information, answer the questions given below.
   (a) How much nitrogen will it take to totally react with 6g of hydrogen?
   (b) How much $NH_3$is produced if 7g of Nitrogen reacts with 1.5g of Hydrogen?
   (c) You are provided with 18g of Nitrogen and 3g of Hydrogen. Which substance will be left unreacted after the reaction is complete? What mass of NH_3 is formed?

22.3 MAKING CHEMICAL FORMULA

A chemical formula is a combination of chemical symbols and numerical subscripts that represent the composition of one unit of a compound.

Chemical formulae **help us to understand the chemical make-up of a substance.** They are the proportions of the number of atoms of the components that come together to produce the compound. When representing a compound in a chemical equation, its chemical formula is critical.

Valency of an atom is it's combining capacity. An atom loses or gains electrons in order to complete its octet. If an atom loses electron/s to become stable, a cation is formed. Metals generally form cations. If an atom gains electron/s to become stable, an anion is formed. Non-metals generally form anions.

Chemical formula can be easily written if the valency of elements is known. A compound is neutral; therefore, the number of cations and anions should be taken in such a way that the charges get cancelled out. Let us understand this with few examples.

The charge of the sodium ion is +1, while the charge of the chloride ion is -1. To make a compound from Sodium and Chloride, one Sodium ion is capable of cancelling -1 charge on one Chloride ion. Thus, the ratio in which Sodium combines with Chloride is 1:1 and the formula of the compound is NaCl.

However, if Calcium is taken in place of Sodium, then the charge on Calcium is +2. Thus, the number of Chloride ions required to neutralize the charge on Calcium is 2. Hence, the ratio of Calcium and Chloride is 1:2. Thus, the formula becomes $CaCl_2$.

Name of the ion	**Chemical symbol**	**Charge**	**Name of the ion**	**Chemical symbol**	**Charge**
Lithium	Li	+1	Nitride	N	-3
Sodium	Na	+1	Oxide	O	-2
Magnesium	Mg	+2	Fluoride	F	-1
Aluminium	Al	+3	Phosphide	P	-3
Potassium	K	+1	Sulphide	S	-2
Calcium	Ca	+2	Chloride	Cl	-1
Lead	Pb	+2	Bromide	Br	-1
Barium	Ba	+2	Iodide	I	-1
Zinc	Zn	+2	Nitrite	NO_2	-1
Iron (II)/ Ferrous	Fe	+2	Nitrate	NO_3	-1
Iron (III)/ Ferric	Fe	+3	Hydroxide	OH	-1
Copper (I)/ Cuprous	Cu	+1	Carbonate	CO_3	-2
Copper (II)/ Cupric	Cu	+2	Hydrogen carbonate/ Bicarbonate	HCO_3	-1
Ammonium	NH_4	+1	Sulphite	SO_3	-2
Silver	Ag	+1	Sulphate	SO_4	-2
Hydrogen	H	+1	Phosphate	PO_4	-3

			Hydride	H	-1

Table 1 shows the charges on some common ions.

Table 1: Charges on some communions

Steps to write the chemical formula

- Write the ions included in the compound's chemical formula.
- Write the charge on each ion below it.
- Cross multiply the charges to get the formula.

A few examples are given below

Aluminium sulphate

Al SO_4
3 2

$Al_2(SO4)_3$

Calcium carbonate

Ca CO_3
2 2

$Ca_2(CO_3)_2$

If the charges are same or have a common factor, they are reduced to the simplest ratio to form the compound. As in calcium carbonate, the charges on calcium and carbonate cancel out each other and the formula reduces to $CaCO_3$.

Sodium hydroxide

Na OH
1 1

NaOH

CHECK YOUR PROGRESS 22.2

Chemical Formula MAZE

Instructions:

In the figure 2, read the question at START and then moving on to the next question by following the correct answer. Continue until you reach the FINISH

HINT: There are 11 questions on the correct path.

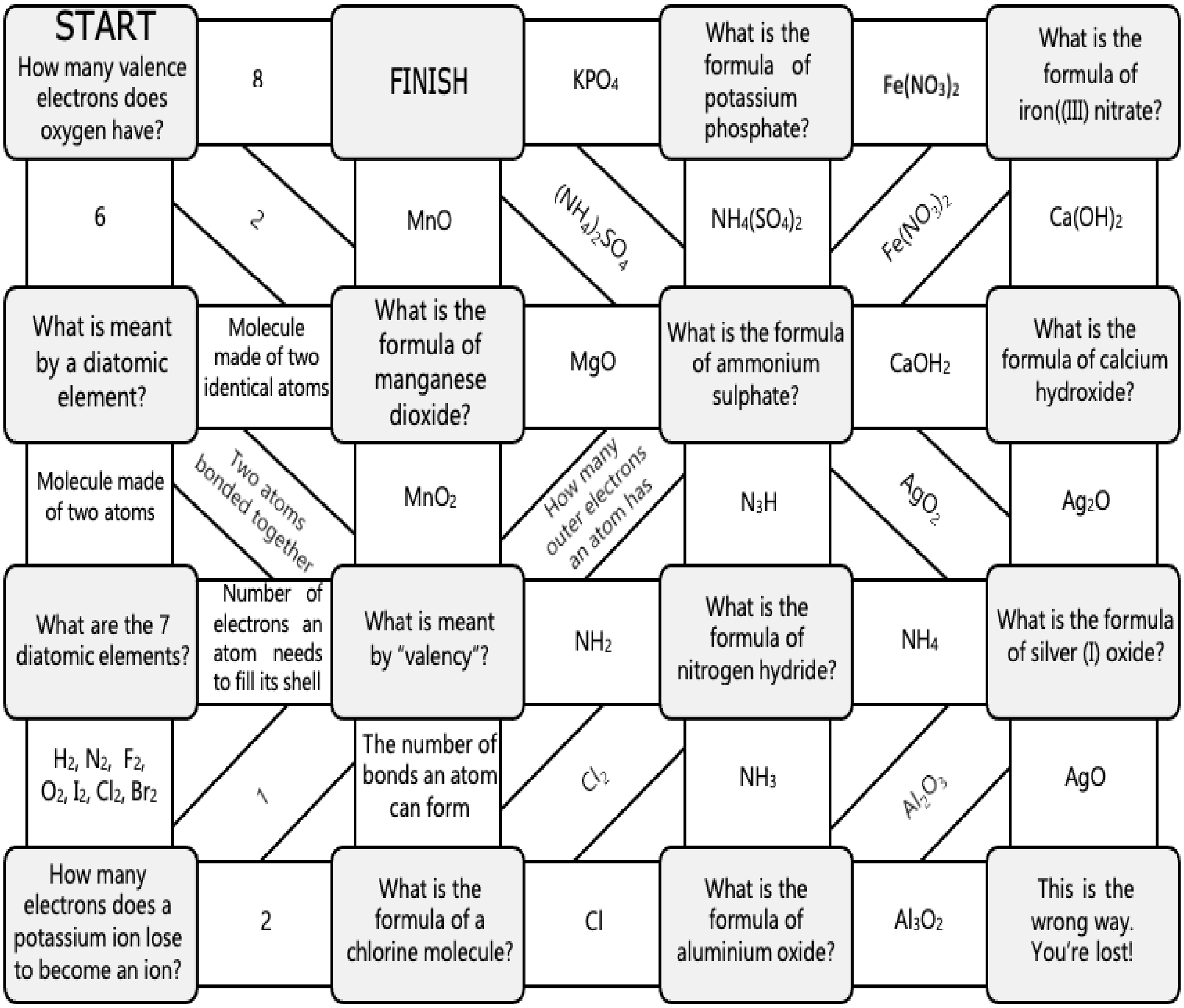


Figure 2: Start -Finish pathway to check your progress

22.4 MOLECULAR MASS

You have studied about the atomic mass and atomic mass unit in Unit 17. Atomic masses are used to find the molecular mass, i.e., the mass of the molecule.

The mass of all the molecules is estimated by adding the masses of the atoms that make up a molecule. The molecular mass is the mass of a molecule in comparison to the mass of the ^{12}C atom, which is assumed to be 12. Although it is a dimensionless quantity, the Dalton or atomic mass unit (amu)or unified mass (u)is assigned to it.

Molecular weight is another term for molecular mass. Because the mass is related to Carbon-12, the term "relative molecular mass" is more accurate.

22.4.1 Calculation of molecular mass

To calculate molecular mass, add the masses (from the periodic table) of all the atoms making up the molecule. For example,

The molecular mass of water, H_2O

= 2 x atomic mass of H atom + 1 x mass of O atom

= 2 (1.008) + 1 (15.99)

= 2.016 + 15.99

= 16.117 u

Similarly, molecular mass of sugar, $C_{12}H_{22}O_{11}$

= 12 x atomic mass of C atom + 22 x atomic mass of H atom + 11 x atomic mass of O atom

= 12 (12.01) + 22 (1.008) + 11 (15.99)

= 144.12 + 22.176 + 175.89

= 342.18 u

22.4.2 Moles and Molar mass

Chemists use the mole as a "counting unit" to describe the number of atoms, ions, molecules, or formula units present in a chemical sample. Other counting units, such as pair (2), dozen (12), and so on, are analogous to the mole. Avogadro's number (6.022×10^{23}) of molecules (molecular compound) or formula units (ionic compound) or atoms or ions are contained in one mole of a substance. Generally, we say that one mole of a compound contains 6.022×10^{23} particles.

A compound's molar mass is the mass of one mole of that material. To put it another way, it shows you how many grams per mole a substance has. As a result, the units for molar mass are grams/mole.

Calculation of molar mass

The molar mass of a compound may be calculated by using the following steps.

- Determine the number of each type of atom in the molecule using the chemical formula.
- Multiply the atomic weight of each element (from the periodic table) by the number of atoms of that element in the compound.

- After you've added everything up, put the units of grams/mole after the number.

The method to calculate the molar mass is similar to that of molecular mass. The only difference is that molecular mass is found out for one molecule while the molar mass is calculated for 6.022 x 10^{23} molecules. Hence, the unit of molecular mass may be written as u while molar mass is calculated in grams/mole.

Know the Scientist!

Amedeo Avogadro

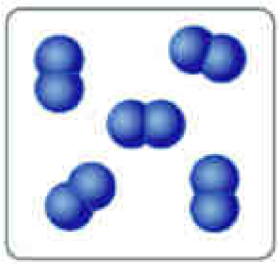
Amedeo Avogadro was born in Turin, Italy, on August 9th, 1776. Count Lorenzo Romano Amedeo Carlo Avogadro di Quaregna e di Cerreto was Avogadro's full name, quite a mouthful!
Amedeo Avogadro is most known for his theory that when equal quantities of different gases are kept at the same temperature and pressure, they contain the same number of molecules. Other scientists disagreed with his hypothesis. It was only after his death that it was accepted. It's now known as Avogadro's law. Avogadro was the first scientist to recognise the existence of elements as molecules rather than single atoms. *(Source: amazon.com)*

CHECK YOUR PROGRESS 22.3

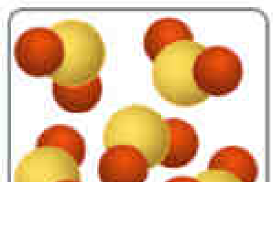
1. Write the chemical formulae for the following compounds.
   (a) Calcium hydroxide
   (b) Ammonium carbonate
   (c) Iron (II) chloride
   (d) Zinc phosphate
   (e) Aluminium bromide
2. Calculate the molar mass of the following compounds. (Atomic masses of H = 1u, S = 32u, O = 16u, Na = 23u, Cl = 35.5u, N = 14u, C = 12u)
   (a) H_2SO_4
   (b) NaCl
   (c) NH_3
   (d) CO_2
   (e) $C_6H_{12}O_6$

21.5 MOLE CONCEPT

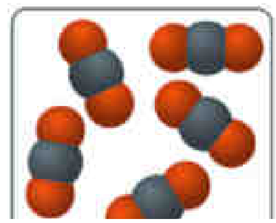
Atoms and molecules are very small hence their masses cannot be measured in terms of unified mass. By weighing macroscopic amounts of material, we may count atoms and molecules.
According to mole concept,
1 mole of any substance (atoms/ molecules/ ions) contains 6.022 x 10^{23} particles of that substance = Molar mass of the substance
Let us look at the following pictures (a) to (e) to understand the above relation.



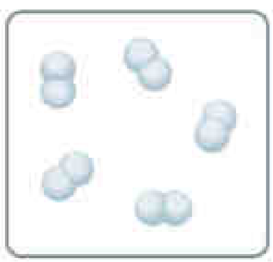
(a)



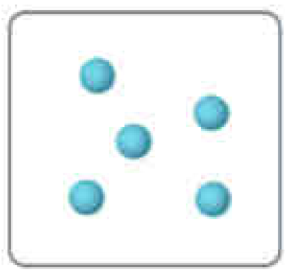
(b)



(c)



(d)



(e)

Figure 3: Mole Concept

Let box (a) contain 5 molecules of O_2
Let box (b) contain 5 molecules of H_2O
Let box (c) contain 5 molecules of CO_2
Let box (d) contain 5 molecules of N_2
Let box (e) contain 5 atoms of O

In all these boxes, the number of particles is same, but the type of particles are different and hence their masses are different.

In box (a), there are 5 molecules of O_2, mass of each molecule = 2 x 16 = 32 u

Therefore, mass of 5 molecules = 5 x 32 = 160 u

In box (e), there are 5 atoms of O, mass of each atom = 16u

Therefore, mass of 5 atoms = 5 x 16 = 80 u

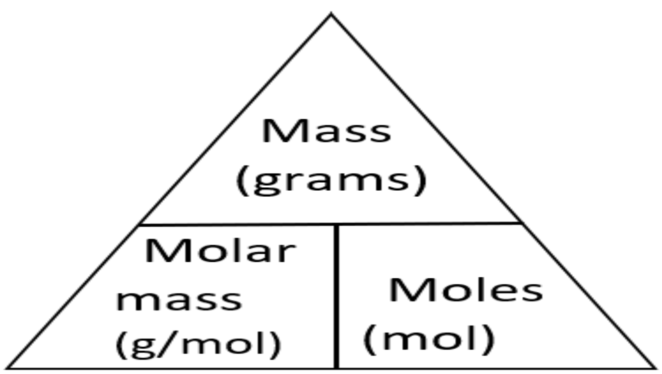
Thus, we see that the number of particles are same but the masses are different.

1 mole of O_2 molecules contains 6.022 x 10^{23} molecules of O_2 = 6.022 x 10^{23} x 2 atoms of O = 32 g/mol
1 mole of O atoms contains 6.022 x 10^{23} atoms of O = 16 g/mol

If 32 g of O_2 molecules = 1 mol
Then, 16 g of O_2 molecules = 0.5 mol

Thus, moles = $\frac{\text{Molar mass}}{\text{Given mass}}$

Equation triangle can be used to remember it, as given below.



Simply cover one of the variables with your thumb and the position of the two remaining variables will tell you how to compute it. For example, to get mass, multiply moles by molar mass; to get moles, divide mass by molar mass.

From the triangle,

Moles = $\frac{\text{Mass}}{\text{Molar Mass}}$

$$\text{Molar mass} = \frac{\text{Mass}}{\text{Moles}}$$

Mass = Molar mass x Moles

CHECK YOUR PROGRESS 22.4

1. Calculate the number of moles in 17g of H_2O_2. (Atomic mass of H = 1u, O = 16u)
2. Convert the following masses into moles:
   (a) 64 g of O_2(Atomic mass of O = 16u)
   (b) 34 g of NH_3 (Atomic mass of N = 14u, H = 1u)
3. Define Avogadro's constant. How is it related to mole?
4. Which has a greater number of atoms, 100 grams of Sodium or 100 grams of Iron? (Atomic mass of Iron = 56u, Sodium = 23u)

RECAPITULATION

- Matter can neither be created nor be destroyed in a chemical reaction. This is called the Law of Conservation of Mass.
- A compound is formed when two or more components combine in a fixed proportion by mass. This is called the Law of Definite Proportion.
- The sum of the atomic masses of all the atoms in a compound is called molecular mass.
- The molar mass of the substance is same as the molecular mass, only the unit of mass changes from u to g/mol.
- Moles of a substance = Given mass/ molar mass
- Molar mass = Given mass/ Moles of the substance
- Given mass = Molar mass x Moles of the substance

TERMINAL EXERCISES

1. A chemical process produces 87 g of carbon dioxide gas on heating a 150 g baking soda mixture containing sodium bicarbonate and vinegar. What amount of solid residue will remain in the food?
2. Silicon dioxide, which is made up of the elements Silicon and Oxygen, has a silicon content of 46.7 percent by mass. 10 g of Silicon will mix with what mass of oxygen?
3. 0.1618 g of Magnesium oxide (MgO) was generated when 0.0976 g of Magnesium was heated in air. How much oxygen is required to make 0.3236 g MgO?
4. 2.8 g of calcium oxide (CaO) was found to contain 0.8 g of oxygen. When one gram of oxygen was combined with calcium, the result was 3.5 grams of calcium oxide. Demonstrate that the results support the Definite Proportions Law.
5. If 42.0 g of carbon reacts entirely with 112.0 g of oxygen, what is the experimental percent of oxygen in CO_2?
6. Convert into mole:
   (a) 12 g of Oxygen gas (Atomic mass of O = 16u)
   (b) 20 g of water (Atomic mass of H = 1u, O = 16u)
   (c) 22 g of Carbon dioxide (Atomic mass of C = 12u, O = 16u)
7. Calculate the mass of the following. (Atomic mass of N = 14u)
   (a) 0.5 mole of N_2 gas
   (b) 0.5 mole of Nitrogen atoms
   (c) 3.011×10^{23} number of N atoms
   (d) 6.022×10^{23} number of N_2 molecules
8. Calculate the number of atoms in.
   (a) 0.02 moles of Carbon (Atomic mass of C = 12u)
   (b) 30 grams of Carbon
   (c) 6 moles of Aluminium ion (Atomic mass of Al = 27u)
9. Write the chemical formulae for the following compounds.
   (a) Magnesium hydroxide
   (b) Aluminium phosphate
   (c) Ammonium hydrogen carbonate

10. Write the names of the following compounds.

(a) NH_4Br

(b) $Fe(OH)_3$

(c) $ZnSO_4$

ANSWERS TO 'CHECK YOUR PROGRESS'

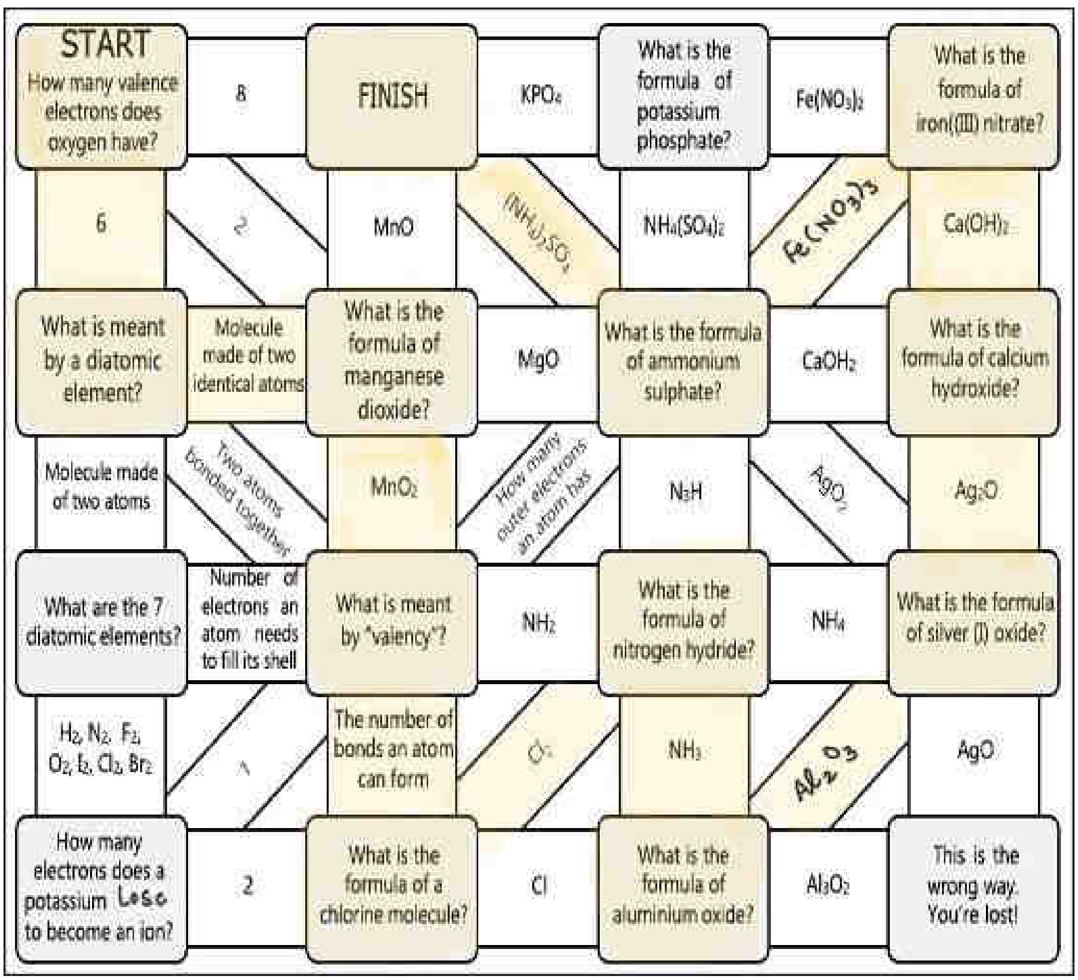
CHECK YOUR PROGRESS 22.1

1. 1:2. Carbon dioxide (CO_2)
2. (a) 28 g of nitrogen

   (b) 8.5 g of NH_3

   (c) Nitrogen will be left unreacted. 17 g of NH_3 is produced.

CHECK YOUR PROGRESS 22.2



CHECK YOUR PROGRESS 22.3

1. (a) $Ca(OH)_2$
   (b) $(NH_4)_2CO_3$
   (c) $FeCl_2$
   (d) $Zn_3(PO_4)_3$
   (e) $AlBr_3$

2. (a) 98 g
   (b) 58.5 g
   (c) 17 g
   (d) 44 g
   (e) 180 g

CHECK YOUR PROGRESS 22.4

1. 0.5 moles
2. (a) 2 moles
   (b) 2 moles
3. Avogadro's constant is the number of particles in one mole of a substance. The value of Avogadro's constant is 6.022×10^{23}. These number of particles are always present in 1 mole of any substance.
4. 100 g of Sodium

23 CHEMICAL REACTIONS AND EQUATIONS

INTRODUCTION

In our daily life , we observe a number of changes in our surroundings. Here, we can categorise these changes into two categories- first, those are very simple and are of temporary nature. For example , water turns into ice when it is kept on low temperature and again turns in to liquid when ice kept on room temperature. This is a temporary change. Second category belongs to compex and permanent changes. Temporary changes are also considered as physical changes and permanent changes are also called as chemical changes.

Present chapters tells that how to write and balance chemical equatiions. We shall also discuss about various kinds of chemical reactions.

23.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Gain knowledge about chemical reactions.
- Write and balance the chemical equations.
- Describe the significance of a balanced chemical equation.
- Know the relationship between mole, mass and volume of various reactants and products.
- Define oxidation and reduction.
- Understand day-to-day problems regarding Corrosion and rancidity and the means to over come them.

23.2 CHEMICAL REACTION

The following are the characteristics of a chemical reaction.

- In a chemical reaction, there may be a change of state or change of colour or evolution of gases or evolution and absorption of heat.
- During a chemical reaction, one or more than one product is formed.
- The products of a reaction do not recombine into the reactants on changing the reaction condition.

Hence a chemical reaction is defined as a chemical change in which one or more substances react to form one or more products by undergoing a change of state or color or temperature or by evolution of gas.

23.3 CHEMICAL EQUATION

The description of a chemical reaction in the form of a sentence would be very long. It can be represented in shorter form by using a word equation.

Chemical equation can be defined as a brief representation of a chemical reaction in terms of symbols for the reactants and products.

a. Reactants are the substances which undergo chemical change and are written on the left side in the equation.
b. Products are the results of the chemical change and are written on the right side in the equation.
c. An arrow is placed between the reactants and the products.

Example: magnesium ribbon burns in air to form a white powder of magnesium oxide, can be represented as

$Mg \quad + \quad O_2 \quad \rightarrow \quad 2Mg$

(Magnesium) (Oxygen) (Magnesium Oxide)

23.3.1 METHOD OF BALANCING A CHEMICAL EQUATION

Let us see the formation of water from the combination of oxygen and hydrogen. The following steps should be taken to balance a chemical equation.

i. Write the skeletal equation first
   $H_2 + O_2 \rightarrow H_2O$
ii. Make one of the atoms equal on both sides by multiplying a molecule or compound with an integral number so that the desired element is balanced. Here, we should start with the compound or molecule having maximum number of atoms. For example, in this reaction, water is having maximum number of atoms. It has one short of oxygen atom so it will be multiplied by two as shown in the following equation.
   $H_2 + O_2 \rightarrow 2H_2O$
iii. If we see the result of multiplication in the above equation, the oxygen balances but now hydrogen on left is 2 less, so multiply hydrogen by 2 on the left.
   $2H_2 + O_2 \rightarrow 2H_2O$

iv. Further count the number of atoms of each type on both sides.

	Right	left
H	4	4
O	2	2

Now the equation is balanced. If the number of atoms on both sides do not agree, continue with the above steps till balanced chemical equation is obtained. This is called hit and trial method.

CHECK YOUR PROGRESS 23.1

1. Write a chemical equation for each of the following reactions:
   (i) Zinc metal reacts with aqueous hydrochloric acid to produce a solution of zinc chloride and hydrogen gas.
   (ii) When solid mercury (II) oxide is heated, liquid mercury and oxygen gas are produced.
2. Balance the following chemical equations:
   (i) $Na\,OH\,(aq) + H_2\,SO_4\,(aq) \longrightarrow Na_2SO_4(aq) + H_2O\,(I)$

   (ii) $Al\,(s) + HCI\,(aq) \longrightarrow AICI_3\,(aq) + H_2\,(g)$
3. What is a balanced chemical equation? Why should a chemical equation be balanced?

23.4 TYPES OF CHEMICAL REACTIONS

1. Combination Reaction
2. Decomposition Reaction
3. Displacement Reaction
4. Double displacement Reaction
5. Oxidation and Reduction Reaction

23.4.1 Combination Reaction

A reaction in which two or more substances (either elements or compounds) combine to form a single new substance, is called combination reaction.
Example: calcium oxide reacts with water and form calcium hydroxide.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

(Calcium oxide) (Water) (Calcium hydroxide)

$$2Mg + O_2 \longrightarrow 2MgO$$

(magnesium) (oxygen) (Magnesium oxide)

- Take a small piece of magnesium ribbon. Make it clean with the help of sand paper.
- Heat it over a sprit lamp until it burns. The magnesium ribbon burns with a dazzling light and liberates a lot of heat.
- Very soon, it is converted into a white powdery substance. This powdery substance is magnesium oxide.

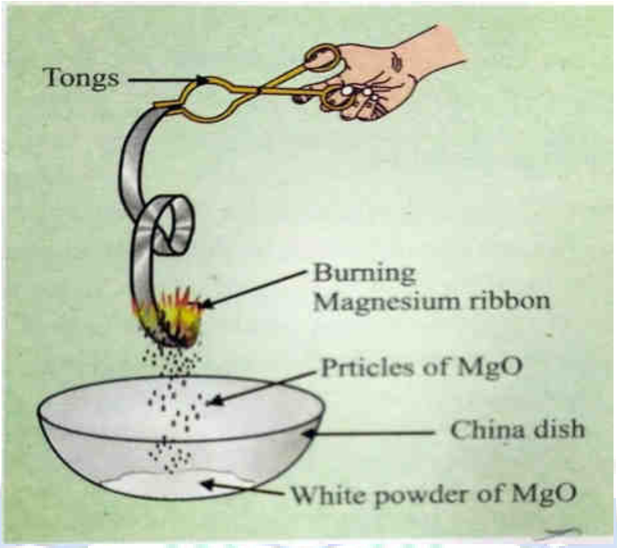


Fig 23.1: Combination Reaction

23.4.2 Decomposition Reaction

These reactions in which a single substance breaks up to give two or more simpler substances, are called decomposition reaction.

Example:

$CaCO_3 \rightarrow CaO + CO_2$

(Calcium Carbonate) (Calcium Oxide)

ACTIVITY 23.2

- Take a hard glass test tube having about 2g of ferrous sulphate.
- Now, gently heat it over a flame.
- After one minute observe the change in colour of ferrous sulphate.
- Smell the odour of the gas carefully.
- The green colour of the ferrous sulphate crystals gradually fades away and a smell of burning Sulphur is found.

$$FeSO_4.7H_2O\ (s) \xrightarrow{heat} FeSO_4\ (s) + 7H_2O\ (g)$$

$$2FeSO_4 \xrightarrow{heat} Fe_2O_3(s) + SO_2 + SO_3$$

Here, ferrous sulphate crystal first loses water and then decomposes to SO_2 and SO_3.in this reaction decomposition occurs by the use of heat, it is called thermal composition.

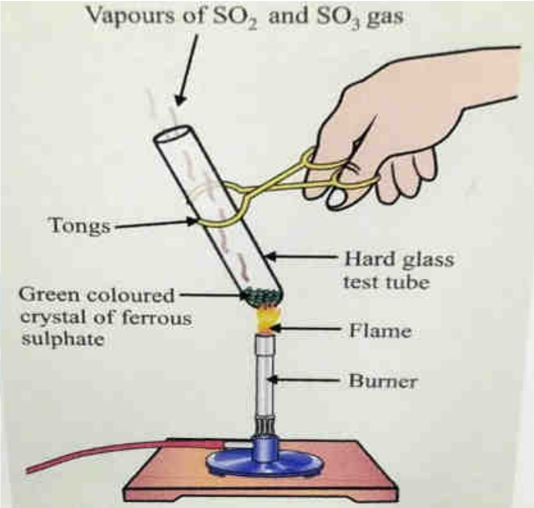


Fig 23.2 Decomposition reaction

ACTIVITY 23.3

- First we take a plastic mug having two holes drilled at its base. Two rubber stoppers are fitted in these holes.
- Insert graphite electrodes in these rubber stoppers and connect these electrodes to a 6 volt battery.
- You will observe gas bubbles over both the electrodes.
- After some time you will observe that the volume ratio of the two gases, i.e. hydrogen and oxygen is 1:2
- A reaction in which a compound decomposes due to electrical energy into two or more than two substances called electrolytic reduction,
  Fig 23.3

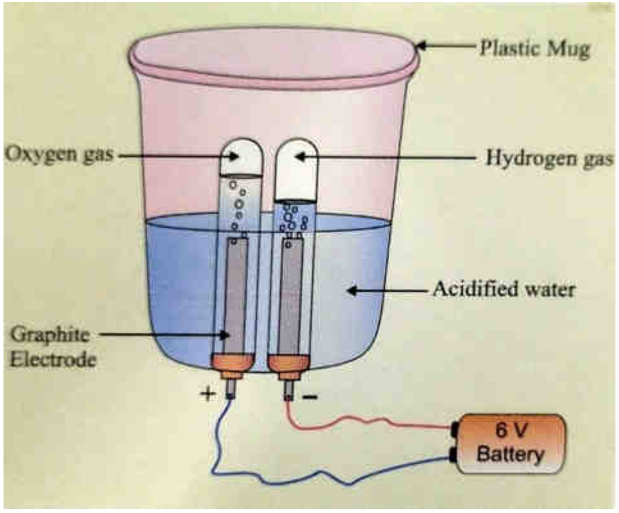


Fig 23.3: Electrolytic Reduction

23.4.3 Displacement Reaction: the reaction in which one atom or a group of atoms of a compound is replaced by another atom is called displacement reaction.

Example:

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

(Iron) (Copper sulphate) (Iron sulphate) (Copper)

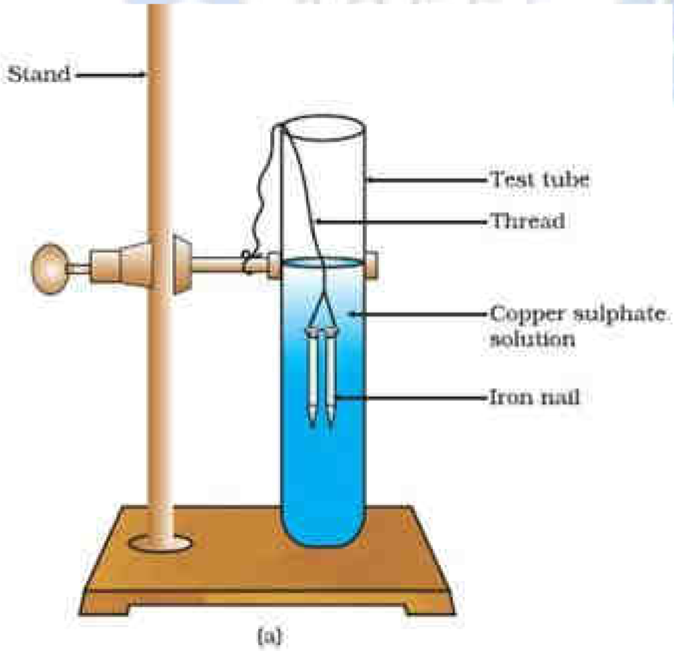


Fig 23.4: Displacement Reaction

ACTIVITY 23.4

- Take two test tube filled with dilute copper sulphate and mark them as A and B.
- Take two iron nails cleaned with sand paper.
- Now, immerse one iron nail in test tube A with the help of a thread.
- Keep it for 20 minutes and then observe the surface of nail and colour of solution,
- When we compare A and B, we observe that colour of A is fade and surface of nail has become brownish.
- It happens due to the following chemical reaction:

Fe	+	$CuSO_4$	→ $FeSO_4$	+	Cu
(Iron)		(Copper sulphate)	(Iron sulphate)		(Copper)

23.4.4 Double displacement Reaction:

Those reactions in which anions and cations of two different molecules switch places forming two extremely different compounds are called double displacement reactions.

Example:

$AgNO_3$ +	$NaCl$	→	$NaNO_3$	+	$AgCl$
(Silver nitrate)	(Sodium chloride)		(Sodium nitrate)		(Silver chloride)
Na_2SO_4 (aq) +	$BaCl_2$ (aq)	→	$BaSO_4$ (s)	+	$2NaCl$ (aq)
(sodium sulphate)	(Barium chloride)		(Barium sulphate)		(sodium chloride)

ACTIVITY 23.5

- Take two test tubes and mark them A and B. in test tube A take about 4mL of sodium sulphate solution and in test tube B take nearly 4 mL of barium chloride solution.
- Now add solution of test tube A to solution of test tube B.
- A white substance is formed which is called precipitate.
- The reaction can be written as -

Na_2SO_4 (aq) +	$BaCl_2$ (aq)	→	$BaSO_4$ (s)	+	$2NaCl$ (aq)
(sodium sulphate)	(Barium chloride)		(Barium sulphate)		(sodium chloride)

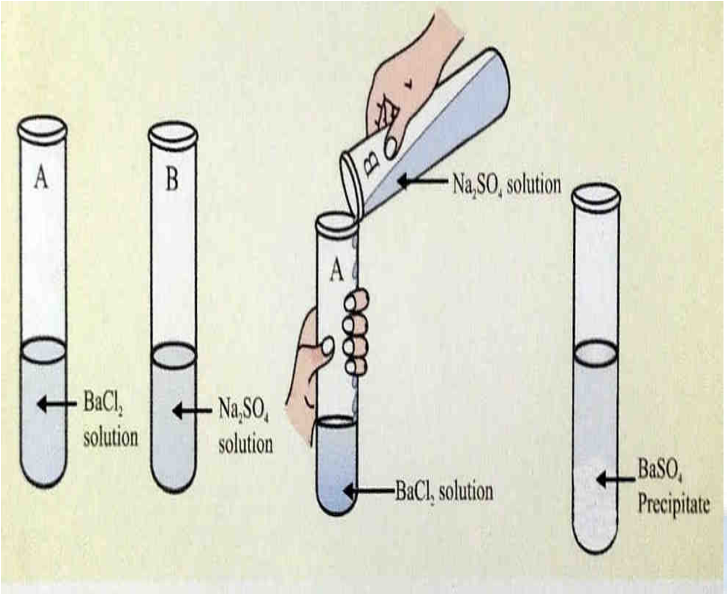


Fig 23.5: Double displacement reaction

23.4.5 Oxidation and Reduction (Redox)

- Oxidation: If a substance gains oxygen or looses hydrogen during a reaction, it is termed as oxidation reaction.
- Reduction: If a substance looses oxygen and gain hydrogen during a reaction, it is termed as reduction reaction.
- Take a China dish having nearly 2 g of copper powder and heat it strongly. Copper powder become black. because when oxygen combined with copper oxide is formed which is black in colour. This reaction can be written as,

$2Cu\ (s)\ +\ O_2 \xrightarrow{heat} 2CuO(s)$ ………………..(1)

Brown Black

- Now when hydrogen gas is passed over this black powder (CuO), the surface of the black powder becomes brown, which is the original colour of the copper. This reaction can be written as,
  $CuO\ (s)\ +\ H_2\ 2Cu \longrightarrow +\ H_2O$ ………..(2)
- In reaction (1) copper gains oxygen and is said to be oxidized. In reaction (2) copper oxides looses oxygen and is said to be reduced. Hydrogen in this reaction is gaining oxygen and is thus being oxidized. When a substance gains oxygen during a reaction, it is said to be oxidized and when a substance loses oxygen during a reaction, it is said to be reduced.

- Thus in this reaction process, one reactant gets oxidized while the other gets reduced. Such reaction is called oxidation reduction reaction or Reactions. This can be depicted in the following way:

$$CuO(s) \quad + \quad H_2 \longrightarrow 2Cu \; + \quad H_2O$$

- In the above scheme, Cu O provides oxygen and therefore is an oxidizing agent and hydrogen takes this oxygen and therefore is a reducing agent. In a redox reaction, an oxidizing agent is reduced and a reducing agent is oxidized.
- Some other examples of redox reaction are:
- In all redox reactions, you have seen that one species is oxidized and the other is reduced. There is no oxidation without reduction and there is no reduction without oxidation. This aspect of redox reaction will be explained broadly in terms of electron gain and electron loss in the following section.

  As reduction and oxidation takes place simultaneously, these reactions are called redox reactions.

23.4.5.1 Electronic concept of Oxidation and Reduction

Oxidation: Loss of electrons by an atom or ion is called oxidation.

Reduction: Gain of electron/s by an atom or ion is called reduction.

Exothermic reactions: The reactions in which heat is released along with the formation of products are called exothermic reactions.

Endothermic reactions: The reactions in which heat is absorbed along with the formation of products are called endothermic reactions.

CHECK YOUR PROGRESS 23.2

1. Examine the following reaction (s) and identify which of them are not example (s) of a Redox reaction?

   (I) $AgNO_3$ (a q) +HCI (a q) $\longrightarrow$ Ag CI (s) + HNO_3 (a q)

   (ii) MnO_2 (s) +4HCI (a q) $\longrightarrow$ $MnCI_2$(a q) +2H_2O (i) +CI_2(g)

(iii) $4Na\ (s) + O_2\ (g) \longrightarrow 2Na_2O\ (s)$

2. Identify the substances which are oxidized and the substances that substances that are reduced in the following reaction:

(I) $H_2\ (g) + CI_2\ (g) \longrightarrow 2HCI\ (g)$

(II) $H_2\ (g) + CuO\ (s) \longrightarrow Cu\ (s) + H_2O\ (I)$

(III) $Zn\ (s) + 2AgNO_3\ (aq) \longrightarrow Zn(NO_3)_2\ (aq) + 2Ag\ (s)$

CORROSION

The process of slow conversion of metals into their undesirable compounds by the action of components of air is called corrosion.

Due to the effect of moisture and acids, metals get corroded.

Corrosion causes damage to articles like car bodies, bridges, iron railings, ships and other substances of daily use.

RUSTING

When iron and iron articles are exposed to atmosphere, they are attacked by oxygen and moisture of the air and a reddish brown coloured layer is formed on the surface, it is called rust. Therefore, corrosion of iron is called rusting.

Rust is mainly hydrated iron oxide. It is a non-sticky substance and therefore it falls on the surface exposing new surface for rusting.

Finally, the whole of iron is lost due to rust.

Rusting can be prevented by applying a layer of oil and grease, a thick layer of paint or a layer of zinc. (Galvanisation).

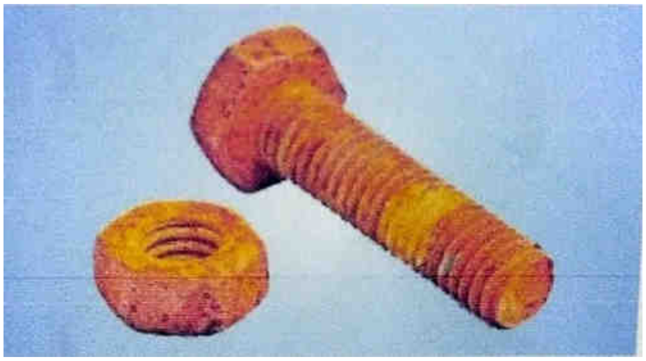


Fig 23.6: Corrosion

RANCIDITY

when food items cooked in oils and fats are kept exposed and unprotected, they give unpleasant smell and become rancid. The phenomenon is called rancidity. This is due to oils and fats present in the food items getting oxidized by some microorganisms.

METHODS TO PREVENT RANCIDITY

1. By adding anti-oxidants such as BHA (Butylated Hydroxy Anisole).
2. By keeping food items at low temperature.
3. Vacuum packing.
4. Replacing air by nitrogen.

RECAPITULATION POINTS

- A chemical equation is a brief description of a reaction .it symbolically represents the reactants, products and their physical states.
- In a balanced chemical equation, number of atoms of all types involved in the chemical reaction is equal on the reactants and products sides of the equation.
- When a chemical equation is balanced, no change in the formula of reactants and products is permitted.
- A balance chemical equation follows the law of conservation of mass and law of constant proportion.
- In a combination reaction two or more substances combine to form a new single substance.
- In a decomposition reaction, a single substance decomposes to give two or more substances.
- The reaction in which heat is given out during product formation are called exothermic reaction .and reactions in which heat is absorbed during product formation is called endothermic reaction.

- A displacement reaction is one in which an element displaces another element from its compound.
- Oxidation is the gain of oxygen or loss of hydrogen and reduction is loss of oxygen or gain of hydrogen. Oxidation and reduction reactions occur simultaneously and called collectively as redox reaction.
- When iron and iron articles are exposed to atmosphere, they are attacked by oxygen and moisture of the air and a reddish brown coloured layer is formed on the surface, it is called rust. Therefore, corrosion of iron is called rusting.
- When food items cooked in oils and fats are kept exposed and unprotected, they give unpleasant smell and become rancid. The phenomenon is called rancidity.

TERMINAL EXERCISE

Answer the following questions

Q1) Write the chemical equations of the following and balance them:

a. Carbon + oxygen $\longrightarrow$ carbon dioxide
b. Hydrogen + Chlorine $\longrightarrow$ Hydrogen Chloride
c. Barium chloride + sodium sulphate $\longrightarrow$ Barium sulphate +sodium chloride

Q2) Write balanced chemical equations with physical state symbols and necessary conditions, if any:

(a) Nitrogen reacts with hydrogen in the presence of iron as a catalyst at 200 atmospheric pressure and 600^o C temperature, and the product obtained is ammonia.
(b) Aqueous solution of sodium hydroxide reacts with hydrochloric acid and produces sodium chloride and water.
(c) Phosphorus burns in chlorine gas to form phosphorous pentachloride.

Q3) Balance the following chemical reactions:

(a) $Ca\ (OH)_2 + HNO_3$ $Ca\ (NO_3)_2 + H_2O$
(b) $BaCI_2\ (aq) + H_2SO_4\ (aq) \longrightarrow B\ a\ SO\ _4(s) + HCI\ (a\ q)$
(c) $CuSo_4\ (aq) + Zn\ (s) \longrightarrow ZnSO4\ (aq) + Cu\ (s)$
(d) $H_2S(g) + SO_2\ (g) \longrightarrow S\ (s) + H_2O(I)$
(e) $BaCI_2\ (aq) + AI_2(SO_4)_3\ (a\ q) \longrightarrow AICI_3\ (a\ q) + BaSO_4\ (s)$
(f) $Pb\ (NO_3)_2\ (aq) + Fe_2\ (SO_4)\ (a\ q) \longrightarrow Fe(NO_3)_3\ (\ aq) + PbSO_4\ (s)$

4. Define a balanced chemical equation? Write any 3 characteristics of a balanced chemical equations?

5. In what way is a displacement reaction different from a double –displacement reaction? Explain with two suitable examples.

6.What happens when dilute hydrochloric acid is added to iron filings? Mark( )at the correct answer from the following:

(a) Hydrogen gas and iron chloride are produced and is classified as a displacement reaction.
(b) Iron chloride and chlorine gas are produced and is classified a decomposition reaction.
(c) Iron hydroxide and water are produced and is classified as a combination reaction.
(d) No reaction takes place but is classified as a double displacement reaction.

7. What do you mean by an exothermic reaction? Give a suitable example.
8. Classify each of the following reactions as combination, decomposition, displacement or double displacement reactions:

(a) $Zn\ (s)\ 2AgNO_3(a\ q) \longrightarrow Zn(NO_3)_2 + 2Ag(s)$
(b) $2KNO_3(s) \xrightarrow{heat} 2KNO_2 + O_2\ (g)$
(c) $Ni\ (NO_3)_2\ (aq) + 2NaOH\ (aq) \longrightarrow Ni(OH)_2\ (s) + 2NaNO_3\ (aq)$
(d) $2KCIO_3(s) \xrightarrow{heat} 2KCI\ (s) + 30_2\ (g)$
(e) $MgO\ (s) + C\ (s) \longrightarrow CO\ (g) + Mg\ (s)$

9. What is the difference between a combination and a decomposition reaction? Explain with suitable examples.
10. Is there any oxidation without reduction? Justify your answer.
11. `Both combination reaction and displacement reaction fall in the category of redox reactions' . Do you agree? If so discuss this aspect with suitable examples.
12. Give two examples from our daily life situation where redox reaction takes place.
13. In the following reactions name the oxidizing substance and reducing substance and also mention the oxidizing and reducing agents:
    (a) $Ca\ (s) + CI_2(g) \xrightarrow{heat} CaCI_2(s)$
    (b) $3MnO_2\ (s) + 4AI\ (s) \xrightarrow{heat} 3Mn\ (I) + 2Al_2O_3\ (g)$
    (c) $Fe_2O_3\ (s) + 3CO\ (g) \xrightarrow{heat} 2Fe\ (s) + 3CO_2\ (g)$

14. Explain the following in terms of electron transfer:
    (a) Oxidation (b) Reduction

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 23.1

1. (i) Zn+2HCl = ZnCl2+H2

(ii) $2HgO(s) \rightarrow 2Hg + O_2$

2. (i) $2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(I)$

(ii) $2Al(s)+6HCl(aq) \rightarrow 2AlCl3(aq)+3H2(g)$

3. Refer to the text

CHECK YOUR PROGRESS 23.2

1. (i) acid-base reaction (neutralization)

(ii) Acid-base reaction (neutralization)

(iii) Redox Reaction

2. a) $H_2 + Cl_2 \rightarrow 2HCl$

That is a balanced redox reaction. Hydrogen is oxidized, while chlorine is reduced.

b) $CuO(s)+H_2(g) \rightarrow Cu(s)+H_2O(l)$

In this reaction hydrogen gains oxygen and forms water, hence it is oxidized. On the other hand copper oxide loses oxygen and hence reduced.

c) It is a redox reaction.

Here oxidation no. of Zn changes from 0 in Zn to +2 in Zn (NO3)2 . It is oxidized.

Ag is reduced because, in AgNO3 , it is in +1 state and reduced to O in Ag. Oxidation and reduction happened in a single reaction.

24

ACIDS, BASES AND SALTS

INTRODUCTION

Various chemical compounds are used for various daily routine work such as we use lemon juice to shine copper vessels. Sodium chloride is used in our food as common salt. Baking soda and bleaching powder are also the part of our kitchen. These chemical compounds are grouped under the category of acid, bases and salt. In this chapter we shall study about the properties of acid, bases and salts and their importance in our daily life.

24.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Define acid, base, salt and indicator.
- Understand some common household acids, bases, salts and some suitable indicators;
- Gain knowledge about properties of acids and bases
- Differentiate between strong and weak acids and bases;
- Explain the role of water in dissociation of acids and bases;
- Explain the term ionic product constant of water;
- Define pH:
- Correlate the concentration of hydrogen ions and pH with neutral, acidic and basic nature of aqueous solutions;
- Recognize the importance of PH in everyday life;
- Define salts and describe their methods of preparation;
- Correlate the nature of salt and the PH of its aqueous solution;
- Describe the manufacture and use of baking soda, washing soda, plaster of Paris and bleaching powder.

24.2 ACID

Those substances which turn blue litmus solution into red litmus solution are called acids. The term acid has been derived from the Latin word 'acidus' which means sour. So, acids are sour in taste. They give hydrogen (H+) ions in aqueous solution, e.g., HCl (Hydrochloric acid), H_2 SO_4 (Sulphuric acid), HNO_2 (Nitric acid), CH_3COOH (Acetic acid), H_2CO_3. (Carbonic acid), H_2SO_3 (Sulphurous acid), etc.

TYPES OF ACIDS

Mineral Acids	Organic Acids	Concentrated Acids
Those acids, which are obtained from minerals like sulphates, nitrates, chlorides,etc., are calledmineral acids, e.g., H_2SO_4, HNO_3 and HCl	Those acids, which are obtained from plants and animals are called organic acids, e.g., lemon contains citric acid, oranges and alma contains ascorbic acid (Vitamin C), curdcontains lactic acid and vinegar contains acetic acid.	Those acids, which contain a minimum amount of water, are called concentrated acids. Concentrated HCl is 39% by mass, concentrated HNO_3, is 69% by mass and concentrated H_2SO_4 is 98% by mass, Pure acetic acid (100%) is called glacial acetic acid.

Fig 24.1: Types of acids

The different types of acids are as follows:

1. Mineral Acids: Those acids, which are obtained from minerals like sulphates, nitrates, chlorides, etc., are called mineral acids, e.g., H_2SO_4, HNO_3 and HCl.

2. Organic Acids: Those acids, which are obtained from plants and animals are called organic acids, e.g., lemon contains citric acid, oranges and amla contains ascorbic acid (Vitamin C), curd contains lactic acid and vinegar contains acetic acid.

3.Concentrated Acids: Those acids, which contain a minimum amount of water are called concentrated acids. Concentrated HCl is 39% by mass, concentrated HNO_3, is 69% by mass and concentrated H_2SO_4 is 98% by mass, Pure acetic acid (100%) is called glacial acetic acid.

24.2.2 Chemical Properties of Acids:

Some chemical properties of acids are as follows:

1. **Reaction with Metals:** When acids react with metals, they produce a salt and hydrogen gas.Most metals react with acids, but not all. The general equation that describes the chemical reaction between an acid and a metal is— Metal + Acid → Salt + Hydrogen gas.

Example: $2HCl + Zn \longrightarrow ZnCl_2 + H_2$

Acid Metal Salt

2. **Reaction with Metal Carbonates:** All metal carbonates and hydrogen carbonates react to give a corresponding salt, carbon dioxide and water. Thus, the reaction can be summarised as-- Metal carbonate/Metal hydrogen carbonate + Acid → Salt + Carbon dioxide + Water Examples:

(a) $2HCl + Na_2CO_3 \longrightarrow 2NaCl + CO_2 + H_2O$

Acid Metal carbonateSalt

(b) $HCl + NaHCO_3 \longrightarrow NaCl + H_2O + CO_2$

Acid Metal hydrogen Salt

carbonate

24.2.3Neutralisation Reaction

The reaction between an acid and a base to give salt and water is known as a neutralisation reaction. In general, it can be written asAcid + Base Salt+water

Example: $HCl + NaOH \longrightarrow NaCl + H_2O$

Acid Base Salt Water

Reaction with Metal Oxides: An acid reacts with a metal oxide/hydroxide to form a salt and water. The general reaction between a metal oxide and an acid can be written as Metal oxide + Acid → Salt + Water

Example: $CuO + 2HCl \longrightarrow CuCl_2 + H_2O$

Metal oxide Salt Water

24.2.4Acids in Water

An acid is a substance which when dissolved in water, ionizes to form a hydrogen ion, H+ (aq). Hydrogen ions cannot exist alone, but they exist after combining with water molecules to form H_3O+ (hydronium ions).

Example: Hydrochloric acid, HCl(aq) breaks up into ions (a cation and an anion) in a water solution

$$HCl(aq) — H^+(aq) + Cl^-(aq)$$

Note: Strong acid: It is an acid that is completely dissociated in an aqueous solution, e.g., HCl, H_2SO_4, HNO_3

Weak acid: It is an acid that is partially dissociated in an aqueous solution, e.g., CH_3COOH

CHECK YOUR PROGRESS 24.1

1. Name the substances in which the following acid are present:

   (a) Ethanoic acids (b) Tartaric acid

2. Which of these acids would be partially dissociated in their aqueous solution?

   (a) HBr (c) HNO_3

   (b) HCN (d) CH_3COOH

3. An acid reacts with a substance X with liberation of a gas which burns with a, pop, sound when a burning match stick is brought near it. What is the nature of X?

4. An acid reacts with a substance Z with the liberation of CO_2 gas. What can be the nature of Z?

5. Which of the following oxides will react with a base?

   (a) Ca O (b) SO_2

24.3BASES

Those substances which change red litmus solution into blue litmus solution are called bases. These bitter in taste. They give hydroxide (OH-) ions in aqueous solution, e.g., NaOH, KOH, etc.

24.3.1Chemical Properties of Bases

Some chemical properties of bases are as follows:

1. **Reaction with Metals:** Only with reactive metals like sodium and potassium.

Example: $2NaOH + Zn \longrightarrow Na_2ZnO_2 + H_2$

Base Metal Salt Gas

2. **Reaction with Non-Metallic Oxides:** Non-metallic oxides are acidic in nature, thus, they will react with bases to form salt and water. They do not react with acids.

Example: $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

Base Non-Metallic Oxide Non-Metallic Salt Water

24.3.2Bases in Water

A base is a substance that when dissolved in water, ionises to form hydroxide ion, OH- (aq). Bases soluble in water are called alkalies.

Example: Sodium hydroxide, i.e., NaOH(aq) breaks up into ions (a cation and an anion) in a water solution.

NaOH(aq) – Na+(aq) + OH-(aq)

Note: **Strong base:** It is a base which completely dissociates in water into the cation and the OH- (hydroxide ion), e.g., NaOH, KOH, etc.

Weak base: It is a base which partially dissociates in water, e.g., NH_4OH, etc.

CHECK YOUR PROGRESS 24.2

Q1 Select the following substances as acid or base.

(a) Milk of magnesia (b) Gastric juice in humans

(c) Soft drinks (d) Lime water

(e) Vinegar (f) Soap

Q2What happens if we add a drop of the following on a cut unripe apple, curd, casticsoda solution and soap solution.

(a) Phenolphthalein (b) Litmus

Q3Why does the colour of dry blue litmus paper remains unchanged even when it is brought in contact with HCI gas?

Q4How does water help in dissociation of acids and bases?

24.4INDICATORS

Indicators are the chemical substances which give different colours in acidic and basic solutions. Acids are sour in taste and change blue litmus solutions to red, whereas bases are bitter in taste and change red litmus solutions to blue. Litmus solution and turmeric are natural indicators. Methyl orange and phenolphthalein are acid-base indicators used to test acids and bases in the laboratory. Those chemical substances which change their colour in acids and bases are called synthetic indicators.

24.4.1Litmus Solution

It is a purple dye which is extracted from lichens. It is used as an acid-base indicator. It is available in the lab as blue or red litmus solution. When the solution is acidified, it turns blue in colour whereas it turns red when a small amount of base is added to the blue litmus solution.

24.5pH SCALE

The concentration of H+ ions in a solution is measured in terms of the pH scale. One can measure pH by pH scale from zero (very acidic) to fourteen (very alkaline) (0-14). It may be pointed out that the pH is a number which indicates the acidic and the basic nature of a solution. Higher the value of hydrogen ion, lower will be its pH value. It may be noted that as pH increases, the concentration of OH-ions also increases, and therefore the strength of the base also increases.

pH of salts of strong acid and strong base are neutral with a pH value 7. Salts of a strong acid and weak base are acidicwith a pH value less than 7 and the salts of a strong base and a weak acid have a pH value more than 7.

24.5.1Importance of pH in Everyday Life

1. pH affects the survival of aquatic life.

2. Plants require a specific pH range for their healthy growth. If the pH of soil is lesser or more than specific pH, it affects the growth of plants.

3. Our stomach produces HĆI, which help in digestion of food without harming the stomach. During indigestion, stomach produces too much acid and it causes too much pain and irritation. It is due to low pH.

4. Tooth decay starts when the pH of mouth is lower than 5.5.

5. Animals and plants protect themselves through chemical warfare

CHECK YOUR PROGRESS 24.3

1. Ph of a solution is 5.2. Comment on the nature (acidic, basic or neutral) of this solution.

2. pH of a solution is 9. What is the concentration of H+ ions in it.

3. What is the nature (whether acidic, basic or neutral) of the following solutions?

(a) Solution A: pH = pOH

(b) Solution B: pH >pOH

(c) Solution C: pH < pOH

24.6SALTS

When hydrogen of an acid is replaced by a metal in displacement reaction, the compounds for called salts and hydrogen gas is liberated. Example:

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

Metal Acid Salt Hydrogen gas

When metal oxides react with acids, salt is formed. Example:

$Na_2O + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

Metal oxide Acid Sodium Water
(Salt) sulphate

Note: The order of reactivity of metals is
K>Ca>Na>Mg>Al>Zn>Fe>Sn>Pb>H>Cu>Hg>Ag>Au.

Common Salt: Sodium chloride obtained from sea is also known as common salt. The salt obtained contains in it and is brown in colour, thus is called rock salt.

24.7 SOME IMPORTANT SALTS

1. Sodium Hydroxide (NaOH)

When electricity is passed through an aqueous solution of sodium chloride, the salt undergo decomposition to produce sodium metal at the cathode and chlorine gas at the anode. Thesemetals react with water to form sodium hydroxide and evolves hydrogen gas at the cathode

Example:

NaCl (aq) Electricity, Na+ + Cl^-

$Na^+ + e \longrightarrow Na$

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$ (at cathode)

$Cl^- - e- \rightarrow Cl \longrightarrow$

$Cl + Cl - \rightarrow Cl_2$ (at anode)

The reaction can be summarised as:

$2NaCl(aq) + 2H_2O(1) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

2. Bleaching Powder (CaOCl2)

When chlorine gas is passed through dry slaked lime [Ca $(OH)_2$], bleaching powder ($CaOCl_2$) is formed

Ca $(OH)_2$	+ Cl	$\longrightarrow$	$CaOCl_2$	+ H_2O
Slaked lime	Chlorine		Bleachingpowder	water

Uses of Bleaching Powder

(a) For disinfecting water.

(b) As a germinate deodorant.

(c) For lab preparation of chlorine and oxygen.

(d) In manufacturing chloroform.

(e) For bleaching in textile industry.

3. Sodium Hydrogen Carbonate (NaHCO3)

It is prepared by passing carbon dioxide gas through a cold saturated solution of sodium carbonate. It is also known as baking soda.

Na_2 CO_3	$+CO_2$	$+H_2O$	$\longrightarrow$	$2NaHCO_3$
Sodium Carbonate	Carbon dioxide	Water		Sodium Hydrogen Carbonate

\The following reaction takes place when it is heated during cooking.

$2NaHCO_3$	$\xrightarrow{\text{heat}}$	Na_2CO_3	+	$H_2O + CO_2$
Sodium hydrogen		Sodium carbonate		

(Baking soda)

USES OF BAKING SODA

(A) As an ingredient in anti-acid medicine.

(b) While cooking food in the form of baking powder.

4. Washing Soda (Na2CO3.10H20)

Washing soda is obtained by recrystallisation of sodium carbonate. It is also known as a basic salt.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + 10H_20 \longrightarrow \underset{\text{Washingsoda}}{Na_2CO_3.10H_2O}$$

Uses of Washing Soda

(a) For washing purposes in laundry.

(b) For softening of hard water.

(c) As a laboratory reagent.

(d) In glass, soap and paper industry.

(e) In the manufacture of sodium compounds such as borax.

5. Plaster of Paris ($CaSO4.\frac{1}{2}H2O$)

It is prepared by heating gypsum ($CaSO_4.2H_2O$) at 373 K causing it to lose water molecules.

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \text{ Heat} \longrightarrow \underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + \underset{\text{Water}}{\frac{3}{2}H_2O}$$

Uses of Plaster of Paris

(a) For making casts of statues.

(b) In orthopedics to rejoin broken or displaced bones and joints.

(c) In making a wall border.

(d) As a fireproofing material.

(e) For making a smooth surface of the wall.

(f) For making toys and decoration material.

CHECK YOUR PROGRESS 24.4

1. Identify acid radical and basic radical in $CaSO_4$
2. $CuSO_4$ was prepared by reacting an acid and a base. Identify the acid and the base that must have been used in this reaction.

ACTIVITIES

ACTIVITY 1

Aim: To study the reaction of acids with metals.

What is required?

A test tube, zinc granules, dilute H_2SO_4, match box and a test tube holder.

What to do?

- Add a few zinc granules in a test tube.
- Add dil. sulphuric acid carefully along the sides of the test tube.
- Set the apparatus as show in the fig. 8.1
- Bring a burning match stick near the mouth of the test tueb.

What to observe?

- When dilute sulphuric acid is added to zinc granules, hydrogen gas is formed. The gas bubbles rise through the solution.
- When the burning match stick is brought near the mouth of the test tube the gas in the test tube burns with a 'pop' sound. This confirms that the gas evolved is hydrogen gas.
- From this experiment it can be said that dilute sulphuric acid reacts with zinc to produce hydrogen gas. A similar reaction is observed when we use other metals like iron. In general, it can be said that in such reactions metal displaces hydrogen from acids and hydrogen gas is released. The metal combines with the remaining part of the acid and forms a compound called a salt, thus,
- Acid + Metal Salt + Hydrogen gas
- Form example, the reaction between zinc and dil. sulphuric acid can be written as:

Zn	+	H_2SO_4	$\longrightarrow$	$ZnSO_4$	+	H_2
zinc metal		dilsulphuric acid		zinc sulphate salt		hydrogen gas

Reactions of acid with metal carbonates and hydrogen carbonates.

Reaction of acids with metal carbonates and hydrogen carbonates can be studies with the help of activity 1.

ACTIVITY 2

This experiment may be carried out in the chemistry laboratory of your study centre.

Aim: To study the reaction of acids with metal carbonates and hydrogen carbonates.

What is required?

One test tube, one boiling tube fitted with a cork, thistle funnel and delivery tube, sodium carbonate, sodium hydrogen carbonate, dilute HCI and freshly prepared lime water.

What to do?

- Take a boiling tube ad add about 0.5g sodium carbonate to it.
- Take about 2ml of freshly prepared lime water in a test tube.
- Add about 3ml dilute HCI to the boiling tube containing sodium carbonate and immediately fix the cork filled with a delivery tube and set the apparatus.
- Dip the other end of the delivery tube in the lime water.
- Observed the lime water carefully.
- Repeat the activity with sodium hydrogen carbonate.

What to observe?

- When dilute HCI is added to sodium carbonate or sodium hydrogen carbonate, carbon dioxide gas is evolved.
- On passing CO_2 gas, lime water turns milky.
- On passing the excess of CO2 gas, lime water becomes clear again.

From the above activity it can be concluded that if sodium carbonate or sodium hydrogen carbonate react with dilute hydrochloric acid, carbon dioxide gas is evolved.

Reactions of Acids with metal oxides

We can study the reaction of acids with metal oxides with the help of activity 2

ACTIVITY 3

This activity may be carried out in the chemistry laboratory of your study centre.

Aim: To study the reaction of acids with metals oxides.

What is required?

A beaker, glass rod, copper oxide and dilute hydrochloric acid.

What to do?

- Take a small amount of black copper oxide in a beaker.
- Add about 10ml of dilute hydrochloric acid and stir the solution gently with the help of a glass rod.
- Observed the beaker as the reaction occurs.

What to observe?

- When a mixture of dilute HCI and copper oxide is mixed, the black particles of copper oxide can be seen suspended in colourless dilute hydrochloric acid.
- As the reaction proceeds, the black particles slowely dissolve ad the colour of the solution becomes bluish green due to the formation of copper (II) chloride (cupric chloride)-a salt.

From this activity we can conclude that the reaction between copper oxide and dilute hydrochloric acid results in the formation of copper(II) chloride (cupric chloride) which is a salt of copper. This salt forms bluish green solution. The reaction is:

$CuO(s)$	+	$2HCI(aq)$	$\longrightarrow$	$CuCI_2(aq)$	+	$H_2O(I)$
Copper oxide oxide		dil hydrochloric acid		copper(II) chloride		water

Many other metal oxides like magnesium oxide (MgO) and calcium oxide (CaO) or quick lime also react with acid in a similar way. For example,

$CaO(s)$	+	$2HCI(aq)$	$\longrightarrow$	$CaCI_2(aq)$	+	$H_2O(I)$
Calcium oxide (quick lime)		dil hydrochloric acid		calcium chloride		water

So, we can summarize with a general reaction between metal oxides and acids as:

Metal oxide + Acid $\longrightarrow$ Salt + Water

RECAPITULATION POINTS

- Acids are the substances having taste sour, change blue litmus red, are corrosive to metals and furnish H+ ions in their aqueous solutions while.
- Bases are the substances which taste bitter, change red litmus blue, feel slippery and furnish OH- ions in their aqueous solutions.
- Indicators are the substances that show one colour in an acidic medium and another colour in a basic medium, Litmus, Phenolphthalein and methyl orange are commonly used indicators.
- Acids are presents in many unripe fruits, vinegar, lemon, sour milk etc., while bases are present in lime water, window pane cleaners, many drain cleaners etc.
- Aqueious solutions for acids and bases both conduct electricity as they dissociate on dissolving in water and liberate cations and anions which help in conducting electricity.
- Strong acids and bases dissociate completely in water. HCI, HBr, HI, H_2SO_4, $Ca(OH)_2$, $Ca(OH)_2$, $Sr(OH)_2$ and $Ba(OH)_2$ are strong bases.
- Weak acids and bases dissociate partially in water, for example, HF, HCN, kCh_3COOH etc. are some weak acid and HH_4OH, $Ca(OH)_2$, $AI(OH)_3$ etc. are some weak bases.
- Acids and bases react with metals to produce salt and hydrogen gas.
- Acids react with metal carbonates and metal hydrogen carbonates to produce salt, water and CO_2.
- Acids react with metal oxides to produce salt and water.
- Bases react with non-metal oxides to produce salt and water.
- Acids and bases react with each other to produce salt and water. Such reactions are called neutralization reactions.
- Acids and bases dissociate only on dissolving in water.
- Water itself undergoes dissociation and furnishes H^+ and OH^- ions in equal numbers. This is called self-dissociation of water. The extent of dissociation is very small.
- Concentrations of H^+ and OH^- ion formed by the self-dissociation of water are 1.0×10^{-7} molar each at 25°C.

- Product of concentrations of hydrogen and hydroxyl ions is called the ionic product or ionic product constant' of water, Kw. It remains unchanged even when some substance (acid, base or salt etc.) is dissolved in it.
- PH is defined as log. 1 H^+ or -log[H], likewise pOH = -log[OH-] and pKw= -log Kw
- Universal indicator is prepared by mixing a number of indicators. It shows a different but characteristic colour at eachpH.
- Maintenance of correct pH is very important for biochemical process occurring in humans and animals.
- If pH of rain water falls below 5.6, it is called acid rain and is quite harmful.
- pH plays an important role in proper growth of plants and also for proper digestion in our bodies.
- Salts are ionic compounds made of a cation other than H+ ion and anion other than OH^- ion. They are formed in neutralization reaction.
- Salts are also formed in reaction of acids and bases with metals, of acid with metal carbonates, hydrogen carbonates and oxides and in reaction of bases with non-metal oxides.

TERMINAL EXERCISE

A. Objective Type Questions

I. Mark the correct choice

1. Following is the main constituent of Lemon juice

(a) tartaric acid (b) ascorbic acid

(c) acetic acid (d) lactic acid

2. Aqueous solutions of acids conduct electricity. This shows that

(a) They contain H+ ions (b) They contain OH-ion

(c) They contain cations and anions (d) They contain both H* and OH ions

3. Following is not a strong acid?

(a) HCI (b) HBr

(c) HI (d) HF

4. Self-dissociation of water produces

(a) a large number of H+ ions (b) a large number of OH-ions

(c) H and OH ions in equal numbers (d) H and OH ions in unequal numbers

7. Which of the following is not a raw material for manufacturing washing soda?

(a) Lime stone (b) Ammonia

(c) Slaked lime (d) Sodium chloride

II. Mark the following statements as true (T) or false (F):

1. Acids furnish H+ ions only in the presence of water.

2. Lime water turns blue litmus red.

3. HF is a strong acid.

4. H_2 gas is produced when acids react with metal oxides.

5. Corrosive action of acids is due to H^+ ions present in them.

III. Fill in the blanks

1. Acids taste……………. while bases taste………………

2. Milk of magnesia turns …………………litmus…………………..

3. One mole of sulphuric acid would furnish……………………mole/s of H+ ions and…………………moles of SO42-

4. ……………………..gas is produced when acids react with metal hydrogen carbonates.

5. Lime water turns milky on passing CO_2 gas due to the formation of……………………..

B. Answers the following questions in one words or sentence.

a. Define an acid?
b. Giveatleast two examples of acids found in food articles.
c. Give two examples of bases.
d. What are indicators?
e. Name thecolour of methyl orange indicator in (i) acidic medium and (ii) basic medium.
f. Why do solutions of acids and bases conduct electricity?

C. Answers the following questions in detail.

1. Which gas is evolved when an acid reacts with metal carbonates? Which other category of compounds would produce the same gas on reacting with acids?
2. What type of oxides react with acids? Give one examples of this type of oxide and write down the balanced equation for the reaction.
3. Give the name the reaction between an acid and a base? What are the products formed in such reactions?
4. "Corrosive action of acids is not related to their strength". Justify this statement.
5. Give one example each of the following (i) a strong base (ii) a weak base.
6. List three categories of substances that can react with a base. Give one example of each and write the chemical reaction involved in each case.
7. What happens when a dry strip of each of red litmus paper and blue litmus paper is brought in contact with HCl gas? In which case a change would be observed if the strips are moistened and then brought in contact with HCl gas and what would be the change?
8. A small palette of NaOH is kept on dry red litmus paper. Initially, no change is observed but after some time its colour starts changing to blue around the place where the palette of NaOH is kept. Explain these observations.
9. How does water help in dissociation of acids and bases? Explain.
10. Define pH? What happens to the pH if the hydroxyl ion concentration in the solution increases?
11. What do you understand by the term 'universal indicator"? 28. What is acid rain?
12. What is the importance of pH for humans and animals, and our digestive system?

13. Define a salt? Give two examples.
14. Give chemical formula of (i) baking soda and (ii) washing soda. 34. List the raw materials required for the manufacture of baking soda and describe the process with the help of suitable chemical equations.
15. What is washing soda? Give its chemical formula. How is it manufactured by Solvey's method?
16. What is the chemical formula of 'Plaster of Paris'? How is it manufactured? What precaution is taken during its manufacture?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 24.1

1. A. Vinegar
   B. Tamarinds
2. CH_3COOH and HCN
3. Metal
4. Salt
5. SO2

CHECK YOUR PROGRESS 24.2

1. **Acid** – gastric juice in humans, vinegar
   Base—milk of magnesia, lime water, soap
2. **Phenophthlein**- colourless, colourless, pink, pink
   Litmus – purple, red, blue, blue

3. Because there is no H+ in HCl gas.

4. Water helps in dissociation of acids and bases resulting in the formation of H+ and OH + respectively.

CHECK YOUR PROGRESS 24.3

1. 1.8
2. 10^{-9}
3. Neutral, acid, base

CHECK YOUR PROGRESS 24.4

1. Acidic –SO4
   Basic – Ca
2. CuOand H_2SO_4

25 METALS AND NON-METALS

INTRODUCTION

We are surrounded by metals at home and non-metals in school, in the street or in office, In the kitchen, we use both metals and non-metals. Cooking utensils are made of metals like iron, aluminum, zinc and copper. Our storage containers could be made of non-metals such as plastics and glass. Thus, metals and non-metals are an integral part of our lives.

You have already read about metal and non-metals in the chapter of periodic classification of elements. You also know the criteria for classifying metals and non-metals which are basically based on electronic configuration of the elements.

Apart from day-to-day life situations, metal and non-metal are industrially very important. They play an important role in our national economy. You might have heard about various iron and steel plants, zinc and copper plants and aluminium plants (factories) established in our country. Have you seen any one of these so far? There are basically metal based industries. Apart from these, you also must have heard acid plants and fertilizer factories. These are basically non-metal-based industries. All these metals and non-metals are obtained from minerals. We are fortunate that we have rich mineral resources. You will study about all these in your higher classes. In this Chapter we will discuss certain relevant properties of metal and non-metals which will be quite significant for you.

25.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Differentiate between metals and non-metals on the basis of their physical properties
- Describe the reactions of metals with oxygen, water and some common acids and bases
- Distinguish between mineral and ores
- Recognize various metallurgical processes in the extraction of common metals
- Explain the phenomenon of corrosion and list various methods to prevent it
- Describe the reactions of non-metals with oxygen; arrange the metals in order of their reactivity and construct reactivity series

26 CARBON AND ITS COMPOUNDS

INTRODUCTION

As we previously concentrated on in our past classes that mixtures are of two types:

1. Organic Compounds
2. Inorganic Compounds

Natural mixtures are comprised of carbon and structure the premise of every living organic entity. Carbon is the third most significant component after oxygen and hydrogen for the presence of life on the planet, the name carbon implies CARBO which means Coal.

The earth outside layer has just 0.02% carbon which is available as minerals (like carbonates, hydrocarbons and so on) and the climate has 0.03% of carbon dioxide.

In this section, we will concentrate on the properties of carbon intensifies which makes them vital to us.

26.1 LEARNING OBJECTIVE

After reading this lesson, you will be able to:

- Understand the Covalent Bonding and Covalent Compounds
- Gain knowledge about Allotropy and Allotropes
- Separate between the immersed and unsaturated hydrocarbons
- Explain Homologous series
- Write IUPAC name of a compound
- Learn about some important carbon compounds
- Explain and draw peculiarity of Isomerism
- Follow some significant carbon compounds and their purposes
- Talk about the assembling of cleansers and cleansers

26.2 COVALENT BONDING IN CARBON COMPOUNDS:

The bonds which are framed by the sharing of an electron pair between the molecules are known as covalent bonds. Nuclear number of carbon (C) is 6. Thus, its electronic arrangement = K-2, L-4. It could acquire 4 electrons and structure C4-anion. Be that as it may, it would be hard for a core having 6 protons and 4 additional electrons. It could lose 4 electrons and structure C4+ cation. In any case, a lot of energy is expected to eliminate 4 electrons.

27

MOTION

INTRODUCTION

Science is a major endeavour of man. Humans are always keen to explore the nature and the world around it. Physics is a branch of science that studies matter, its motion and its behaviour in space-time. The basis of physics is based on physical quantities, through which the laws of physics are expressed.

Physical quantities are quantities that can be measured directly or indirectly. Examples: mass, volume, speed, energy, work, pressure, distance, time.

A physical quantity is represented by a number and its unit. The number indicates the magnitude.

Suppose the length of the car is 5 meters, then '5' is magnitude and meter (m) is the unit. Some physical quantities (vector quantities*) also require direction for their complete specification.

Physical quantities can be broadly classified into two categories:

(i) A **scalar quantity** is a quantity that can be completely specified by magnitude alone. Examples: time, mass, distance, pressure, energy.

(ii) A **vector quantity** is a quantity that is represented by both magnitude and direction. Examples: velocity, displacement, acceleration

27.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Understand the concept of motion
- Distinguish between scalar and vector quantities
- Explain the concept of speed and velocity
- Discuss the meaning of average speed and average velocity
- Define acceleration and its types
- Draw and explain the distance – time and speed – time graphs
- Derive the equations of motion by graphical method
- Develop a relationship between acceleration, velocity, distance travelled and time
- Understand the concept of slope and its importance in graphs

2 LAWS OF MOTION

INTRODUCTION

In the last chapter, we learnt about the motion of an object, distance travelled by it, speed and acceleration. In this chapter we are going to study about what causes motion and the various laws which govern the motion of objects when a force is applied on them.

28.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Understand force as an agency that can bring a change in the state of rest or uniform motion of an object.
- State the three laws of motion.
- Identify the relationship between the mass of an object and inertia.
- Define momentum.
- Derive a mathematical formulation for force and acceleration.
- Justify the action-reaction forces in different situations in their surroundings.
- Explain the law of conservation of momentum and its applications.

28.2 EFFECTS OF FORCE

Force is a push or pull on an object that produces a change in the state of motion i.e., acceleration or deceleration in the body on which it acts. S.I. unit of force is Newton (N).

A force can bring the following changes in a body (an object):

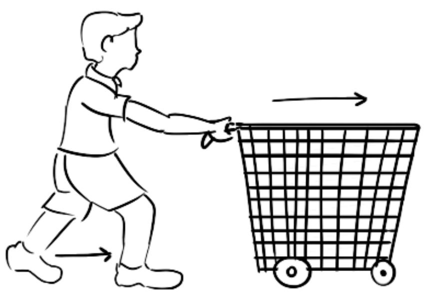


Fig 28.1: Effects of force

a. It can change the speed of a body (an object).

Example: When force is applied in the same direction as the direction of the moving object, its speed increases i.e., acceleration, whereas when the force is applied in a direction opposite to the direction of motion then its speed decreases i.e., deceleration.

> **State of Motion**
>
> An object can have two states of motion:
>
> At rest or in motion.

b. It can change the state of motion of the object.

Example: The application of brakes brings a vehicle to rest.

c. It can change the direction of motion of a body (an object).

Example: In a game of football, when we kick the football, its direction is changed due to the application of force.

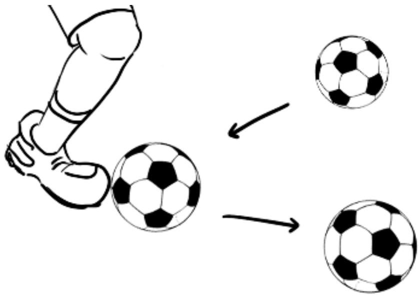


Fig 28.2: Change in direction of motion

d. It can change the shape of a body (an object).

Example: When we apply muscular force while kneading the dough, its shape changes.

Fig 28.3: Change in shape

28.3 BALANCED AND UNBALANCED FORCES

When balanced forces are applied to an object, there will be no net effective force acting on the object. Balanced forces do not cause a change in motion.

Unbalanced forces acting on an object change its speed and/or direction of motion. The object moves in the direction of the net force. The net force acting on a body will not be zero.

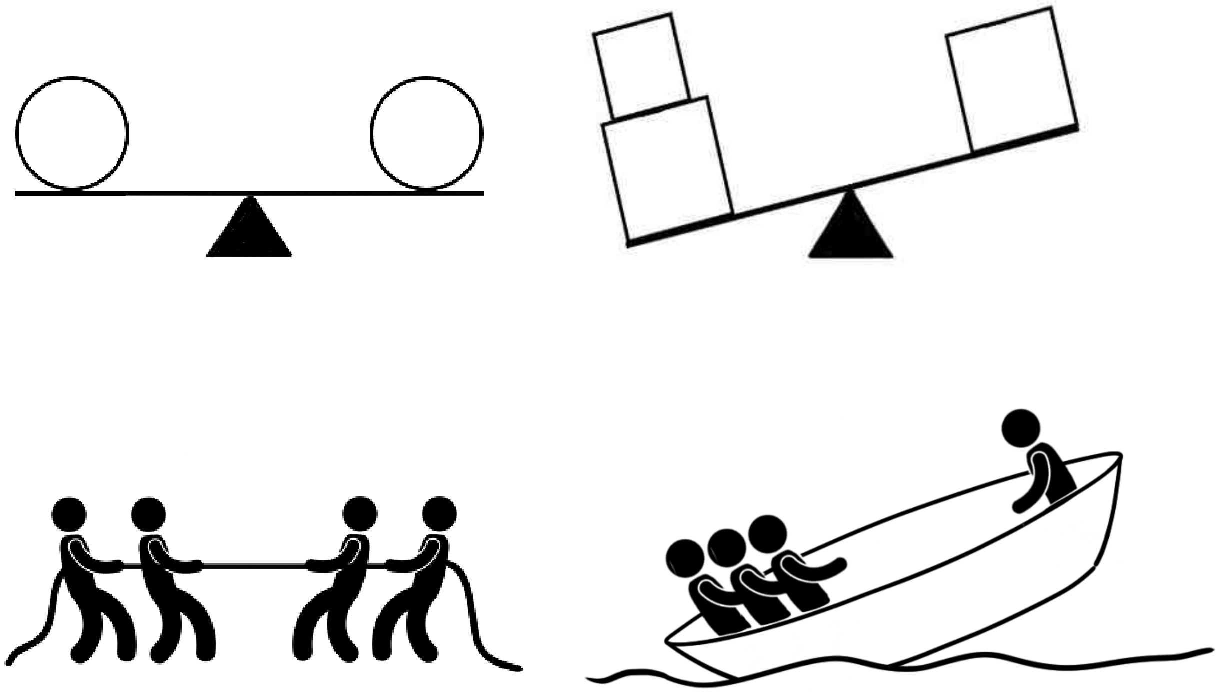
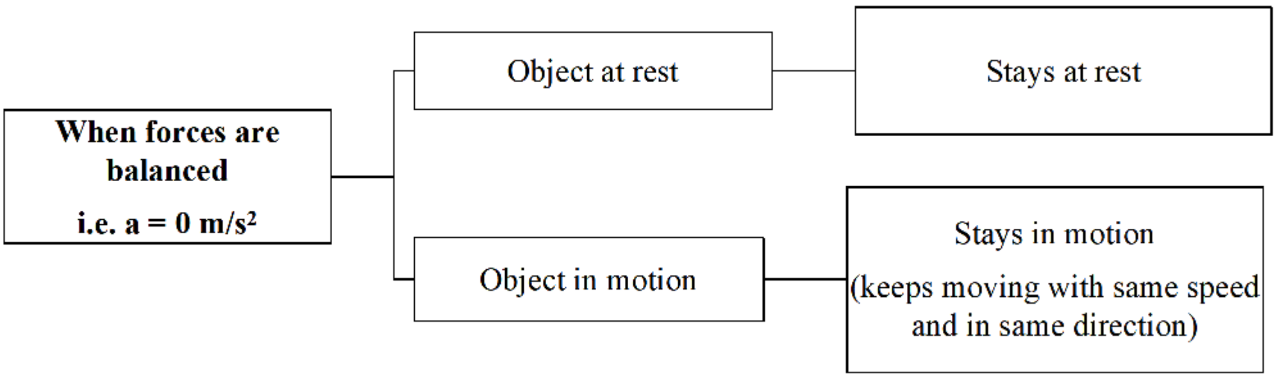
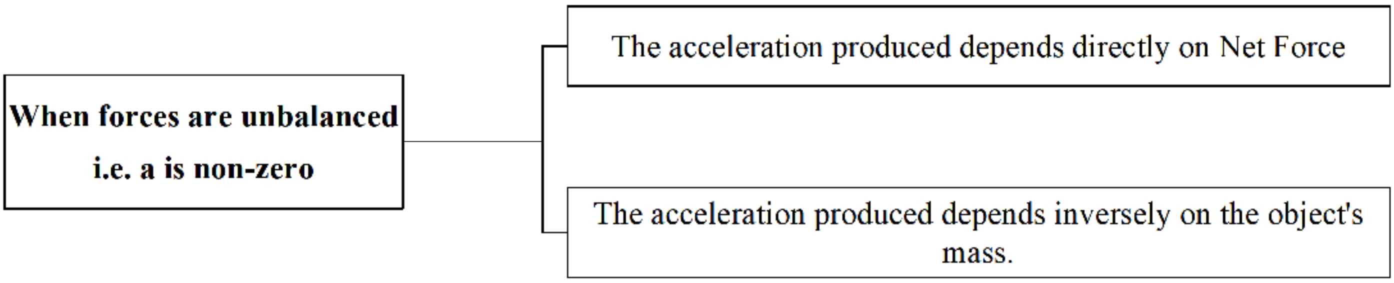


Fig 28.4: Balance and unbalanced forces





CHECK YOUR PROGRESS 28.1

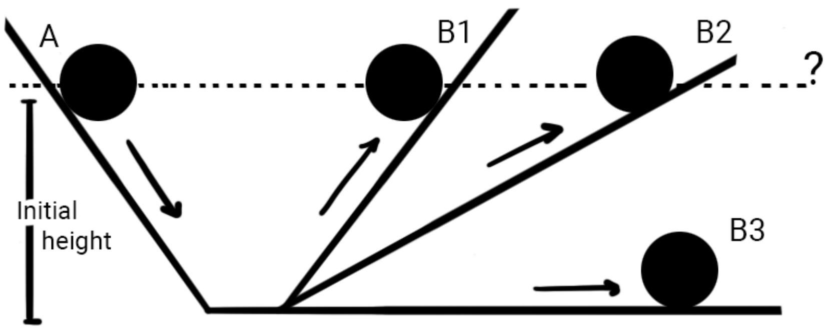
1. Give an example to explain how force can change the state of motion of a body (an object).
2. Differentiate between balanced and unbalanced forces.

Galileo's Thought Experiment

Galileo thought that a ball, rolling or sliding down a frictionless inclined plane, would run up to the same height on an opposite hill. If the inclination of the second slope is decreased, then the ball would travel further distances till it reaches the original height.

If the slope is reduced to zero, then the ball will continue to travel forever trying to reach the same height that it was released from. It thus suggests that an unbalanced force is required to change the motion of the ball but no force is needed to sustain the uniform motion of the ball.

In practical situations, it is difficult to achieve a zero unbalanced force because of the presence of the frictional force acting opposite to the direction of motion.



28.4 INERTIA AND MASS

All objects tend to resist the change in the state of motion or rest. This tendency is called inertia.

All bodies (objects) do (does) not have the same inertia. Inertia depends on the mass of a (the) body (object). Mass of an object is the measure of its inertia. More the mass, more will be the inertia of the object.

28.5 NEWTON'S FIRST LAW OF MOTION

"A body continues to be in the state of rest or uniform motion in a straight line, unless acted upon by an external unbalanced force to change that state."

First Law is also called the '**Law of Inertia**'.

This law consists of three parts:

1. **Inertia of rest**: A body at rest continues to remain at rest until some external unbalanced force is applied on the body to move it.

2. **Inertia of motion**: A body in uniform motion continues to move uniformly unless an external force is applied to change its speed.
3. **Inertia of direction**: A body moving along a straight line will continue to move along the same straight line unless an external force is applied on the body to change its direction of motion.

28.5.1 Applications of Newton's First Law of Motion

Coin and glass tumbler

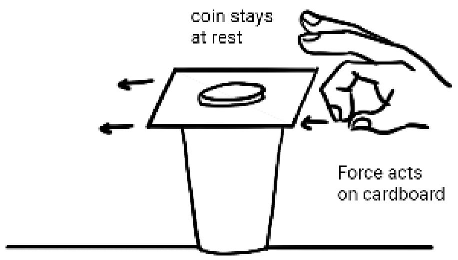


Fig 28.5: Newton's first law of motion

A small coin is put on a card and placed over a glass. When the card is flicked away with the finger. The coin drops into the glass. When we flick the card, the card comes in motion but the coin tends to be in the state of inertia of rest. Therefore, it drops into the glass.

Carpet and dust

When you beat a dusty carpet, you are forcing the dust to move along with the carpet. The dust particles resist motion due to the inertia of rest. This is why dust comes out of a carpet when it is beaten with a stick.

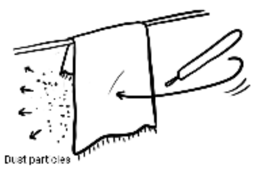


Fig 28.6: Carpet and dust

Backward jerk when a vehicle starts suddenly

If a vehicle starts moving suddenly, we will feel a jerk in the backward direction. It is because the lower portion of our body is in contact with the seat of the vehicle and comes in motion with the vehicle while the upper portion of our body remains at the rest due to inertia and so we feel a jerk in the backward direction.

Forward fall when a vehicle stops suddenly

We fall in a forward direction when moving bus stops suddenly. When a passenger is sitting or standing in a moving bus, both the bus and the passenger are in a state of uniform motion. When the bus stops suddenly, the lower part of the passenger's body comes to rest along with the bus. The upper part of his body tends to remain in a state of motion due to its inertia of motion. As a result, the passenger tends to lean forward.

Sidewards fall when a vehicle takes a turn

When a car rounds a curve suddenly, a person sitting inside is thrown outwards. This is because while the car turns, the person tries to maintain his original direction of motion due to the inertia of direction.

CHECK YOUR PROGRESS 28.2

1. Why do leaves and fruits fall down when we shake the branch of a tree vigorously?
2. The luggage kept on the top of bus and train roof is generally tied with ropes. Explain why.

28.6 MOMENTUM

Momentum is defined as the quantity of motion of the body. It is measured as a product of mass and velocity. As momentum depends upon velocity, it also depends on the direction of the motion of the body. It is a vector quantity and is denoted by 'p'.

$$\text{Momentum} = \text{Mass x Velocity}$$

$$\mathbf{p = mv}$$

S.I. Unit of momentum is kg ms^{-1}(kilogram meter per second)

Please note that velocity is a vector quantity while mass is a scalar quantity.

NUMERICALS

N.1 Calculate the momentum of a toy car of mass 200 g moving with a speed of 5 m/s.

Solution: We know that: Momentum = mass × velocity

$$p = m \times v$$

Here, mass, m = 200 g = 0.2 kg

And, velocity, v = 5 m/s

Putting these values in the above formula, we get:

$$\text{Momentum} = 0.2 \times 5 \text{ kg.m/s}$$

$$p = 1 \text{ kg.m/s}$$

N.2 A body of mass 25 kg has a momentum of 125 kg m/s. Calculate the velocity of the body.

Solution: We know that: Momentum = mass × velocity

$$p = m \times v$$

Here, mass, m = 25kg

And, Momentum = 125 kg.m/s

Putting these values in the above formula, we get:

$$125 \text{ kg.m/s} = 25 \text{ kg} \times v$$

$$v = 125 / 25 \quad \text{or } v = 5 \text{ m/s}$$

28.7 NEWTON'S SECOND LAW OF MOTION

Newton's second law of motion gives the relationship between force and acceleration. It states that "The rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the force."

The rate of change of momentum of an object is directly proportional to the applied force. So, Newton's second law of motion can be expressed as:

$$Force \propto \frac{Change\ in\ momentum}{\text{Time taken}}$$

28.7.1 Derivation of Newton's Second Law of Motion

Suppose an object of mass, m is moving along a straight line with an initial velocity, u. It is uniformly accelerated to velocity, v in time, t by the application of a constant force, F throughout the time, t.

Initial momentum of the object, $p_1 = mu$

Final momentum of the object, $p_2 = mv$

Now,

$$Change\ in\ momentum = p_2 - p_1 = m\,(v - u)$$

$$Rate\ of\ change\ of\ momentum \propto \frac{m\,(v-u)}{t}$$

Now force applied is proportional to the rate of change of momentum. So,

$$Force \propto \frac{Change\ in\ momentum}{\text{Time taken}}$$

$$Force \propto \frac{m\,(v-u)}{t}$$

$$F = \frac{k\,m\,(v-u)}{t} = kma$$

where, k is a constant of proportionality and, $\frac{(v-u)}{t} = a$

The unit of force is chosen in such a way that the value of the constant, k becomes one.

Hence, **F = ma**

The second law of motion gives us a method to measure the force acting on an object as a product of its mass and acceleration.

How much is one Newton of Force?

1 unit of force is defined as the amount of force that produces an acceleration of 1 m/s^2 in an object of a mass of 1 kg.

1 unit of force = 1 N = 1 kg x 1 m/s^2

NUMERICALS

N.4 Find the acceleration produced by a force of 5 N acting on a mass of 10 kg.

Solution: We know that, Force = mass × acceleration or, F = m × a

Here, mass, m = 10 kg and force, F = 5 N

Putting these values in the above formula we get:

5 = 10 a

or, a = 5 / 10

Hence a = 0.5 m/s^2

N.5 A car of mass 2400 kg moving with a velocity of 20 m s^{-1} is stopped in 10 seconds on applying brakes. Calculate the retardation and the retarding force.

Solution: Here, m = 2400 kg, u = 20 m/s, t = 10 s and v = 0 m/s

We know that,

$a = (v – u) / t$

$= (0 – 20)/ 10$

So, $a = -2\ m/s^2$

Now, Force, F = ma

$= 2400 \times (-2)$ So, F = -4800 N

N.6 A sedan car of mass 200 kg is moving with a certain velocity. It is brought to rest by the application of brakes, within a distance of 20m when the average resistance being offered to it is 500N. What was the velocity of the motor car?

Solution: Here, m = 200 kg, v= 0 m/s, s = 20 m and F = -500 N

We know, F = ma So, a = F / m

$a = -500 / 200$ or, $a = -2.5\ m/s^2$

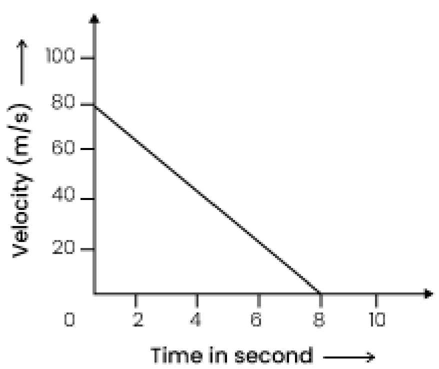
Now $v^2=u^2+2as$

So, $0^2 + u^2 = 2 \times (-2.5) \times 20$ or $u^2 = 100$

Hence, u =10 m/s

CHECK YOUR PROGRESS 28.3

1. A car starts from rest and acquires a velocity of 54 km/h in 2 sec. Find
   i. the acceleration.
   ii. distance traveled by car (assume motion of the car is uniform.)
   iii. If the mass of the car is 1000 Kg, what is the force acting on it?
2. Velocity versus time graph of a ball of mass 100 g rolling on a concrete floor is shown below. Calculate the acceleration, and the frictional force of the floor on the ball?



28.7.2 Application of Newton's Second Law of Motion

1. In the long jumps and high jumps, a sand bed or cushioned bed is provided at the place of landing for the athletes. This is because when an athlete falls on the ground after performing a high or a long jump, the momentum of his body is reduced to zero. If the momentum of an athlete will be reduced to zero instantly, it will result in a large force which may hurt the player.

2. A fielder pulls his hands backward while catching a cricket ball coming with a great speed. While catching a cricket ball the momentum of the ball is reduced to zero. If the ball is stopped abruptly, its momentum will be reduced to zero instantly due to which the ball will exert a large force on the hands of the player. Therefore, by pulling the hands backward a fielder gives more time to the change of momentum to become zero. This prevents the hands of the fielder from getting hurt.

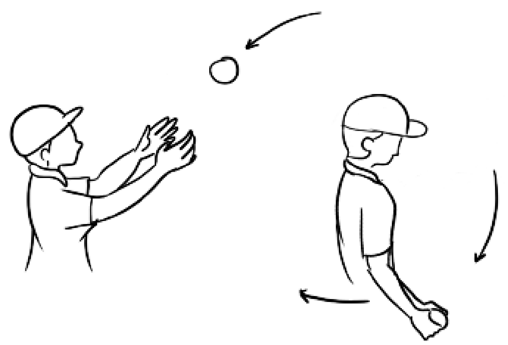


Fig 28.7: Change of Momentum

3. Seat belts in a car are provided to prevent the passenger from getting thrown in the direction of motion. In case of sudden braking or any accident, passengers may get thrown in the direction of motion of the vehicle and may get fatal injuries. Whereas, the stretchable seat belts prevent the passenger's body to fall suddenly and thus increase the time in which the momentum becomes zero. This reduces the effective force, hence preventing the passenger from getting any fatal injury.

CHECK YOUR PROGRESS 28.4

1. Explain how a karate player is able to break a pile of tiles with a single blow of his hand.
2. As per Newton's second law of motion, write the formulae for relationship between
   a. Force and acceleration.
   b. Force and momentum.

27.8 THIRD LAW OF MOTION

Newton's third law of motion states "For every action, there is an equal and opposite reaction."

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. These two forces are acting on two different objects. Although the action and reaction forces are always equal in magnitude, these forces may not produce accelerations of equal magnitude due to the difference in mass of two objects.

28.8.1 Applications of Newton's Third Law of Motion

Recoiling of Gun

When a bullet is fired from a gun, it moves ahead. By Newton's third law of motion, the bullet applies the same force on the gun in the backward direction. Due to this force, the gun moves back giving a jerk to the shoulder of the gunman. This is called the recoil of a gun.

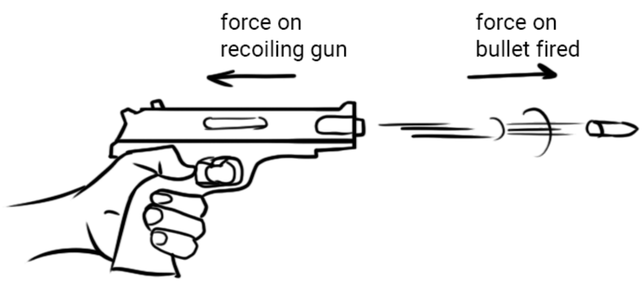


Fig 28.8: Recoil of a gun

Walking of a person

A person is able to walk due to Newton's third law of motion. During walking, a person pushes the ground in backward direction, and in reaction the ground pushes the person with a force of equal magnitude but in opposite direction. This causes him to move in the forward direction against the push.

Jumping out of the boat

When you jump off a boat, you will push yourself forward towards the ground. The same force you used to push forward will make the boat move backward.

Rocket propulsion

In a **rocket**, burning fuel creates a push on the front of the **rocket** pushing it forward. This creates an equal and opposite push on the exhaust gases backward.

Flying of a bird

A bird while flying pushes the air downwards with the help of its wings. Consistent with Newton's third law of motion, the air pushes the bird upwards.

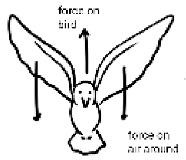


Fig 28.9: Application of Newton's third law of motion while flying

CHECK YOUR PROGRESS 28.5

1. Why is it difficult for a fireman to hold the hose pipe when water rushes out of the nozzle?
2. Explain how Newton's third law of motion is applicable when a person swims in water.

28.9 LAW OF CONSERVATION OF MOMENTUM

The principle of conservation of momentum states that 'If two objects collide, then the total momentum before and after the collision will be the same if there is no external force acting on the colliding objects.'

In other words: According to the law of conservation of linear momentum, if the net external force acting on a system of bodies is zero, then the total momentum of the system remains constant.

Suppose two balls A and B of masses m_A and m_B are travelling in the same direction along a straight line at different velocities u_A and u_B, respectively as shown in Fig. (a). And there are no other external unbalanced forces acting on them.

Let $u_A > u_B$ and the two balls collide with each other as shown in Fig. (b). During collision which lasts for a time t, the ball A exerts a force F_{AB} on ball B and the ball B exerts a force F_{BA} on ball A.

Suppose v_A and v_B are the velocities of the two balls A and B after the collision, respectively.

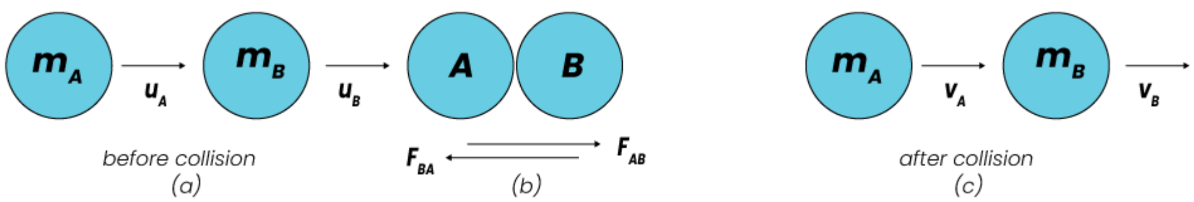


Fig 28.10: Law of Conservation of Mass

The momenta (plural of momentum) of ball A before and after the collision are $m_A u_A$ and $m_A v_A$, respectively. The rate of change of its momentum (or F_{AB}, action) during the collision will be

$$F_{AB} \propto \frac{m_A(v_A - u_A)}{t}$$

Similarly, the rate of change of momentum of ball B (= F_{BA} or reaction) during the collision will be

$$F_{BA} \propto \frac{m_B(v_B - u_B)}{t}$$

According to the third law of motion, the force F_{AB} exerted by ball A on ball B (action) and the force F_{BA} exerted by the ball B on ball A (reaction) must be equal and opposite to each other.

Therefore, $F_{BA} = - F_{AB}$

Now, $F_{BA} = - F_{AB}$ gives

$$\frac{m_B(v_B - u_B)}{t} = -\frac{m_A(v_A - u_A)}{t}$$

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

Total momentum before collision = Total momentum after collision

Since ($m_A u_A + m_B u_B$) is the total momentum of the two balls A and B before the collision and ($m_A v_A + m_B v_B$) is their total momentum after the collision, we observe that the total momentum of the two balls remains unchanged or conserved provided no other external force acts.

This is known as the law of conservation of momentum.

28.9.1 Applications of Conservation of Momentum

Flight of jet planes and rockets

Before firing, the momentum of the rocket is zero. On firing, the gases rush out through the nozzle in the downward direction. The rocket moves such that

momentum of rocket + momentum of escaping gases = 0

Hence, momentum of rocket = - momentum of escaping gases

Negative sign implies that the rocket moves upwards.

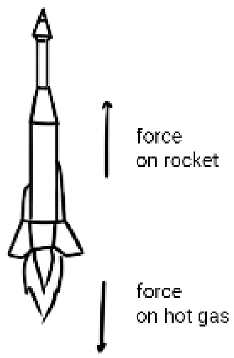


Fig 28.11: Flight of jet planes and rockets

Recoiling of a Gun

Let mass of bullet be m and mass of gun be M, velocity of bullet be v and velocity of gun be V.

Total momentum of gun and bullet before firing is zero as they both are at rest.

On firing, total momentum of gun and bullet = mv + MV

As no external forces are involved in the process, therefore applying law of conservation of momentum, we get

$$mv + MV = 0$$

Now, $mv + MV = 0$

Or, $MV = - mv$

Or, $V = \frac{-mv}{M}$

Negative sign shows that the gun recoils or moves backwards when the bullet moves forward.

Also, M >> m, therefore, V <<v, i .e. as the gun is much heavier than the bullet, the recoil velocity if the gun is much smaller than the velocity of the bullet.

NUMERICALS

N.7 Find the recoil velocity of a gun having mass equal to 5 kg, if a bullet of 25 g acquires the velocity of 500m/s after firing from the gun.

Solution: Mass of bullet (m_1) = 25 g = 0.025 kg

Velocity of bullet before firing (u_1) = 0

Velocity of bullet after firing (v_1) = 500 m/s

Mass of gun (m_2) = 5 kg

Velocity of gun before firing, $(u_2) = 0$

Velocity of gun after firing = ?

We know that, $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$$(0.025 \text{ kg} \times 0) + (5 \text{ kg} \times 0) = (0.025 \text{ kg} \times 500 \text{m/s}) + (5 \text{ kg} \times v_2)$$

$$v_2 = -2.5 \text{ m/s}$$

Thus, recoil velocity of gun is equal to 2.5 m/s. Here negative sign shows that gun moves in the opposite direction of bullet.

N.8 A boy of 50 kg mass is running with a velocity of 2 m/s. He jumps over a stationary cart of 2 kg while running. Find the velocity of cart after jumping of boy.

Solution: Mass (m_1) of boy = 50 kg

Initial Velocity (u_1) of boy = 2 m/s

Mass (m_2) of cart = 2 kg

Initial Velocity (u_2) of cart = 0

Since, boy jumped over cart thus, thus the final velocity (v_1) of boy will be equal to final velocity of cart (v_2). Therefore, $v_1 = v_2 =?$

We know that, $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$$(50 \text{ kg} \times 2 \text{ m/s}) + (2 \text{ kg} \times 0) = (50 \text{ kg} \times v_1) + (2 \text{ kg} \times v_2)$$

$\therefore 100 \text{ kg m/s} = 50 \text{ kg} \times v_2 + 2 \text{ kg} \times v_2$ This gives, $v_2 = 1.92$ m/s

So, the velocity of cart after the jumping of boy is 1.92 m/s

N.9 A truck of mass 500 kg moving at 4 m/s collides with another truck of mass 1500 kg moving in the same direction at 2 m/s. What is their common velocity just after collision if they move off together?

Solution: Mass of the first truck, m_1 = 500 kg and Speed of the first truck, u_1= 4 m/s

Mass of the second truck, m_2 = 1500 kg and Speed of the second truck, u_2= 2 m/s

Combined mass of both trucks, M= 500 +1500 = 2000 kg

And Combined velocity of both the trucks = v =?

Acc. to the law of conservation of momentum

$$m_1u_1 + m_2u_2 = Mv$$

$$500 \times 4 + 1500 \times 2 = 2000 \times v$$

$$v = 2.5 \text{ m/s}$$

So, after collision both the trucks will move off together with a velocity of 2.5 m/s.

CHECK YOUR PROGRESS 28.6

1. A girl of mass 50 kg jumps out of a rowing boat of mass 300 kg on to the bank, with a horizontal velocity of 3 m/s. With what velocity does the boat begin to move backwards?
2. Write the mathematical form of the law of conservation of momentum.

RECAPITULATION POINTS

Some Important Terms

- State of motion – An object has two states of motion: rest and motion.
- Balanced forces – When the number of forces acting on a body produce zero net effect.
- Unbalanced Force – When the number of forces acting on a body produce a non-zero net effect.
- Inertia – The tendency of a body to resist any change in its state of motion.
- Momentum – A physical quantity which is equal to the product of mass and velocity.
- Balanced forces do not bring a change in the state of motion of an object.
- Unbalanced forces produce acceleration or deceleration in objects on which they act.
- Inertia is the tendency of a body to resist a change in its state of motion.
- More the mass of the body, more is its inertia.
- Momentum is the quantity of motion contained by a moving object.
- The magnitude of applied force is directly proportional to the change in momentum and is inversely proportional to the time taken for the change in momentum.
- For every action, there is an equal and opposite reaction.
- Action and reaction forces always exist in pair.
- Action and reaction always act on different objects.
- According to the law of conservation of momentum, the total momentum of a system always remains conserved in the absence of any external force.

TERMINAL EXERCISE

1. Is it possible that an object is at rest even when several forces are acting on it?

2. Two cuboids of same dimensions and same volume are made of different materials. One is made up of wood and the other is made up of iron. Which will have more inertia?
3. When we are riding on a bicycle, why do we have to keep applying force to keep the bicycle moving?
4. Which will have more momentum – a ball of mass 0.5 kg moving with a speed of 10 m/s or a ball of mass 0.2 kg moving with a speed of 5 m/s.
5. What is the momentum of a body at rest?
6. How will the momentum of a body be changed when its velocity is increased by 3 times?
7. Why is glass or chinaware packed with straw?
8. If action and reaction are equal and opposite forces, why do they not cancel each other?
9. State whether the given statements are True or False:
   a. Inertia of an object depends on its mass as well as shape and size.
   b. A constant force is needed to maintain an object in its state of uniform linear motion.
   c. We obtain a definition of force from first law of motion and a measure of the force from second law of motion.
   d. When two moving objects collide among themselves, there is a change in total momentum of the system.

10. Fill in the blanks with appropriate words:

   a. Inertia of _________________ is the property of moving object due to which it cannot change its direction of motion.
   b. Only an __________________ force can change the state of rest or uniform motion of an object.
   c. Force opposing the motion of an object on a rough surface is called _________________.
   d. SI unit of momentum is ____________________.
   e. 1 newton force = __________________ x _________________ .

11. Choose the correct alternative:

   i. **A body at rest can have:**

      a) speed b) momentum
      c) energy d) velocity

   ii. **Newton's second law gives the measure of**

      a) acceleration b) velocity
      c) momentum d) force

   iii. Whenever an object A exerts a force on another object B, object B will exert a return force back on object A. The two forces are:

      a) equal in magnitude and in same direction

b) equal in magnitude but opposite in direction

c) not equal and in opposite direction

d) not equal and in same direction

12. Assertion – Reason Questions:

Note: Read the Assertion and Reason statements carefully and mark the correct option out of the following options:

A. If both assertion and reason are true and the reason is the correct explanation of the assertion.

B. If both assertion and reason are true but the reason in not the correct explanation of the assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

i. Assertion: Momentum of a cricket ball is greater than that of a rubber ball moving with same velocity.
Reason: Momentum of an object is defined as the product of its mass and velocity.

ii. Assertion: A gun recoils when it fires a bullet.
Reason: In the case of gun-bullet system the law of conservation of momentum does not hold good.

iii. Assertion: When a striker hits at the bottom of a pile of coins, the bottom coin comes out without disturbing other coins.
Reason: For every action there must be an equal and opposite reaction.

iv. Assertion: A fielder lowers his hands while catching a cricket ball and suffers less reaction force.
Reason: The time of catch decreases when fielder lowers his hands while catching a ball.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 28.1

1. Force can change the state of motion of a body. For example – if a body is at rest, you kick it and it starts moving. With the application of force, you changed the state of rest to motion. Similarly, if a moving ball is coming toward you, by blocking it with your feet you can bring it to rest. Here, you changed the state of motion to rest with the application of force.
2. When more than one force act on an object in such a way that they balance out each other, the forces are called balanced forces. There will be no net effective force acting on the

object. Balanced forces do not cause a change in motion i.e., the object at rest will continue to be at rest whereas the one in motion will continue to move in the same direction with the same speed. The net force acting on a body is zero.

When more than one force act on an object in such a way that they do not balance each other, the forces are called unbalanced forces. Unbalanced forces acting on an object change its speed and/or direction of motion. It moves in the direction of the force with the highest magnitude. The net force acting on a body will not be zero.

CHECK YOUR PROGRESS 28.2

1. When we shake vigorously a branch of tree, the fruits fall down. It is because on shaking, the fruits tend to be at rest due to inertia whereas the branches are in motion. Hence, the fruits get detached from the branches.

2. When a moving bus suddenly stops, the luggage on its roof tends to resist this change due to the inertia of motion and may get displaced from its position or fall off. Thus, to avoid the falling of the luggage, it is tied with a rope on the roof of a bus.

CHECK YOUR PROGRESS 28.3

1. When car starts from rest, $u = 0$

   Final velocity = 54 km/h = 15 m/s

   Time taken = 2 s

   i. Using $v = u + at$ to find the acceleration

      So, $15 = 0 + a \times 2$

      $a = 15/2 = 7.5\ m/s^2$

   ii. Using $s = ut + \frac{1}{2} at^2$ to calculate the distance travelled by car

      So, $s = 0 \times 2 + \frac{1}{2} \times 7.5 \times (2)^2$

      $= 15$ m

   iii. Mass of the car = 1000 kg

      We know, from Newton's second law of motion $F = ma$

      Here, acceleration, $a = 7.5\ m/s^2$

      So, $F = 1000 \times 7.5$

      $F = 7500$ N

2. Mass of the ball = 100 g

   From the graph, $u = 80$ m/s and $v = 0$ m/s, and the time taken for this change = 8 s

   We know acceleration, $a = (v - u)/t$

So, $a = 0 - 80 / 8 = -10\ m/s^2$

where negative sign indicates that the acceleration is in a direction opposite to the direction of motion, or we can say retardation = $10\ m/s^2$

Now, frictional force of the floor on the ball, f = ma

$F = 100\ g \times 10\ m/s^2$(Here we take retardation as we are calculating retarding force.)

Or, $F = 0.1\ kg \times 10\ m/s^2 = 1\ kg.m/s^2 = 1N$

CHECK YOUR PROGRESS 28.4

1. A karate player can break a pile of tiles with a single blow of his hand. This is because he strikes the piles of tiles with the very fast motion of his hand. In doing so, the large momentum of the fast-moving hand is almost reduced to zero in a very short time. This exerts a very large force on the pile of tiles which is sufficient to break them apart.

2. As per Newton's second law of motion,

   a. Force = mass x acceleration
   b. Force = rate of change of momentum

   or, $\text{Force} = \frac{\text{final momentum} - \text{initial momentum}}{\text{time taken for the change in momentum}}$

CHECK YOUR PROGRESS 28.5

1. When a fireman directs a powerful stream of water on a fire, the hose pipe tends to go backward due to the reaction force of the water rushing through it in the forward direction at a great speed.

2. Man pushes water back by applying force. By Newton's third law of motion, water applies equal and opposite force on the swimmer. Due to this force man moves ahead.

CHECK YOUR PROGRESS 28.6

1. Mass of the girl = 50 kg

   Mass of the boat = 300 kg

   Velocity of the girl = of 3 m/s

   The velocity with which the boat begins to move backwards =?

   Initially, both the girl and the boat are at rest so the initial momentum of the system is zero. Therefore, the final momentum of the system will be zero as per the law of conservation of momentum.

   So, 0 = Final momentum of girl + Final momentum of boat

   Or, Final momentum of Girl = - Final momentum of Boat mass of girl x velocity of girl = - mass of boat x velocity of boat

50 kg x 3 m/s = - 300 kg x v

Or, v = - 0.5 m/s

Hence, the boat moves backwards with a speed of 0.5 m/s

2. According to law of conservation of momentum,

   Total momentum before collision = Total momentum after collision

   Or we can write, $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

   where m_1 and m_2 are the masses of object 1 and 2 respectively, 'u' refers to initial velocity and 'v' refers to the final velocity of the two objects which undergo collision.

29 GRAVITATION

INTRODUCTION

You have learned about how objects move in the previous Chapters. We discovered that the force is what causes the object's speed and direction to change. It's a common observation that anything raised above the earth's surface wants to return to the surface. Planets, as we all know, revolve around the sun. The Moon is orbiting the Earth. So it follows that there must be a force behind all of these observations.

29.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Visualise gravitational force as the underlying force that holds this solar system, and indeed the entire universe
- Apply Newton's law of gravitation to various objects
- Understand the meaning of gravity acceleration
- Apply equations of motion to an object falling under gravity
- Solve problems involving one-dimensional motion under gravity
- Distinguish between mass and weight
- Show free fall motion and explain weightlessness
- Use pressure knowledge to explain various concepts
- Show the force of buoyancy experienced by a body immersed entirely or partially in a fluid.
- Define density mathematically and physically.
- Investigate Archimedes' principle and apply it to problem solving.

29.2 GRAVITATION

For a moment, imagine a falling leaf from a tree towards the earth, and the earth revolving around the sun. Can you think of anything they have in common? Yes, both situations involve some form of force. In 1687, Isaac Newton proposed that a single type of force controls these phenomena. This force came to be known as gravitational force. Due to this force, fruits and leaves falls from a tree and due to same force provided by Sun, the Earth orbits the Sun. The same force causes the Moon to orbit the Earth, stars to orbit the centre of the galaxy, and galaxies to collide.

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Figure 29.1: Andromeda Galaxy at a distance of 2.5 million light years.

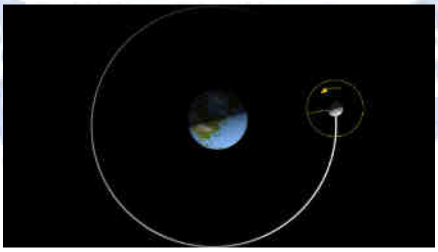


Figure 29.2: Moon orbiting Earth

29.2.1 History of Gravitational theory

1. 15th century BC - The oldest record of this force in the history of human kind finds its mention in Rig veda: “Savita yantraihprithiveem aramnaatdyaamandahat atoortebaddhamashwamaevadhukshat” [rig veda 10.149.1]
   -Meaning “The sun has attracted the earth and other planets and moves them around itself as if a trainer moves newly trained horses around itself while holding their reins.
2. 4thcentury BC -Aristotle, the Greek philosopher, believed that objects gravitate toward a point due to their inner gravitas (heaviness).

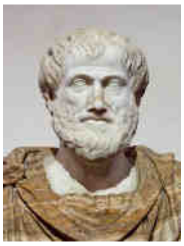


Figure 29.3: Aristotle

3. 6^{th} century CE – Aryabhata calculated solar and lunar eclipses. He discovered that the apparent westward motion of stars is caused by the rotation of the spherical Earth about its own axis. Aryabhata also observed that the luminosity of the Moon and other planets is due to reflected sunlight; he was also involved in calculating the diameter of the Earth and the length of the Earth's sidereal year.

Figure 29.4: Aryabhat

4. 7^{th} century CE – Using the term "gurutvakarshanam", Brahmagupta first described gravity as an attractive force. He gave methods for calculating the position of celestial bodies over time (ephemerides), their rising and setting, conjunctions, and solar and lunar eclipses.

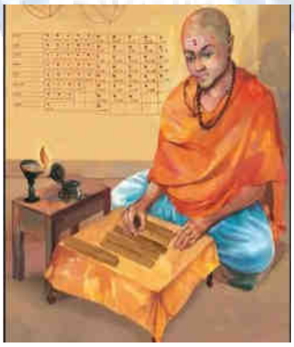


Figure 29.5: Brahmagupta

5. 14th century CE - Jean Buridan and Albert of Saxony, linked impetus(inertia) to object acceleration and mass.

6. 17th century CE – Galileo Galilei, an Italian astronomer, discovered that all objects accelerate equally in free fall. Various researchers began investigating the existence of

the gravitational constant in the mid-17th century. Galileo observed that the force of gravity appears to depend solely on an object's mass and not on any of its other characteristics.

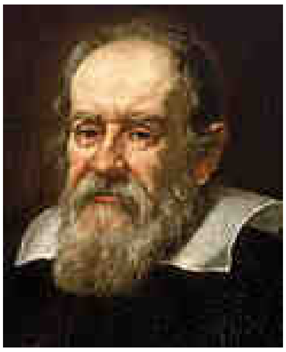


Figure 29.6: Galileo Galilei

7. In 1687 CE– Isaac Newton, developed a mathematical model of the universal law of gravitation.

Figure 29.7: Isaac Newton

8. 20th century CE – Einstein gave general theory of relativity also known as "Einstein theory of gravity".

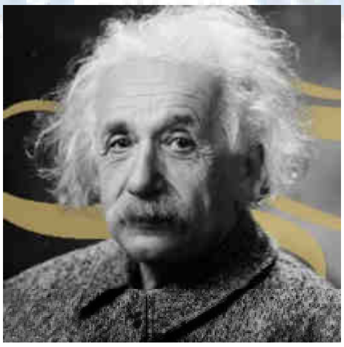


Figure 29.8: Einstein

CHECK YOUR PROGRESS 29.1

1. Perform the activity as shown in the figure below with the help of a thread and stone in first step. In the second step release the stone. Observe the path of stone before and after release.

Based on activity, answer the following questions

(a) What is the path of stone before release?
(b) What is the path of the stone after release?
(c) What holds the stone in circular path?
(d) What is the direction of this force?
(e) What is the name of the force directed towards centre in circular motion.?

Q.2 Compare the model in the activity 1 to revolution of moon around earth (fig. 29.2), and answer the following questions.

(a) Which force holds the moon in circular path around the Earth?
(b) What would happen to the Moon if suddenly this force disappears?

29.3 UNIVERSAL LAW OF GRAVITATION

Isaac Newton used to ponder deep on the phenomenon of objects falling downwards. People Say that One day while sitting under a tree an idea clicked to him. He thought that if gravitational force has its effect on objects above ground, it might have its effect on large distances such as on the moon, sun, and other planets. After extensive research and mathematical calculations Newton gave Gravitational theory.

According to Newton's gravitational theory, there is a force with which every particle attracts every other particle along a line connecting them. This force depends directly on the mass of the particles and depends inversely on the distance between the particles.

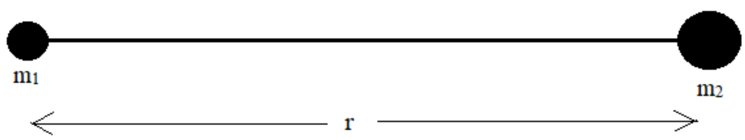


Fig 29.9: Force between two bodies

Newton expressed the attractive force between two objects of masses m_1 and m_2 at a distance of r, mathematically as follows:

$$F \propto \frac{m_1 m_2}{r^2}$$

or

$$F = G\frac{m_1 m_2}{r^2} \ldots\ldots\ldots (29.1)$$

where G is a constant of proportionality. It is called the universal gravitational constant. Its value is same everywhere on the earth or in the universe. In SI units, where m is measured in kilogram, F in newton, r in metre, the accepted value of G is 6.67 × 10–11 Nm^2kg^{-2}. The force is very negligible for small masses as one can see the value of G being very small.

The force between a person and the earth is very high as compared to the force of attraction between two persons sitting at a distance of about 1 metre. Therefore, one can see the effect of gravitational force only when large masses are involved.

Example 1: The mass of the earth is 6×10^{24} kg and that of the moon is 7.4×10^{22} kg. If the distance between the earth and the moon is 3.84×10^5 km, calculate the force exerted by the earth on the moon. (Take $G = 6.7 \times 10^{-11}$ N m^2 kg^{-2})

Solution: The mass of the earth, $m_1 = 6 \times 10^{24}$ kg
The mass of the moon, $m_2 = 7.4 \times 10^{22}$ kg
The distance between the earth and the moon,
$r = 3.84 \times 10^5$ km
$= 3.84 \times 10^5 \times 1000$ m
$= 3.84 \times 10^8$ m

$G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}

From Eq. (28.1), the force exerted by the earth on the moon is

$$F=G\frac{m1m2}{r^2}$$

$$=6.7 \times 10^{-11} \times \frac{6 \times 10^{24} \times 7.4 \times 10^{22}}{(3.84\times10^8)^2} \frac{N \times m^2 \times kg^{-2} \times kg \times kg}{m^2}$$

$= 2\times10^{20}$N

Thus, the force exerted by the earth on the moon is 2×10^{20} N.

Example 2: 2A 45-kilogram boy stands on the earth's surface. Find the force of attraction between the boy and the earth if the earth's mass is 6 x 10^{24} kg and its radius is 6.4 x 10^{6}m. Take the value of Gas 6.67×10^{-11}Nm^{2} kg^{-2}.

Solution:

Mass of the earth = 6×10^{24} kg

Mass of the boy = 45 kg

Radius of the earth = 6.4×10^{6} m

(This is the distance separating the boy from the centre of the earth)

The force of attraction (F) between the boy and the earth is given by formula

$$F=G\frac{m_1m_2}{r^2}$$

$$= 6.67 \times 10^{-11}\times \frac{6\times10^{24}\times45}{(6.4\times10^{6})^{2}}\frac{\text{N}\times\text{m}^{2}\times\text{kg}^{-2}\times\text{kg}\times\text{kg}}{\text{m}^{2}}$$

= 440 N

CHECK YOUR PROGRESS 29.2

Q.1 Find the force between you and your friend if both of you are 35 kg each at 1 metre distance. Why you could not feel this force?

Q.2 How much will the gravitational force change if the distance between two bodies is tripled?

29.4 IMPORTANCE OF THE UNIVERSAL LAW OF GRAVITATION

The universal law of gravitation gave a breakthrough in the field of physics as it gave a common basis to explain a number of phenomena like pulling of objects towards the earth, the revolution of the moon round the earth, the revolution of planets round the sun , the tides in oceans due to the pull of celestial objects in space like the moon and the sun .

29.5 ACCELERATION DUE TO GRAVITY

Do you aspire to skydive one day? Imagine yourself skydiving with your friends. the experience of skydive is large scale version of what you feel when you come down in free-fall in merry-go and Columbus rides. Now, discuss these questions in your class.

Figure 29.10: Skydiving

Why do you think your speed increases as you jump out of plane? Why do you feel weightless when coming down the slide towards earth?

When objects fall towards the earth under the influence of gravity, it is said that they are in free fall. So, when the object is in free fall its velocity increases. Due to change in velocity we say that the object is accelerating. This acceleration is known as the acceleration due to the earth's gravitational force (or acceleration due to gravity). It is represented by the letter g. The unit of “g” is same as that of acceleration i.e. ms^{-2}.

The second law of motion states that force is the product of mass and acceleration. In activity 29.2, let the mass of the sky diver be m and the mass of the earth be M. The magnitude of the gravitational force F will be equal to the product of mass and gravitational acceleration, i.e.

$$F=mg......(29.2)$$

Also, force is given as, $F=G\frac{mM}{r^2}$

Combining the above two equations we get,

$$mg=G\frac{mM}{r^2}$$

Rearranging,

$$g = \frac{GM}{r^2} \qquad \ldots\ldots (29.3)$$

Let an object be on or near the surface of the earth. The distance r in Eq. (29.3) can be taken as equal to R, the radius of the earth,

$$g=G\frac{M}{R^2} \quad \ldots\ldots (29.4)$$

As you can see the value of 'g' is independent of the mass of the freely falling body. Putting the values of G, R and M in Eq. (29.4) we get the value of gas 9.8 ms^{-2}. The radius of the earth is not same at all the places on the surface of the earth. So the value of 'g' changes from place to place on the earth. Its value is greater at the poles than at the equator.

29.6 MOTION OF AN OBJECT UNDER GRAVITY

When an object moves in space near the surface of earth, under the influence of gravitational force of earth it is attracted towards the earth with a constant acceleration 'g' as discussed in the previous section. Therefore, the acceleration 'a' in the three equations of motion can be replaced with 'g'.

$$v = u + gt \ldots\ldots (29.5)$$

$$s = ut + \frac{1}{2}gt^2 \ldots\ldots (29.6)$$

$$v^2 = u^2 + 2gs \quad \ldots\ldots (29.7)$$

where u and v are the initial and final velocities and s is the distance covered intime t .

Example 29.3: A ball thrown vertically upward rises to a height of 150 m.
(i) Find the velocity with which the ball was thrown upwards and
(ii) Find the time the ball takes to reach to the highest point.
(Take g = 9.8 ms^{-2})

Solution: At the highest point the velocity of ball becomes zero.

Therefore,

Distance travelled, s = 150 m

Final velocity, v = 0 ms^{-1}

Acceleration due to gravity, g = 9.8 ms^{-2}

From equation (29.7)

$v = u^2 + 2gs$

$0 = u^2 + 2(-9.8\ ms^{-2}) \times 150\ m$

For upward motion g is taken as negative.

Therefore,

$-u^2 = -2 \times 9.8 \times 150\ m^2s^{-2}$

$u^2 = 2940\ m^2s^{-2}$

$u = 54.2ms^{-1}$

Thus the velocity with which the ball was thrown upwards is $54.2ms^{-1}$.

(ii)From equation (29.5),

$v = u + gt$

$0 = 54.2ms^{-1} + (-9.8\ ms^{-2}) \times t$

$-54.2=-9.8\times t$

$t = 5.5s$

Therefore, time taken by the ball to reach the highest point is 5.5 seconds.

CHECK YOUR PROGRESS 29.3

I. Choose the correct option

i. The value of acceleration due to gravity

(a) is same on equator and poles

(b) is least on poles

(c) is least on equator

(d) Increases from pole to equator

2. What is the SI unit of acceleration due to gravity.

29.7 MASS AND WEIGHT

29.7.1 MASS

The mass of a body is the amount of matter contained within it. The mass of an object is constant and does not vary with location. It does not matter whether the object is on Earth, the Moon, or anywhere else in space. A pan balance is used to determine the mass of an object.

We also learned in the previous chapter that an object's mass is a measure of its inertia. It means that the greater the object's mass, the greater its inertia.

Figure 29.11: Prototype of Kilogram

29.7.2 WEIGHT

The weight of an object is the force with which it is attracted towards the earth. Can you recall the relation between force and acceleration?

Force = Mass × Acceleration

Therefore, F = mg

If weight of an object is denoted by W, then

$$W = mg \qquad \text{.......(29.8)}$$

As weight is a force, its SI unit is the same as that of the force as Newton with symbol N. The weight acts in a vertical downward direction. It has magnitude as well as direction.

As you can see that the weight of an object is determined by its mass and the value of g. Because the value of g is constant at any given point, the weight of an object at any given point is directly proportional to its mass. But as the value of "g" changes from planet to planet & from moon to moon, so, does the weight of an object varies.

29.7.3 WEIGHTLESSNESS

You may have noticed increase in weight while in moving in Lift/Elevator upward and decrease in weight when moving downward. Similar case you can experience in merry-go-round. Also, you have heard that an astronaut experiences weightlessness in space. What does the term weightlessness mean?

ACTIVITY 1

Hold a heavy book in your hand. Can you feel the book's weight in your hand? Now, move your hand quickly and with some acceleration downward. What are your thoughts? Do you notice a reduction in the weight of the book? Can you think of the reason for this

Figure 29.12: Experience in weight

We usually weigh things with a spring balance or a weighing machine that sits on a rigid floor. How does a weighing machine determine an object's weight? Assume a child is standing on a floor-mounted weighing machine. On the machine, the child applies a downward force equal to his weight W.

The machine exerts an upward reaction 'R' on the boy that is equal to W, according to the third law of motion. The weighing machine determines the reaction R, which is the boy's weight. Assume the floor beneath the weighing machine is suddenly removed. What would occur? The boy and the scale would both fall to the ground at the same rate. The boy cannot exert force on the weighing machine. In this case, the weighing machine would display a zero weight. As a result, we can say that a body falling freely under gravity is weightless.

You can now understand why an astronaut feels weightless in a spaceship. The astronaut's spaceship falls freely towards the Earth. As a result, the astronaut appears to be weightless.

CHECK YOUR PROGRESS 29.4

1. Write two differences between mass of an object and its weight.

2. State two factors on which weight of an object depends.

3. What will be the weight of an apple while it is falling from a tree?

29.8 THRUST, PRESSURE, BUOYANCY

29.8.1 THRUST

Have you ever wondered why a camel can run so easily in the desert? Why is an army tank weighing over a thousand tonnes supported by a continuous chain? Why do trucks and buses have much wider tyres? Why are the edges of cutting tools so sharp? To answer these questions and comprehend the phenomena involved, it is useful to first introduce the concepts of net force in a specific direction (thrust) and force per unit area (pressure) acting on the object in question.

You have learned that weight is the vertical downward force. The force is acting perpendicular to the sand's surface here. Thrust is the force acting on an object perpendicular to the surface. When you stand on loose sand, the force, that is, your body's weight, acts on an area equal to the area of your feet. When you lie down, the same force acts on an area equal to your entire body's contact area, which is larger than the area of your feet. As a result, the effects of forces of the same magnitude on different areas differ. The thrust is the same in all of the examples above. However, the effects vary. As a result, the effect of thrust is determined by the area on which it acts. When standing, the effect of thrust on sand is greater than when lying. Pressure is the thrust per unit area:

$$pressure=\frac{Thrust}{Area} \qquad ....(29.9)$$

Substituting the SI unit of thrust and area in above Eq (29.9), we get the SI unit of pressure as N/m^2 or $N\ m^{-2}$.

In honour of scientist Blaise Pascal, the SI unit of pressure is called pascal, denoted as Pa.

Example 4: A block of wood is kept on a tabletop. The mass of wooden block is 10 kg and its dimensions are 50 cm × 20 cm × 10 cm. Find the pressure exerted by the wooden block on the table top if it is made to lie on the table top with its sides of dimensions (a) 20 cm × 10 cm and (b) 50 cm × 20 cm.

Solution: The mass of the wooden block = 10kg. The dimensions = 40 cm × 20 cm × 10 cm
Here, the weight of the wooden block applies a thrust on the table top.

That is, Thrust = F = m × g = 10 kg × 9.8 m s–2 = 98 N

Area of a side = length × breadth = 20 cm × 10 cm = 200 cm^2 = 0.02 m^{2}From Eq. (28.9),

$$pressure = \frac{Thrust}{Area}$$

Pressure=$\frac{98}{0.02}$ N/m

= 4900 Pa

When the block lies on its side of dimensions 50 cm × 20 cm, it exerts the same thrust.

Area= length × breadth = 50 cm × 20 cm = 1000 cm2 = 0.1 m^2 , Pressure = $\frac{98}{0.1}$= 980 N m^{-2}.

The pressure exerted by the side 20 cm × 10 cm is 4900 N m^{-2} and by the side 50 cm × 20 cm is 980 Nm^{-2}. So, you can see how pressure decreased when area increased.

29.8.2 BUOYANCY

Have you ever noticed that a mug full of water feels lighter inside the bucket of water to that outside of the bucket? Why is this case? Let us look at it through the lens of an activity.

ACTIVITY 2

Take a large wooden block and put it in a bucket filled with water. What do you observe? You will see that the wooden block floats when placed on the surface of water.

Now push the block into the water. What do you feel? Why do you feel an upward push on your hand? What does it indicate? This indicates that water exerts an upward force on the wooden block. Now, push the wooden block further down till it is completely immersed in water. Release the wooden block. What do you observe? The block bounces back to the surface of water.

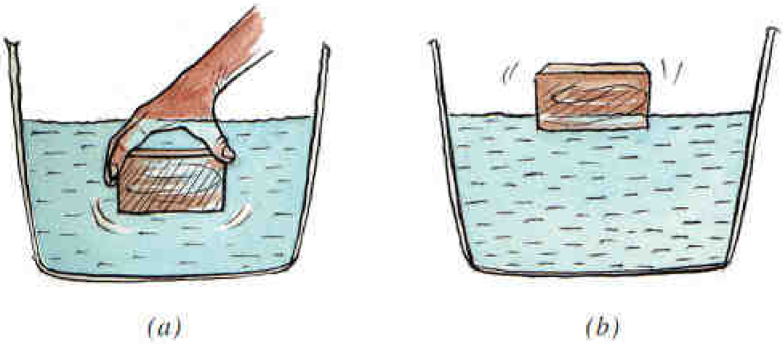


Figure 29.13 (a) Block inside water (b) block floating at surface

The upward force exerted by the water on the wooden block is referred to as buoyant force. This force is also referred to as upthrust. In fact, when immersed in a fluid, whether liquid or gas, all bodies experience a buoyant force. Can you provide any additional examples of buoyant force?

What is the magnitude of a buoyant force felt by an object? Is the buoyant force experienced by all objects in a given fluid the same? Isn't this true for all fluids in a given object? After studying Archimedes' principle, you will be able to answer all of these questions.

Figure 29.14: Can you now tell why does our body feel light in water?

29.9 RELATIVE DENSITY

The amount of mass contained in a given volume of a substance is referred to as its density. The density of a specific substance remains constant under specified conditions. One of a substance's distinguishing characteristics is its density. It varies depending on the substance. Silver, for example, has a density of 10490 kgm^{-3}, whereas water has a density of 1000 kgm^{-3}. The density of a given substance sample can help us determine its purity. Mathematically, Density is mass divided by volume of substance:

Density$=\frac{\text{mass}}{\text{volume}}$ (kg/m^3) ……(29.10)

Can you explain why wooden objects float while iron objects sink in water? The density of a substance is defined as its mass per unit volume. Wood has a lower density than water. This means that the upthrust of water on the cork is greater than the weight of the cork. So it floats. The density of an iron nail is greater than that of water, implying that iron has more mass for the same volume as water. This means that the upthrust of water on the iron nail is less than the weight of the nail. So it sinks. As a result, objects with a density less than that of a liquid float on it. The objects of density greater than that of a liquid sink in the liquid.

It is often convenient to express density of a substance in comparison with that of water. The relative density of a substance is the ratio of its density to that of water:

$$\text{Relative density} = \frac{\text{Density of substance}}{\text{Density of water}} \qquad \ldots\ldots(29.11)$$

29.10 ARCHIMEDES' PRINCIPLE

ACTIVITY 3

Take a piece of stone and suspend it with a thread from a spring balance. Take note of the spring balance reading. This is the stone's weight in air. Now, slowly immerse the stone in a container of water.

Pay close attention. What happens to the balance's reading? The reading of the spring balance will decrease as the stone is gradually lowered into water. When the stone is completely immersed in water, the reading of the spring balance does not change. What conclusions do you draw from this observation? The decrease in the reading of the spring balance indicates that when the stone is dipped in water, an upward force acts on it.

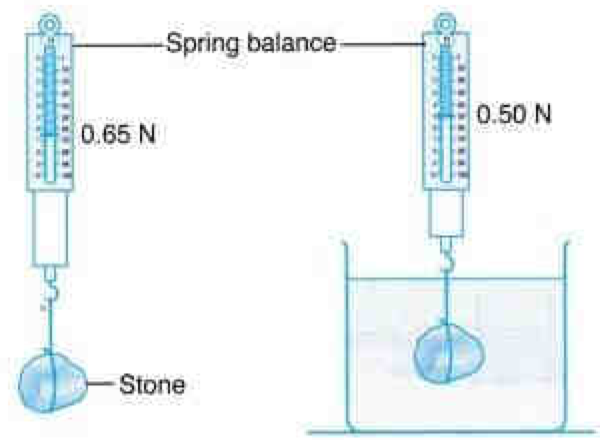


Figure 29.15: Reading of the spring balance decreases when the stone is immersed in water

This upward force is known as the buoyant force, as previously discussed. Archimedes discovered a principle for calculating the magnitude of buoyant force.

The following is Archimedes' principle: "When a body is fully or partially immersed in a fluid, it experiences an upward force equal to the weight of the fluid displaced."

According to Archimedes' principle, the magnitude of the buoyant force acting on a body at a given location is determined by the density of the fluid and the volume of the body immersed in the fluid.

Archimedes' principle has a wide range of applications. It's used in the design of ships and submarines. Archimedes' principle underpins hydrometers, which are used to determine the density of liquids. This principle is also used in lactometers, which are used to determine the purity of milk.

CHECK YOUR PROGRESS 29.5

1. Why does lifting a mug inside water feel lighter?
2. Why does a piece of cork released under water bounce back?
3. What do you understand by buoyant force?
4. Will the buoyant force act in a vacuum?
5. What are the applications of Archimedes' principle?

RECAPITULATION POINTS

- According to Newton's law of gravity, every particle in the cosmos attracts every other particle with a force proportional to the product of their masses and inversely proportional to the square of their separation.
- The gravitational force between typical mass objects is quite weak. When big masses are involved, however, the force becomes much stronger.
- Gravity is the gravitational force exerted by the earth.
- The value of gravity's acceleration is independent of the body's mass.
- An object's weight is equal to the product of its mass and gravitational acceleration, and it is the force that pulls it to the ground. An object's mass is constant and does not

change with its location. However, the weight of an object may differ from one location to the next.

- The force exerted on an item perpendicular to the surface is termed thrust.
- A body falling freely under gravity is called weightless.
- When immersed in a fluid, all objects experience a buoyant force. The magnitude of the buoyant force acting on a body at a given place depends on density of the fluid and volume of the body immersed in the fluid.
- When a body is submerged totally or partially in a fluid, it experiences an upward force proportional to the weight of the fluid displaced by it, according to Archimedes' principle.

TERMINAL EXERCISE

Q1. Choose the correct option

i. The earth holds the atmosphere around it with the application of earth's:

(a) gravity

(b) wind

(c) clouds

(d) earth's magnetic field

ii. What do we call the force of attraction between two unit point masses which are at a distance of one unit?

(a) gravitational potential

(b) acceleration due to gravity

(c) gravitational field

(d) universal gravitational constant

Q2. Answers the following questions

a) Define Newton's gravitational law.

b) The distance between two objects is increased by 2 times, by what factor gravitational force will change?

c) When the masses of two objects are doubled, how does the gravitational force between them change?

d) Derive the expression of the acceleration due to gravity on earth.

e) Write the motion equations for an object that is solely moving or falling due to gravity.

f) What is the difference between an object's mass and its weight?

g) What causes a sealed empty plastic bottle thrown beneath water to bounce back to the water's surface?

h) What is buoyancy force? On what factors the magnitudes of the buoyant force depend?

i) How will you define Archimedes principle. Also give examples?

j) What would be the gravitational force between the earth and the sun. Take distance between them as 1.5 $x10^{11}$metres. (Take the earth's mass is 6 $x10^{24}$ kg, the sun's mass as 2 $x10^{30}$ kg, and the value of Gas 6.7x 10^{-11} $Nm^2kg^{-2)}$

k) What would be the mass of an object weighing 49N? ($g = 9.8\ ms^{-2}$)

l) What would be velocity of an object thrown from a 100 m high building when it reaches the ground? ($g = 10\ ms^{-2}$).

m) If the weight of an object in air is 3N and in waters it is 2N. How much is the Buoyant force acting on the object?

n) How much is the Buoyant force acting on the body if the liquid displaced by the body weighs 1 N when immersed in water?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 29.1

1. (i) The stone moves in a circular path.

   (ii)The stone starts on a straight path when released.

   (iii) the force (due to tightness in the thread) holds the stone in circular path.

   (iv) This force is directed towards the center where thread is being held.

   (v) Centripetal force.

2. (i) gravitational force

   (ii) moon would stop orbiting earth and would travel in a straight-line path in space with uniform speed.

CHECK YOUR PROGRESS 29.2

1. $F=G\frac{m1m2}{r^2}$

$= 6.67 \times 10^{-11} \times \frac{35\times35}{(1)^2}\frac{N\times m^2\times kg^{-2}\times kg\times kg}{m^2}$

$= 8.17 \times 10^{-8}$ N

The Gravitational force of attraction between objects of small mass is very small. Therefore we do not feel this attractive force .

2. Decrease by a factor of 1/9.

CHECK YOUR PROGRESS 29.3

1. (c)
2. m/s^2

CHECK YOUR PROGRESS 29.4

1. Difference between mass and weight:
   - Mass is the measure of how much amount of matter is contained in a body.
   - Mass of a body does not change from place to place.
   - Weight of an object is the measure of the net force with which it is attracted towards the Surface of any celestial body on which it is present.
   - Weight of an object can change from place to place.

2. The Weight of an object is dependent on

(i) mass of object

(ii) acceleration due to gravity.

3. The weighing machine in this case would show a zero weight. Thus, we can conclude that an apple falling freely under gravity is weightless.

CHECK YOUR PROGRESS 29.5

1. A buoyant force is applied on the mug in an upward direction when it is immersed in water. Because of this upward, the object feels lighter inside water. When the object is lifted above the surface of water the upward buoyant force is no longer there as it is outside the water therefore it feels heavier.

2. Inside the water an upward buoyant force is applied on the cork which is more than the weight of the cork. Therefore it bounces back out of the water.

3. When an object is immersed in a fluid an upward force is applied by the fluid on the object. This upward force is named as the buoyant force.

4. No.

5. Archimedes's principle is used:

(i) In the design and manufacturing of ships and submarines.

(ii) In the making of hydrometers or lactometers.

(iii) In finding the purity of a substance

SUPPLEMENTARY STUDY MATERIAL

1.https://courses.lumenlearning.com/physics/chapter/6-5-newtons-universal-law-of-gravitation/

2. https://knowingmahadev.wordpress.com/2015/01/18/vedic-science-on-gravitation/

3. NCERT

4. NIOS

5. https://www.mphysicstutorial.com/2021/06/laws-of-motion-class-11th-physics-notes.html

6. https://www.scienceabc.com/eyeopeners/skydiving-how-fast-can-you-fall-through-the-air-terminal-velocity.html

7.https://www.vox.com/science-and-health/2018/11/14/18072368/kilogram-kibble-redefine-weight-science

SOURCES OF ENERGY

ON

ed life span from now on is about 5 billion years. Think of t

ur sky. Think of the time when our coal mines have no dep

y. What do you think about our life then? There will be no l

ot germinate, plants will die and there will be no food for us

able. There will be no means of transport, and industrial pro

me dull (not to speak of animals), lose all the intelligence, p

d over millions of years. They will wait helplessly for imm

uld such things happen? If we look for the reason, we can id

ources are exhausted.

...NERGY?

...work is defined as energy. Energy plays an important role i... ...nd a variety of examples in which energy is used to do work... ...cycles and cars, cooking food on stoves and lighting our ho... ...orms such as heat, mechanical, light, sound, chemical, elect... ...ole universe is conserved but in daily life it can be transform... ...nple, we can convert electrical energy into heat energy by el... ...l energy in to electrical energy by dynamo, light energy int... ...The most common form of energy is mechanical energy. It ... ...and potential energy. The kinetic energy of flowing water i... ... energy and that again can be used as light and heat energy ... ...know the sources and nature of all kind of energies.

...S OF ENERGY

...of any life activity where we do not require energy. Is this e...

TERISTICS OF A SOURCE OF ENERGY

gy should satisfy certain conditions. A block of coal wh

nnot be called a source of energy because source of ene

l quantity of energy at a steady rate over a long period o

heat and used in thermal power stations to produce electri

the world would sustain generation at the present rate for

s deposits similarly can supply energy for over a numb

ded as source of energy. By this definition, can you call a b

y should be convenient for extraction; must be convenient t

od is burnt for cooking. But if the trees are in such inac

orted from that region, it is not a dependable source

source of energy is that it should be capable of providi

hat is meant by useful energy? To lift coal from a mine, ele

The energy required for running the machines is the inpu

replenished or supply renewed any more are therefore, cl
The known deposits of non-renewable sources of energy wi
for alternative sources has gathered momentum in recent ye

and, the solar energy harnessed from flowing water, tide, oc
gy sources that are directly or indirectly related to the S
as the sun shines in our sky. Nuclear and thermal energies
rgy available for a long period. The availability of this type
of time. These sources of energy are classified as renewabl
y from flowing water of the river are two types of ener
as and nuclear energy are referred to as non- conventional s

y firewood obtained by cutting of tree belong? It is renew
ace those cut down to maintain the availability level. In fac
we get firewood from it. Therefore, large scale cutting

ERGY

of solar energy in our daily life is evident through vario

growth. Salt is obtained by evaporation of sea water due

by sunrays. Food grains, wet cloth and fish etc. are also dri

alternate sources of energy, it was observed that solar ene

c needs like cooking food and heating water by using sola

ely. The solar energy is also used in solar cells to directly

ges of use of solar energy for such uses. No running expens

is used. It can be used anywhere. The upkeep and mainte

ment friendly and do not cause pollution in any form. T

ken for cooking by solar cooker, the description of which

ar cells are very expensive. Also alternative arrangement h

of energy during the night or in the cloudy day in the abse

OF ENERGY IN THE SUN

om 4 to 7kW/km^2 depending on the location. With the use
MW/km^{2}of energy can be harnessed from solar energy.

ITION OF SOLAR ENERGY

onsists of a type of waves. Radiation coming from the Sun,
wave lengths. A part of the solar radiation is visible to u
ngths in the visible part, give sensation of different color
esponds to red light while the smallest wave length rel
ave length more than that of red color are called infrared a
t light. Our eye is not sensitive to the wavelength in this
he solar radiation.

of the energy in solar radiation lies in the form of in
the objects that lie on its path. The heat that we feel in the
tion present in it. In the visible part of the sunlight, red

mponent of sunlight that mainly carries heat with it.

mponents of solar radiation that are not visible to us.

activities from our daily life in which solar energy is utiliz

NERGY DEVICES

ve been utilizing solar energy for various purposes throu incident over the earth is effectively used. Hence technol y in a more convenient and efficient manner. Based on the ces can be broadly classified into two types. Solar cooker, s solar water pumps belong to the 1st group. In these device tor or concentrate. Solar cells belong to the second gro ectricity directly.

LAR ENERGY IS TRAPED

t. So both, visible and infrared light, enter into the box. Mo
lack surface of the inner walls. Once the walls become ho
of infrared radiation. But this infrared radiation is of longe
e black surface (black body) is quite low compared to the
glass which is transparent to the infrared radiation of shorte
to the infrared radiation of longer wavelength coming fro
pped inside the box.

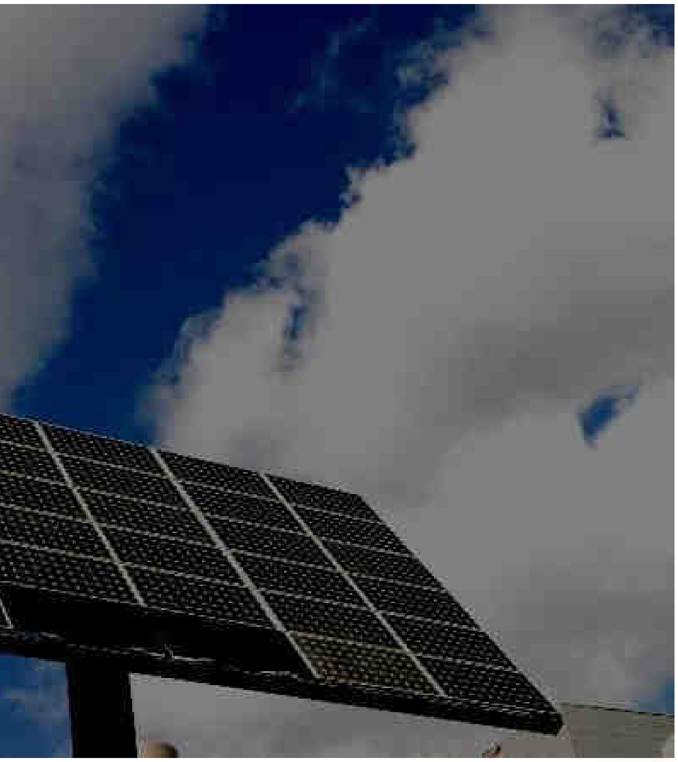
a practical application. If a house like structure made of gl
d climatic condition, the heat trapped in the house will mai
e. This is called greenhouse effect. Seeds germinate easily
e the greenhouse grows at the appropriate temperature.

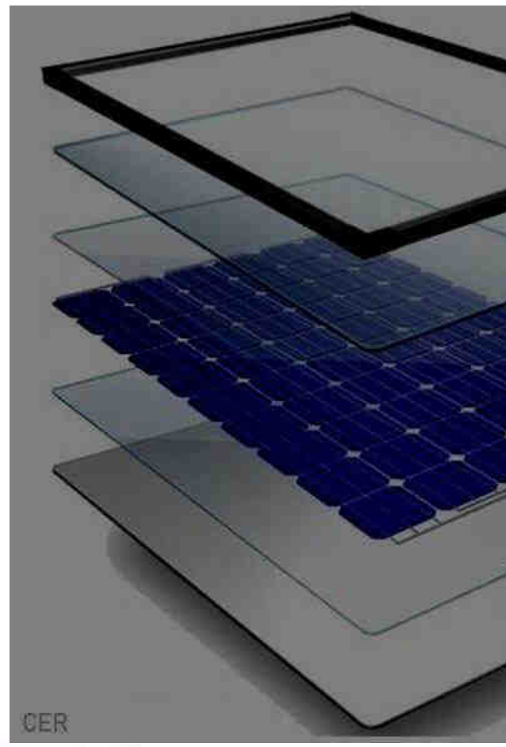
CHECK YOUR PROGRESS 30.3

glass windows and a closed wind screen is placed in the Su
hy does the interior of the car become hot compared to the
ce absorbs more heat-black surface or white surface?

rve from this activity? Solar energy can be used as an alter running expenses are incurred but the process is not suitabl ood items that can be processed by slow heating for examp g effect, however, can be enhanced by using a large conc cus the sunlight into the cooker. The parallel beam of rays e focus of the concave mirror and produce more heat n a device is called 'solar concentrate'. If the cooking ve ster.

cial type solar heaters, instead of a single large mirror, ged in such a way that all of them concentrate solar radiat in a boiler due to heat. Steam is used to rotate the turbine oducing electricity is known as solar power tower. Because t amount of solar energy for a greater part of the year. A lo st renewable source of energy. In 1962, India became the fi





elops a voltage 0.5-1 V and can produce about 0.7 watts o
e number of solar cells are however, combined in an arra
iver enough electricity for practical use. The principal a
t they have no moving parts, require little maintenance an
f any focusing device. They provide a clear pollution free
ty. Another advantage is that they can be set up in remot

f storage cells or accumulators as the alternative. They are

d deliver electricity when the solar cells are not producing e

ERGY

heard or read about cyclones, hurricanes or torn a does that

lboats float easily in the direction of the wind. The husk fro

l these activities require energy and it comes from the wind

oving air is called wind. Due to the speed, the air particles a

nergy. What causes air to move and wind to blow? Unequa

r bodies by the solar radiation generates air movement a

rect form of solar energy. About 2% of solar energy reach

y of wind. This kinetic energy of wind can be used to do w

icity in windmills. A windmill essentially consists of a st

erected at some height on a rigid support.

pump the rotatory motion of the wind mill is utilized to

ty, the rotatory motion of the windmill is used to rotate

tput of a single windmill is quite small and cannot be used

mber of windmills are erected over a larger area, which

output of each windmill in a farm is coupled togeth

d the country of winds. More than 25% of its electricity ne

windmills. In terms of total output, German is the leader w

nd energy for production electricity. By the end of 2005

ectricity generated from wind sources is abou

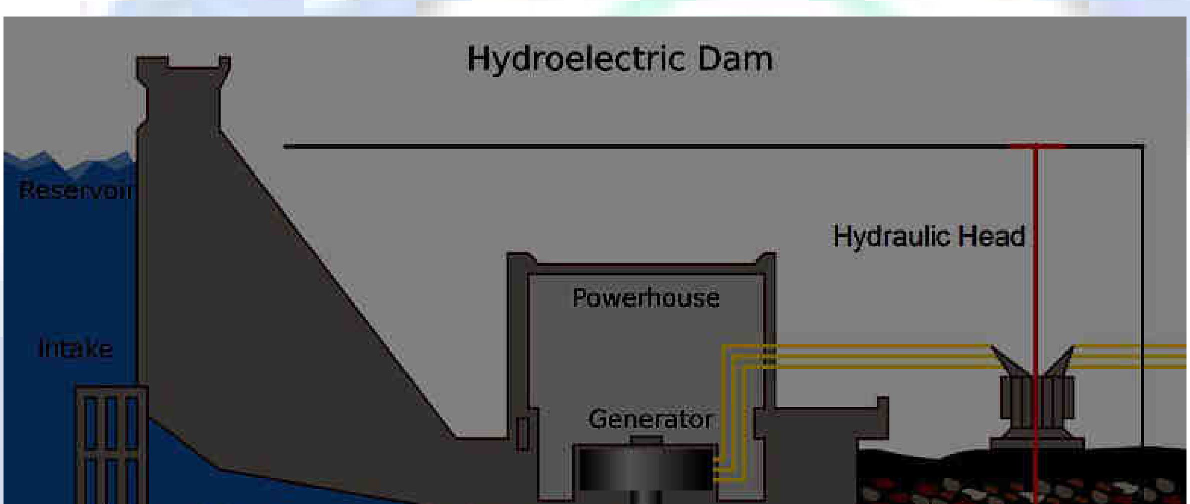
powerneeds is being supplied from wind sources. It is est

power can be generated if India's wind potential is fu

is a meager 2000 MW. Tamil Nadu, has the maximum nu

R ENERGY

sing water as a source of energy for centuries. A boat ca
urrent without any other effort. In older days, heavy logs o
gh river route. You are familiar with water cycle in natu
an indirect form of solar energy which is also renewabl
verplants. Electricity is generated in these plants by expend
one? High-rise dams are constructed on the river to obstr
ater in larger reservoirs. The water level rises and in the pr
gets transformed into potential energy. The water from th
ipes to rotate the turbine at the bottom of the dam. Movi



erent means. They are tidal energy, wave energy and ocea

ational pull on earth, the level of water in the sea rises up

veen consecutive rises is 12 hours 25minutes.This phenome

by the water during tide is known as tidal energy. To harne

oss a narrow opening to the sea and a turbine is fixed at th

rough the opening during the onset and withdrawal of tida

generated. But the locations where such a generator can be

in Gujarat namely Bhavnagar (Gulf of Cambay), Navalakh

nd Sagarin Hooghly river in West Bengal are identified as

ant.

etic energy possessed by huge waves near the sea shore, tha

me manner to generate electricity. The surface water of th

n the depth below is relatively cold. Thus the solar energ

rence. It is called **ocean thermal energy**. Ocean Thermal E t of production is less, but commercially viable sites are

ns in M.P. There are a number of geothermal energy based

USA.

CHECK YOUR PROGRESS 30.4

windmill work? Explain.

be the minimum wind speed for obtaining useful energy wi

ndfarm?

untry that leads in exploitation of wind energy.

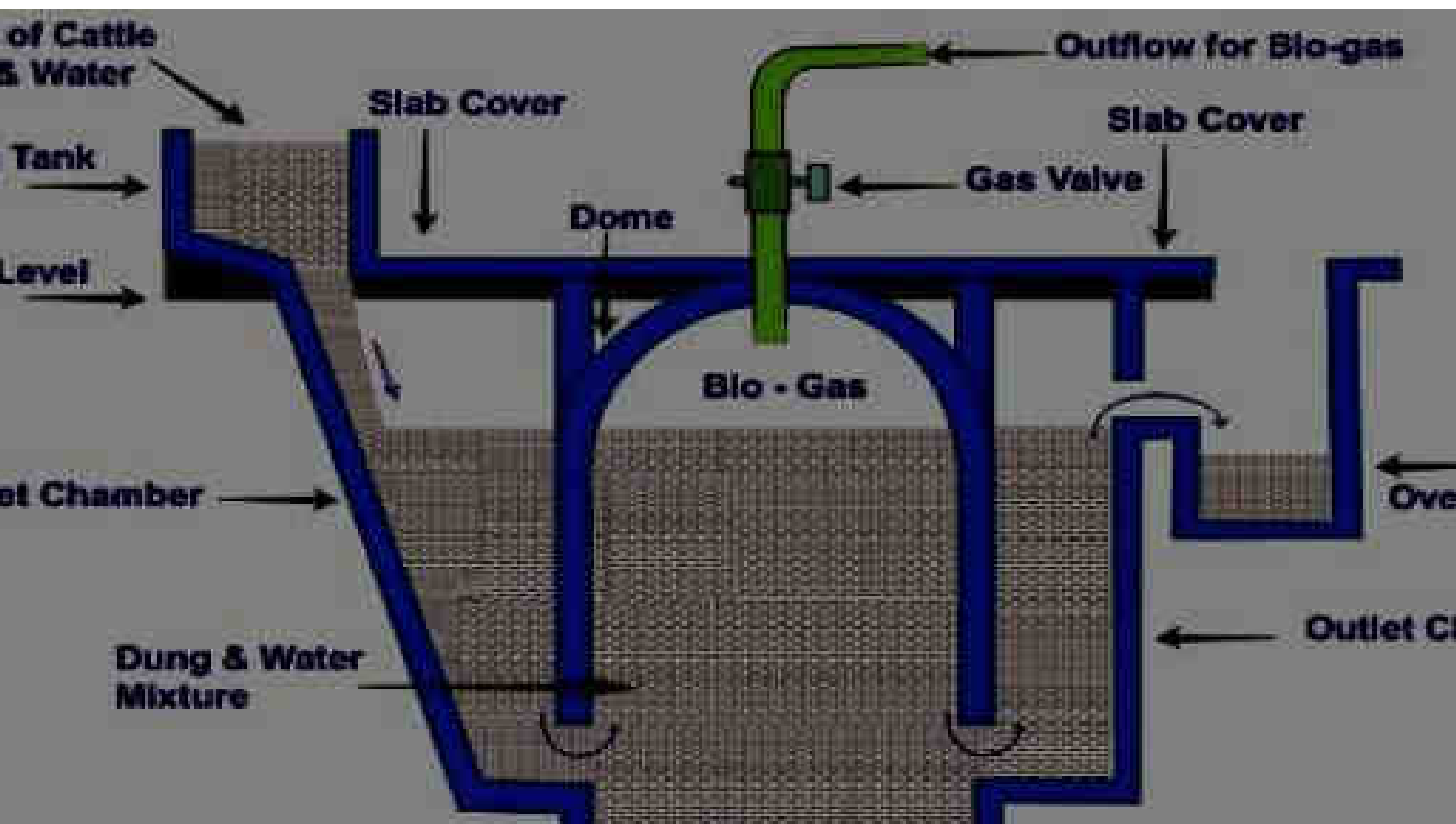
leading state in India for the exploitation of wind energy?

VEMENTS IN THE TECHNOLOGY FOR USI NERGY

matter created by the process of photosynthesis is called bio

ng process which derives its energy requirement from so

nciple, all bio-materials like animal dung, sewage, vegetabl
But it is cow dung that finds wide use on a limited scale m
gas is popularly known as 'Gobar Gas': Since India ha
as as a source of energy is very encouraging. There are ma
gas. We will describe here the fixed dome type, Fig. 4.



in wood, charcoal and coal. Its heating capacity is high
ry left behind is periodically removed and used as excellen
osphorous. The use of largescale utilization of bio-was
d efficient method of waste-disposal besides supplying ene

CHECK YOUR PROGRESS 30.5

he process that converts solar energy into chemical energy

he main constituent of biogas.

n the advantages of biogas as fuel.

biogas generated?

L ENERGY SOURCES

nd natural gas are classified as fossil fuels. We have discus
w transformation of plants and animals buried under the ea
transformation process, therefore, enormous amounts of

nt, carbon present in it reacts with oxygen to produce CO_2,
roduced. Coal is used as a source of energy for a variety of
es by black smiths, in brick kilns, industry and most impo
ve use of coal, however causes environmental pollutio
ly ash generated at thermal power stations creates storage
ash, however, is being used for making bricks of very goo
coal, with maximum concentration in the Eastern Indian
d to be 786 billion tons and India's share is about 6%
e available coal reserve may last 250 years more.

LEUM

diesel, aviation-turbo fuel, lubricants, naphthalene, para
ts. They are not available in nature in this form. The fossi
have been preserved by nature between porous rock benea

(petroleum) resources have ranged from 1450 to 2685 bill

o 7.32 barrels). Nearly half of the deposit is in the Middle

ort of our need. The oil reserves are estimated to run dry wi

AL GAS

other fossil fuel that is found with petroleum in oil depos

so found. It contains mainly methane and can be burnt ea

subjected to high pressure is available as CNG.CNG is dist

ported in tankers and cylinders. CNG is used as a fuel in

lso used as a source of hydrogen for manufacture of fertiliz

nce it causes less environmental pollution.

erves of natural gas estimated at over 100 billion cubic me

regularly, the present indications are that the gas production

ast larger than oil.

CHECK YOUR PROGRESS 30.6

sformation of the atoms of one heavy element into the a
dioactive energy come from? Analysis showed that when a
toms, the total mass of the products is less than the mass of
disappears and it is converted into energy. The amount o
ing Einstein's famous relation for mass-energy equiva
Δmc^2 where Δm is the loss of mass, c is the velocity of

proved that the atom consists of a small central nucleus
gible mass. The mass of the atoms is condensed in the nu
ed to the nucleus and the energy emitted in the process is k
s the energy of particles and emitted radiation are measured
MeV). Note 1 electron volt (eV) = 1.602×10^{-19}J. The
reactions are of the order of several electron volts per mol
ergies are of the order of several MeV. Thus nuclear trans

235 releases nearly 200MeV energy and also 2-3 more n

ssion of uranium possess energy ~ 2 MeV which is much

that caused fission. The energies of these neutrons are re

V) in a nuclear reactor by surrounding the fissile materi

ators. The neutrons then cause further fission and releas

chain reaction will start and be sustained till uranium-

vy water (D_2O) are important moderators. The moderator

d heat is to be removed by a coolant which is usually water

d by the coolant produces steam at high pressure, which is

generator. Thus nuclear reactors are used for generation of e

l with nuclear power generation is the storage and dispos

ste retains a sufficient degree of radio activity. Improper

n environmental contamination and hazard. Further, the nuclear power installations in India.

on: Nuclear fusion involves the union or fusion of the nu

the nucleus of high atomic number. Such reactions are pos

igh energy in the particle accelerator before bombarding ea

temperature the kinetic energy of nuclei is sufficient t

ween the light nuclei and fuse them. The nuclear fusion

mo-nuclear reaction. The product of the nuclear fusion has

nd this loss of mass is converted into energy like in the

agnitude of energy released in the nuclear fusion process

gy released in a fission process. The reactions of interest

s of hydrogen-deuterium, Deuteruim and tritium, into the ne

naturally in seawater and it is estimated that the fusion o

awater would yield 12 x 10^{19} kJ of energy. Thus the fusio s amount of energy in a short time.

eactions are the sources of energy of the sun and other s
for generation of energy in them are suggested. One sugge
on Weiz sacker in Germany in dependently and almost s
oon cycle. It starts with fusion of carbon-12 and proton pass
s also carbon-12 and helium. At each stage of conversion,

ss is H-H fusion process. It was developed almost the sar
Washington University. In the H-H process, hydrogen nucl
y. In both processes, however, hydrogen is used and the en
o produce energy at a rate to last for a star's life time. Henc
r the acceptability of one over the other. Finally, it is estab
the carbon cycle and in stars fainter than the sun, the H-H p

tant is the solar energy received on a unit area exposed perp

verage distance between the sun and the earth. The value of

1.4kJ per second per square meter or 1.4 kW/m².

solar heaters and solar concentrators are some of the device

solar energy in to heat.

devices that convert solar energy directly in to electricity.

energy due to water flowing through rivers, energy from tid

energy is also derived from solar energy. As such, all of the

sed through wind energy devices like windmill and windfar

rk or to produce electricity.

flowing water in a river is harnessed by building dams acro

work on this principle.

l from tides and waves is also harnessed by building small

e ocean shore.

is a process of combining two light nuclei into a heavier nu

ergy released in fusion reactions is of higher magnitude co

sun is generated due to fusion reactions involving hydrogen

TERMINAL EXERCISES

e following is not derived from fossil source of energy-Coa

source of energy not related to the sun-coal, river energy, g

e following contributes minimum to environmental pollutio

g of firewood

g of Coal

g of Charcoal

ergy be a dependable source of energy in Greenland?

eveloped to filter out the infrared part from the solar radiati

n earth be affected?

reasons why windmills will not serve as a source of energy

all hamlet on the top of a hillock in an inaccessible area. Po

ally viable. You are assigned the task of giving them oppor

re is a report that a hole in the ozonosphere is developing ov

its effect on India?

oduction cost of hydroelectricity being cheaper than the ele

r station?

is the energy of flowing water can be harnessed?

y or water energy is an indirect form of solar energy. Comm

energy converted into electricity?

wet wood is burnt. It produces lot of smoke and leaves a res

and what is its use?

vater pump in my house and pump water to a storage tank a

the tank is drawn through a pipe to rotate a small turbine t

generation of energy acceptable to you? Discuss.

e to have biogas as a viable source of energy in a big city li

use peat the lowest grade of coal for domestic purposes?

nk that different types of trees have same heating capacity w

examples from your experience.

rgy is an indirect source of solar energy.' Justify this statem

ANSWERS TO 'CHECK YOUR PROGRESS'

PROGRESS 30.1

PROGRESS 30.3

ht which is transmitted into the interior of car is again refle
glasses and the inside of a Car is more dark as compared to

PROGRESS 30.4

ergy of wind can be used to do work. A windmill essenti
large electric fan that is erected at some height on a rigi
designed to create a pressure difference between its differ
This pressure difference produces a turning effect to make

f a single windmill is quite small and cannot be used
umber of windmills are erected over a larger area, which is
t of each windmill in a farm is coupled together to get elect

troleum gas and propane is its main constituent.

Natural Gas and methane is its main constituent.

PROGRESS 30.7

released during the nuclear fission process again participat

This is called as chain reaction.

educe the kinetic energy of neutrons generated in the fissio

zard with nuclear power generation is the storage and dispo

e retains a sufficient degree of radio activity. Improper nucl

lts in environmental contamination and leads to several hea

ear power station

PROGRESS 30.8

31 WORK AND ENERGY

INTRODUCTION

You must have heard these terms work, energy, and power very frequently in your day to day life, like a barber cutting hair, a laborer lifting bricks and transporting them and a student studying are all said to be working. But here in physics, work is defined using very specific words and it has a very precise meaning. Similarly, a gymnast who can do a lot number of pull-ups we say that he/she has very good stamina or in other words, he/she has a good amount of energy. This means energy is something which tells about the capacity to do the work. In physics as well energy is related to work similarly but as already mentioned the definition of the word Work is very precise itself in Physics hence the definition of energy as well. We often come across the word Power as well, for example, the bodybuilder hit the punching bag with huge power, so in a very crude way, we could say that the rate of doing work is power. We could loosely correlate the physical definitions and physiological pictures. In this chapter, we would go in depth of the definitions and relations between these three physical quantities.

LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Define the terms work and energy
- Work done by a constant force.
- Explain the term power and define its SI unit.
- Define and explain potential and kinetic energy with suitable examples;
- List various forms of energy-like mechanical, thermal, light, sound, electrical, chemical, and nuclear energy with examples
- The law of Conservation of Energy

31.1 WORK, ENERGY AND POWER

WORK

> Work is a situation when there is a displacement of an object from point A to point B by an applied force.

Factors Affecting Work

1. Force

Force is a physical pull or push that leads to a change in an object's velocity and acceleration. It is a vector quantity and focuses on direction and magnitude both. In the case of zero force on an object, the work done becomes zero.

2. Displacement

Displacement refers to the shortest distance covered by an object from start to end position. If the displacement is zero in a direction, whatever is the force the work done will be zero.

Let a constant force, F act on an object, the object be displaced through a distance 's' in the direction of the force and W be the work done.

We define work to be equal to the product of the force and displacement.

Work done = force × displacement

$W = F\ s$

Thus, work done by a force acting on an object is equal to the magnitude of the force

multiplied by the distance moved in the direction of the force.

Work has only magnitude and no direction.

If F = 1 N (Newton) and s = 1 m (metre),

Then the work done by the force will be 1 N m.

Here the unit of work is Newton metre (N m) or joule (J).

Work formula is used to compute work done, force or displacement in any problem. It is written as in Newton meter or Nm.

Thus 1 J is the amount of work done on an object when a force of 1 N displaces it by 1 m along the line of action of the force.

The SI unit of work is Joule (J).

For example, if a force of 5 newtons is applied to an object and moves 2 meters,

the work done will be

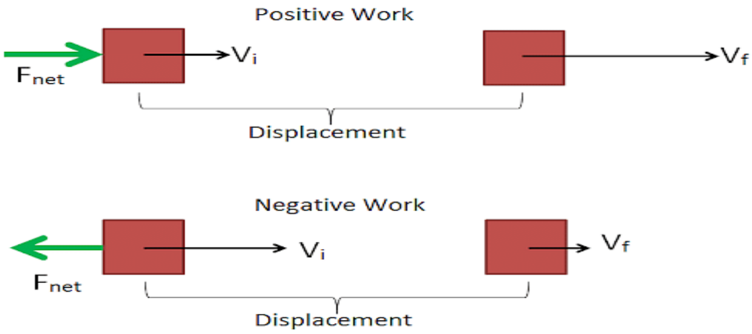
$W= F\ s$

$= 5 \times 2$

= 10 newton-meter or 10 Joule.

3. Positive Work Done

A work done is positive when the direction of the force applied and the direction of the displacement made by the object because of the force applied is the same. For example, consider a ball falling towards the ground. Here, the ball is falling because of gravity. We can notice that the direction of the pull of gravity is the same as the direction in which the ball is falling.



4. Negative Work Done

When the direction of the force applied is opposite to the direction of the displacement made by the object. For example, consider the same ball when thrown in an upward direction. In that case, the ball is moving upward against the direction of acceleration which is downwards.

When does the work done correspond to Zero?
There are several conditions in which the work done is zero. Let's see them one by one-

- As we have already read before in this article, no displacement means no work done. If the body does not move due to the applied force, then regardless of how large the force is, work done will be zero.
- Not only when the displacement is zero, but also, you may come across some situation in which the force applied is zero. For example, if an ice cube is floating on another slippery surface without any external force being applied. Here, the force is zero, so the work done will also be zero.
- In a condition, where the direction of the force applied is perpendicular to the direction of the displacement, the work done will come out as zero.

Take another example of work done problem

Q: A force of magnitude 24 N acts at a distance of 10 m in the force direction. Calculate the Work Done?

Ans: Here, we have been provided with-

Force applied, F = 24 N (Newton)

Displacement made, s = 10 (metres)

We have a formula-

W = F . s

Both the direction of force and the displacement is the same direction

W = F s

W = 24 N x 10m

= 240 Nm

OR

W = 240 Joules

5. ENERGY

Scientists define energy as the ability to do work. Modern civilization is possible because people have learned how to change energy from one form to another and then use it to do work. People use energy to walk and bicycle, to move cars along roads and boats through water, to cook food on stoves, to make ice in freezers, to light our homes and offices, to manufacture products, and to send astronauts into space.

In the simplest terms, energy is the ability to do work, which is when a force is applied to an object and it moves.

Primarily, energy is of two main types:

Kinetic Energy by virtue of it's motion and Potential Energy by virtue of it's position.

SI unit of energy

The common symbol for energy is the uppercase letter E. The standard unit is the joule, symbolized by J. One joule (1 J) is the energy resulting from the equivalent of one newton (1 N) of force acting over one meter (1 m) of displacement. The SI unit of kinetic energy is Joule (J) or kg.m2.s-2.

6. Kinetic Energy

The kinetic energy by an object is defined as the energy that is generated due to the motion of the object. The kinetic energy by an object arises when it is allowed to accelerate; it requires the application of some forces on it that leads to the work done. Therefore, after the work is done the energy is transferred to the objects that lead to the motion of the object at a constant velocity. The energy that is transferred is called **kinetic energy** that totally depends on the speed and mass of the object.

Objects in motion possess energy. This energy is simply known to be kinetic energy. A falling coconut, a flying aircraft, a speeding car, flowing water, a rolling stone, blowing wind, a running athlete, etc. i.e. any moving object possesses kinetic energy.

In short, kinetic energy is the energy possessed by an object due to its motion. The kinetic energy of an object increases when the speed of the object increase.

Formula for Kinetic Energy: As kinetic energy of an object depends on its mass and speed therefore mathematically; the kinetic energy is defined as:

K.E = ½ mv2

Here, m is the mass of the object and

v is the speed or velocity of the object.

This, expression obtained is called **kinetic energy equation**.

Derivation for the equation of Kinetic Energy:

The relation connecting the initial velocity (u) and final velocity (v) of an object moving with a uniform acceleration a, and the displacement, S is

$$v2 - u2 = 2aS$$

This gives

$$S = ½a(v2 - u2)$$

We know F = ma. Thus using above equations, we can write the work done by the force, F as

$$W = ma \times ½a(v2 - u2)$$

or

$$W =m(v 2 - u 2) ½$$

If object is starting from its stationary position, that is, u = 0, then

$$W = ½mv2$$

It is clear that the work done is equal to the change in the kinetic energy of an object.

If u = 0, the work done will be W = ½mv2

Thus, the kinetic energy possessed by an object of mass, m and moving with a uniform velocity, v is Ek= ½mv2

A few solved problems on kinetic energy formula KE = ½ mv^2

Q. What is the Kinetic Energy of a 150 kg object that is moving with a speed of 15 m/s?

KE = ½ mv2

KE = ?

m = 150kg

v = 15m/s

KE = ½ (150kg) (15 m/s)2

KE = ½ (150kg)(225)

KE = 16875J

Q. What is the Kinetic Energy of a 1200 kg object that is moving with a speed of 24 m/s?

KE = ½ mv2

KE = ?

m = 1200kg

v = 24m/s

KE = ½ (1200kg) (24 m/s)2

KE = ½ (1200kg)(576))

KE = 345,600J

Q. An object moving with a speed of 35 m/s and has a kinetic energy of 1500 J, what is the mass of the object.

KE = ½ mv2

KE = 1500J

m = ?

v = 35m/s

2KE/v2 = m OR m = 2KE/v2 (rearrange equation)

m = 2(1500J)/(35)2

m = 3,000/1225

m = 2.45kg

Unit of Kinetic Energy
SI unit is 1 J (joule)

Types of Kinetic Energy

There are five types of kinetic energy:

Radiant energy

Radiant energy is a form of kinetic energy, in which it is always in motion traveling through a medium or space.

e.g.:

- *Ultraviolet light*
- *Gamma rays*

Thermal energy

Thermal energy can be also known as heat energy. It is generated due to the motion of atoms when they collide with each other.

e.g.:

- Hot springs
- Heated swimming pool

Sound energy

Sound energy is the energy, produced by the vibration of an object. It travels through the medium but cannot travel in vacuum or space, as there are no particles to act as a medium.

e.g.:

- Tuning fork
- Beating drums

Electrical energy

Electrical energy can be obtained from the free electrons that are of positive and negative charge.

e.g.:

- *Lightning*
- *Batteries when in use*

Mechanical energy

The sum of kinetic energy and potential energy is called mechanical energy. It can neither be created nor destroyed but it can be converted from one form to other.

e.g.:

- Orbiting of satellites around the earth
- A moving car

POTENTIAL ENERGY

An object can store energy as the result of its position. For example, the heavy ball of a demolition machine is storing energy when it is held at an elevated position. This stored energy of position is referred to as potential energy. Similarly, a drawn bow is able to store energy as the result of its position. When assuming its usual position (i.e., when not drawn), there is no energy stored in the bow. Yet when its position is altered from its usual equilibrium position, the bow is able to store energy by virtue of its position. This stored energy of position is referred to as potential energy. Potential energy is the stored energy of position possessed by an object.

Gravitational Potential Energy

Gravitational potential energy is the energy stored in an object as the result of its vertical position or height. The energy is stored as the result of the gravitational attraction of the Earth for the object. The gravitational potential energy of the massive ball of a demolition machine is dependent on two variables - the mass of the ball and the height to which it is raised.

There is a direct relation between gravitational potential energy and the mass of an object. More massive objects have greater gravitational potential energy. There is also a direct relation between gravitational potential energy and the height of an object. The higher that an object is elevated, the greater the gravitational potential energy. These relationships are expressed by the following equation:

PEgrav = mass • g • height

PEgrav = m *• g • h

In the above equation, m represents the mass of the object, h represents the height of the object and g represents the gravitational field strength (9.8 N/kg on Earth) - sometimes referred to as the acceleration of gravity.

Elastic Potential Energy

The second form of potential energy that we will discuss is elastic potential energy. Elastic potential energy is the energy stored in elastic materials as the result of their stretching or compressing. Elastic potential energy can be stored in rubber bands, bungee chords, trampolines, springs, an arrow drawn into a bow, etc. The amount of elastic potential energy stored in such a device is related to the amount of stretch of the device - the more stretch, the more stored energy.

Springs are a special instance of a device that can store elastic potential energy due to either compression or stretching. A force is required to compress a spring; the more compression there is, the more force that is required to compress it further.

Examples

The diver has just jumped up from the end of the diving board. After he dives and is falling toward the water, he'll have kinetic energy, or the energy of moving matter. But even as he is momentarily paused before his jump high above the water, he has energy. Do you know why?

Stored Energy

The diver has energy because of his position high above the pool. The type of energy he has is called potential energy. Potential energy is energy that is stored in a person or object. Often, the person or object has potential energy because of its position or shape.

Q: **What is it about the diver's position that gives her potential energy?**

A: Because the diver is high above the water, he has the potential to fall toward Earth because of gravity. This gives him potential energy.

Some basic numerical

Consider the little girl on the sled. She weighs 140 Newtons, and the top of the hill is 4 meters higher than the bottom of the hill. As she sits at the top of the hill, the child's gravitational potential energy GPE is:

GPE = 140 N × 4 m = 560 N • m = 560 Joules

Notice that the answer is given in Newton • meters (N • m), which is the SI unit for energy. A Newton · meter is the energy needed to move a weight of 1 Newton over a distance of 1 meter. A Newton • meter is also called a joule (J).

The female gymnast on the balance beam weighs 360 newtons. If the balance beam is 1.2 meters above the ground, what is the gymnast's gravitational potential energy?

A**:** Her gravitational potential energy is:

GPE = 360 N × 1.2 m = 432 N • m, or 432 J

Relationship between Potential and Kinetic Energy?

The relationship between potential energy and kinetic energy is that potential energy can transform into kinetic energy. Potential energy is position relative. In other words, it changes depending on an object's height or distance and the mass of the object. Kinetic energy changes depending on an object's speed and its mass.

If we think about a waterfall, some still water at the top of the waterfall has potential energy. It isn't moving and hasn't gone over the edge. The water flowing from the waterfall has kinetic energy as it flows.

A pendulum is an excellent example of this relationship. As the pendulum swings ever higher upwards, its potential energy increases until it reaches its optimum at the highest point of the swing. At the top of the arc, the potential energy turns into kinetic energy as it swings back down.

To summarize, potential energy is the energy that is stored in an object due to its position relative to some zero position. An object possesses gravitational potential energy if it is positioned at a height above (or below) the zero height. An object possesses elastic potential energy if it is at a position on an elastic medium other than the equilibrium position.

Comparison Kinetic Energy versus Potential Energy comparison chart

	Kinetic Energy	Potential Energy
Definition	The energy of a body or a system with respect to the motion of the body or of the particles in the system.	Potential Energy is the stored energy in an object or system because of its position or configuration.
Relation to environment	Kinetic energy of an object is relative to other moving and stationary objects in its immediate environment.	Potential energy is not relative to the environment of an object.
Transferability	Kinetic energy can be transferred from one moving object to another, say, in collisions.	Potential energy cannot be transferred.
Examples	Flowing water, such as when falling from a waterfall.	Water at the top of a waterfall, before the precipice.
SI Unit	Joule (J)	Joule (J)
Determining factors	Speed/velocity and mass	Height or distance and mass

POWER

Power is a measure of the amount of work that can be done in a given amount of time. Power can be represented by the equation:

Power is defined as the rate of work done.

$$P = \frac{\text{Work}}{\text{Time}}$$

$$P = \frac{\text{Joules}}{\text{Second}}$$

$$\text{watt} = \frac{\text{Joules}}{\text{Second}}$$

Power is said to be 1 watt when 1 Joule work is done in 1 second.

In this equation, work is measured in joules (J) and time is measured in seconds (s), so power is expressed in joules per second (J/s). This is the SI unit for power, also known as the watt **(W)**. A watt equals 1 joule of work per second.

You're probably already familiar with watts. Light bulbs and small appliances such as microwave ovens are labeled with the watts of power they provide.

Calculating Power from Work and Time

Power can be calculated using the formula above if the amount of work and time are known.

For example, assume that a microwave oven does 24,000 joules of work in 30 seconds. Then the power of the microwave is:

From the above,

Work = 24000 joules

Time = 30seconds

Use the formula:

Another microwave oven does 5,000 joules of work in 5 seconds. What is its power?

The power of the other microwave oven is:

Power=5000 J / 5 s

=1000 J/s, or 1000 W

Power is 1000W of microwave

Calculating Work from Power and Time

You can also calculate work if you know power and time by rewriting the power equation above as:

Work = Power × Time

For example, if you use a 1000-watt microwave oven for 20 seconds, how much work does it do? First express 1000 watts in J/s and then substitute this value for power the work equation:

Work = 1000 J/s × 20 s = 20,000 J

Horsepower

Sometimes power is measured in a unit called the horsepower. For example, the power of car engines is usually expressed in horsepower

One horsepower is the amount of work a horse can do in 1 minute, which equals 745 watts of power.

ELECTRICAL POWER

To find out, the electrical power; we use current (I) and voltage (V)

Current is measured in amperes (A)

Voltage is measured in volts (V)

The equation for power

Power = Current x Voltage

P = I x V

Let us take a problem

Calculate the electrical power generated if the current is 3 amperes at 10 volts in the given circuit

So, we have

I = 3 amperes

V= 10 volts

The equation is

P= I x V

= 3 x 10

= 30 watts

Hence, the power is 30 watts in the given circuit

$$P = \frac{\text{Work}}{\text{Time}}$$

$$P = \frac{\text{Joules}}{\text{Second}}$$

$$\text{watt} = \frac{\text{Joules}}{\text{Second}}$$

= 24000 J / 30 s

=800 J/s, or 800 W

So, the power of microwave is 800 watts.

CHECK YOUR PROGRESS 31.1

1. Give the formula of work done by constant force.

2. What is meant by positive work done.

3. When is work done zero.

4. A force of 10 Newton is applied and object moves 5 metres in direction of applied force. Calculate the work done.

5. Define energy and its SI unit.

6. What is meant by Kinetic Energy.

7. Define Potential Energy.

8. Tell the definition of Power and its SI unit.

31.2 FORMS OF ENERGY AND LAW OF CONSERVATION OF ENERGY

FORMS OF ENERGY

Forms of energy

Many forms of energy exist, but they all fall into two basic categories:

- Potential energy
- Kinetic energy

Mechanical Energy

The capacity of an object to do work by virtue of its motion or position is its Mechanical Energy. It is the sum of the kinetic energy and potential energy.

Heat Energy

Heat energy is associated with the frictional force. For example, if we rub our hands together in the winter, they feel warm. Similarly, the tip of a dentist's drill gets extremely heated while drilling into a tooth.

Chemical Energy

Chemical energy can be most simply defined as the energy that binds together the atoms and molecules of various materials. When these molecular bonds are broken, a large amount of energy is released. For example, when we light a fire to some wooden logs, we break down the complex organic molecules, and their chemical energy is released.

Nuclear Energy

Nuclear energy binds together the protons and neutrons in the nucleus of each element. It is the strongest force in the universe. Nuclear bombs harness the nuclear energy of uranium and plutonium. The devastation of Hiroshima and Nagasaki at the end of the Second World War was caused by a minuscule amount of nuclear matter when compared to the traditional bombing materials. Nuclear reactions can be categorized into:

- Fission: When a larger nucleus disintegrates into smaller nuclei. For example, the fission of uranium nucleus into smaller nuclei like thorium and radium etc.
- Fusion: When two or more smaller nuclei fuse together to form a bigger nucleus. For example, our sun's energy is derived by the fusion of hydrogen atoms.

Electrical Energy

Charges exert forces on each other and hence give rise to an electrical energy. The flow of electrical current has energy. This energy can be harnessed by passing the electrical current through various materials and apparitions. For example, when electrical current passes through the filament of a bulb, it produces light. And when electrical current is passed through the motor of a fan, it rotates the blades.

Sonic Energy

Sonic energy is the energy of sound waves. Sound waves travel through the air or another medium.

Example: A sonic boom, a song played on a stereo, your voice.

Gravitational Energy

Energy associated with gravity involves the attraction between two objects based on their mass. It can serve as a basis for mechanical energy, such as the potential energy of an object placed on a shelf or the kinetic energy of the Moon in orbit around the Earth.

Example: Gravitational energy holds the atmosphere to the Earth.

Kinetic Energy

Kinetic energy is the energy of motion of a body. It ranges from 0 to a positive value.

Example: An example is a child swinging on a swing. No matter whether the swing is moving forward or backward, the value of the kinetic energy is never negative.

Potential Energy

Potential energy is the energy of an object's position.

Example: When a child swinging on a swing reaches the top of the arc, she has maximum potential energy. When she is closest to the ground, her potential energy is at its minimum

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Light is one type of radiant energy. Sunshine is radiant energy, which provides the fuel and warmth that make life on earth possible.

Law of Conservation of Energy

We know that energy is available to us in various forms such as:

1. Mechanical energy
2. Electrical energy
3. Heat energy
4. Light energy
5. Sound energy
6. Chemical energy
7. Nuclear energy etc.

The various forms of energy are inter-convertible.

Robert Mayer stated that "Energy can neither be created nor be destroyed, it can only be converted from one form to another and as such, the total energy in this universe remains constant" is known as Law of Conservation of Energy. Itwas later established by Helmholtz in the year 1842.

While the total energy remains constant, it can and often does change form. Potential might change into kinetic, kinetic might change into thermal energy and so on. But the total amount always remains the same.

The loss of energy of one system is exactly equal to the gain of energy of the other system. This law is true for all situations and for all kinds of transformations. There are many such examples of energy conversion.

When we lit an electric bulb, electric energy is converted into light energy. When we use a loudspeaker, electrical energy is converted into sound energy. When we switch on an electric fan, the blades of the fan start rotating as electric energy is converted into kinetic energy which is actually a form of mechanical energy. When we charge a battery, electrical energy changes into chemical energy. A solar cell converts light energy into electrical energy.

CHECK YOUR PROGRESS 31.2

1.Define the law of conservation of energy.

2.What are two main types of energy.

3. Tell about nuclear energy.

4.What do you understand by chemical energy?

5. Give two examples of conservation of energy.

RECAPITULATION POINTS

- What is work from science point of view
- Work done by constant force
- Defining energy and its SI unit
- What is Kinetic Energy- definition, formula and solved examples
- Similarly, about Potential Energy- Definition, examples and formula
- Kinds of energy
- Law of Conservation of Energy

TERMINAL EXERCISE

1. Give differences between kinetic and potential energy
2. State the law of conservation of energy with examples
3. Derive the kinetic energy formula
4. Define energy and state five forms of energies
5. Can potential energy be converted to kinetic energy. Give examples
6. What is electrical power. Give formula and state it's SI unit
7. Tell more about nuclear and radiant energy with examples

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 31.1

1. Formula of work done

If the constant force (F) moves an object through a distance (s) ,

Then the work done (W) is given by the equation

W = F x s

2. Work done positive

Work done is positive when the direction of the force applied and the direction of the displacement made by the object because of the force applied is the same direction.

3. Work done zero

When displacement is zero even when force is applied

When force applied is zero even when displacement takes place

Direction of force is perpendicular to direction of displacement

4. Work done formula

W = F x s

= 10 x 5

= 50 Nm OR 50 Joules of work done

5. Scientists define energy as the ability to do work. In the simplest terms, energy is the ability to do work, which is when a force is applied to an object and it moves.

6. The kinetic energy by an object is defined as the energy that is generated due to the motion of the object.

7. Potential energy refers to the energy which an object holds due to its position relative to other objects.

8. Power is a measure of the amount of work that can be done in a given amount of time. Power can be represented by the equation: Power is defined as the rate of work done.

$$P = \frac{\text{Work}}{\text{Time}}$$

$$P = \frac{\text{Joules}}{\text{Second}}$$

$$\text{watt} = \frac{\text{Joules}}{\text{Second}}$$

It's SI unit is Watt.

CHECK YOUR PROGRESS 31.2

1. Law of Conservation of Energy States Energy can neither be created nor be destroyed, it can only be converted from one form to another and as such, the total energy in this universe remains constant". This is called the law of conservation of energy.

2. Two main types of energy are

Kinetic Energy and potential energy.

3. Nuclear energy binds together the protons and neutrons in the nucleus of each element. It is the strongest force in the universe

4. Chemical energies can be most simply defined as the energy that binds together the atoms and molecules of various materials. When these molecular bonds are broken, a large amount of energy is released.

5. Two examples of conservation of energy are

When we lit an electric bulb, electric energy is converted into light energy. When we use a loudspeaker, electrical energy is converted into sound energy.

3 SOUND ENERGY

INTRODUCTION

Sound is a form of energy which generates sensation in our ears and we are able to heart he sound. In our surrounding, we hear many types of sounds like the calling bello four homes, songs on our mobile phones and television, horn of vehicles etc. At home, while washing our steel utensils, when the utensils hit each other, vibrations are produced and a sound is heard. As we have read earlier, there are different forms of energy and they can be converted from one form to another. Sound can be produced by rubbing a balloon, clicking a computer mouse, hitting objects etc. These mechanical activities produce vibrations in the objects and thus a sound is produced. Hence, we can say that sound can be produced by vibrating material objects and can be heard when these vibrations reach our ears. The type of sound produced depends upon the nature of vibrating body.

32.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

-

32.1 PRODUCTION OF SOUND

Sound is produced when an object is set to vibrate. Vibrations are produced when an object moves to and from its mean position with small amplitude. The vibrations can be felt by touching the source of sound. Figure 1 shows a man holding a metallic bell on one hand & hammering it with the other hand. This is commonly found in schools for alerting students and teachers about class timings. When we hit the bell

Figure1: Metallic bell producing sound when hit with a wooden hammer

When we hit the bell with the wooden hammer and gently touch the body of the bell, we feel the vibrations. These vibrations make sound. Now if this vibrating body is hold tightly, it stops vibrating and the sound also disappears. In the same manner, a ringing calling bell also vibrates

while producing sound. From this, it is concluded that sound is a mechanical wave that is produced when an object is set to vibrate (moves back and forth) rapidly. A vibrating object producing sound has a certain amount of energy which travels in the form of sound waves.

Sound can be produced by other different methods such as;

a) By vibrating strings (a sin a guitar),

b) By vibrating membranes (a sin table),

c) By vibrating air (as in a flute) and

d) By tuning fork (used in laboratory)

32.2 PROPAGATION OF SOUND

The term propagation means transfer of sound from the source (where it is created) toother places. For sound to propagate, it needs a medium. The matter or body through which sound is transferred is called as a medium. The medium can be a solid, liquid or gas. The medium of transmission or propagation of sound must be a material medium, elastic and continuous. When an object vibrates, it displaces the particles around it from its equilibrium position. The particles do not travel itself from the vibrating source to the ear. Rather, the vibrating particles exert a force on their adjacent particles in the medium. These in turn produce similar effect in others and this process continues in the medium. We know that a disturbance that moves through a medium is called as a wave. Thus sound can be visualized a same chanical wave that travels through a medium, where the particles of the medium do not move forward, but the disturbance is carried forward. Air is a common media through which sound travels. Sound waves in air creates compressions and rarefactions of air molecules. We can verify this by taking a tuning fork, which is a U shaped thick structure made of iron/steel, attached to a stem (figure2a). When we strike it with a soft rubber pad, immediately the fork starts vibrating about its mean position.

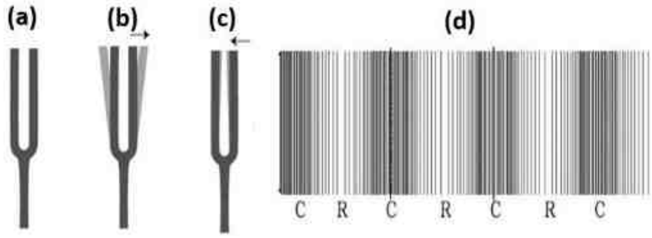


Figure2: Tuning fork vibrations (outward (c) & inward (b)) about its original position (a) and compression and rarefactions (d).

During this process, when the tuning fork vibrates forward, it pushes forward or compresses the air molecules (figure2b). It results in arise in air pressure amplitude. However, when the tuning fork vibrates inward, it leaves a rarefied region behind it (figure 2c). This results in the fall of air pressure amplitude. On continuous and rapid movement of the fork back and forth, a series of compressions and rarefactions are produced in the air (figure 2d). Thus a continuous motion of the prongs sends a stream of alternate compressions and rare factions through the medium. These make the soundwave that propagates through a given medium.

Activity:

It can be shown experimentally that sound needs a material medium for its propagation. Thus, it cannot travel through vacuum. Can you demonstrate this experiment?

Hints: Take a glass jar with a cork attached to the mouth of the jar as shown in figure 3. An electric bell is fitted inside the glass jar from the open bottom of the jar. The electrical wires from the bell comes out of the jar through two pin holes on the surface of the cork and connected to a battery. Then close the bottom of the jar with an air tight lid with a nozzle. Then with the help of a rubber tube, the nozzle is connected to a vacuum pump. Initially close the key (switch on the electrical circuit). Hear the sound coming from the electric bell. In the next step, suck the air out of the glass jar with the help of a vacuum pump. Is there any difference you observe in the intensity or quality of sound? What happens to the quality of sound with the passage of time while you continuously run the vacuum pump?

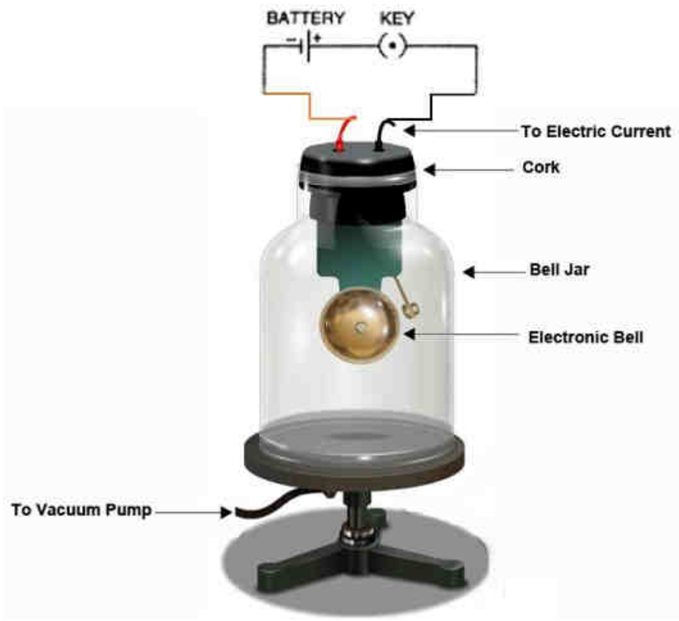


Figure 3: Bell jar experiment

What will happen if the air is removed completely with the help of some vacuum pump? Will you still be able to hear the sound coming from the cell?

32.3 CHARACTERISTICS OF A SOUND WAVE

Sound is a longitudinal wave, where particles of the medium oscillates in the same direction along which the wave propagates. We can describe sound wave by its wavelength, frequency, time period and speed. Figure 4 (a & b) represents the graphical form of a sound wave showing the change in density and pressure respectively when it moves in a medium. Compressions are the regions where particles are closer enough and the density as well as the air pressure is high. Rare factions are the regions of low pressure where particles are spread apart. Due to the periodic to and fro vibrations, sound wave propagates along the direction of motion of particles as shown in figure 4(c). Thus the upper portion of figure 4(c) can be considered as compression and the lower portion can be considered as rare factions. The region of maximum compression
(C) or rare factions (R) is called as amplitude of the wave.

Wavelength:

Wave length of a wave is defined as the distance travelled by the wave during the time a particle completes one complete oscillation. In other words, it is the distance between two consecutive maximum rare faction region (R) or two consecutive maximum compression region (C). The wavelength is usually represented by a Greek letter lambda (λ). Its SI unit is metre (m). Thus the distance between a compression and next rare faction is $\lambda/2$.

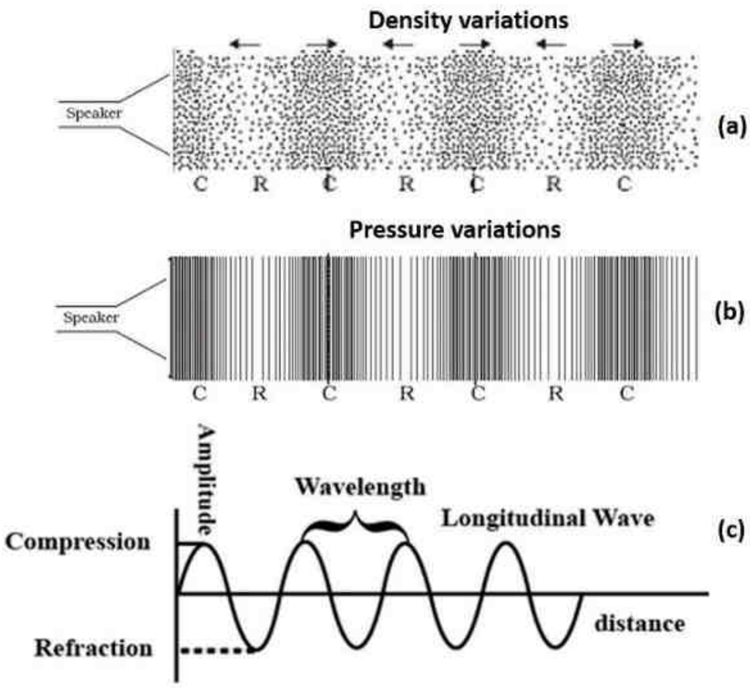


Figure 4: Propagation of sound wave in a medium

Frequency:

We have already learned that when sound waves propagates through a medium, the particles of the medium vibrates between a maximum value and a minimum value. The change in density oscillates from the maximum value to the minimum value, then again to the maximum value which makes completes one full oscillation. Hence the number of vibrations or oscillations completed by a particle in one second is the frequency of the sound wave. Frequency is represented by a Greek letter *v (nu)*. Its SI unit is hertz (Hz).

Time period:

The time taken by the particle of the medium to complete one oscillation is called as the time period of the sound wave. It is denoted by the symbol *T*. Its SI unit is second (*s*).

Frequency and time period are related to each other as stated below:

If '*v*' oscillations are completed in a time=1 *second, then*

1 oscillation is completed in a time = 1/*v second*.

So $T = 1/v$.

Now, let two different musical instruments are played at the same time. Both sounds travel through air at same speed and arrive at our ear at the same time. But the quality or soothing nature of sounds received by us are different. This is due to the different properties associated with the sound. Pitch is one of the characteristics. The quicker the vibration of the source, the greater is the frequency and the higher is the pitch. Thus, a high pitch sound represents higher number of compressions and rarefactions per unit time, passing a fixed point. Objects of different shapes and sizes, vibrating in varying conditions, produce sounds of different pitch. For example, males generally have low pitched (deeper) voices as compared to high pitched voices in female. Due to biological conditions, men's vocal cords are elongated and thicker than women's which makes their voices deeper.

CHECK YOUR PROGRESS 32.1

1. Give two examples of mechanical waves
2. What is wave-motion?
3. What are the types of wave-motion?
4. What type of process takes place in a medium when a longitudinal wave propagates through it?

From figure 4, we can notice that the magnitude of the maximum compression/rarefaction on either side of the mean value is called the amplitude of the wave. It is usually represented by the letter A. In case of sound, the unit of amplitude will be that of density or pressure. The loudness or intensity of a sound is determined basically by its amplitude.

Heinrich Rudolph Hertz was a German Physicist, born on 22 February 1857 in Hamburg, Germany. Hertz obtained his Ph.D. at the University of Berlin. He was the first scientist who experimentally confirm the existence of electromagnetic waves predicted by J.C. Maxwell's electromagnetic theory. His contribution to physics led to the future development of radio, telephone, telegraph and even television.

Velocity of sound wave:

Sound travels with a different velocity in different medium. Velocity of sound has a characteristic/specific value in a definite medium. The velocity is related to frequency and wave length, given by the relation

$$\text{Velocity}(V) = \text{wavelength}(\lambda) \times \text{frequency}(v)$$

In rainy seasons, we frequently observe lightening/thunder. During lightening, when there is discharge between two cloud patches, light and sound are produced simultaneously. Light reaches the surface of the earth earlier than the sound. This is due to the fact that velocity of sound is much slower than that of light. In air, sound travels at a speed of 344 *m/s* (20 °C), while light travels at a speed of 3×10^8 *m/s*. If we stand near a railway track and when the train is very far away from us, we cannot hear its sound through the air. However, if we put our ear to the rail track, we can hear the sound of an approaching train. The tracks are made up of solid substance like steel/iron. Thus we can conclude that sound travels much faster in solids than in air.

Caution: Do not try this without permission and vigilance of railway professionals as this may cause any accident.

CHECK YOUR PROGRESS 32.2

1. What is meant by time period? What is its SI unit?
2. What is meant by frequency? What is its SI unit?
3. What is the relation between time period and frequency?
4. What is velocity of sound in air at 0°C?

The table below shows the speed of sound in different medium at different temperatures.

Table1: Speed of sound in different medium at specific temperatures:

Medium	Speed of sound(m/s)	Temperature °C
Dry air	322/344	0/20
Hydrogen	1284	0
Water	498	25
Sea water	1531	25
Blood	1570	37
Copper	3750	20
Aluminium	5100	20
Iron	5130	20
Glass	5170	20
Granite	6000	20
Woodash	4670	20
Nickel	6040	20
Steel	5960	20

From this table, it is clear that the speed of sound in solid medium is much more than the speed of sound in liquids or gaseous medium. That is why, sound travels faster in solids than in air.

32.4 FACTORS AFFECTING SPEED OF SOUNDINAIR:

There are different factors on which speed of the sound depends. As we can see from the table in the previous section, the speed of sound depends on the nature of material (or medium) through which it travels: It is generally less in air than in other dense medium. But there are also other factors by which the speed of sound in a given medium (for example air) depends. They are listed below;

(a) Temperature: The velocity of sound in air varies directly as the square root of absolute temperature of air. Hence an increase in temperature of air will increase the velocity of the sound.

$$V_t \propto \sqrt{T}$$

$$V_t = V_0 \sqrt{\frac{273+t}{273}}$$

Where V_t = velocity of sound at t $°C$ and V_0 = velocity of sound at 0$°C$.U sing above equation, we can calculate that if temperature of air rises by 1$°C$, velocity of sound will increase by 0.608m/s. This value is called as *temperature co-efficient of velocity of sound.*

(b) Density of air: Velocity of sound varies inversely as the square root of the density of air. Lesser the density, greater is the velocity of sound.

Velocity of sound, $V \propto \frac{1}{\sqrt{\rho}}$

(c) Pressure: The change in pressure of air has no effect on the velocity of sound.

(d) Humidity: Moist air (dry air + water vapour) is lighter than dry air. Therefore, sound travels faster in moist/humid conditions.

(e) Effect of wind: If the wind blows towards the direction of propagation of sound, the velocity of sound increases, if the wind blows in opposite direction of sound propagation, velocity of sound decreases.

Solved Examples:

Example 1. Distance between first compression and the fifth rarefaction after that is observed to be 180 cm. Find the frequency and time period of sound wave Velocity of sound is 340m/s.

Solution. Distance between 1stand 5thcompression =(5-1)λ=4λ.

Distancebetween5thcompressionand5thrarefaction=λ/2

Total distance between 1st compression and 5th rarefaction = $4\lambda + \lambda/2 = (9/2)$

$\lambda(9/2)\lambda = 180\ cm$

$\lambda = 40 cm$

$V = 340 m/s = 34000\ cm/s$

Since $V = v\lambda$

$34000 = v \times 40$

$v = 34000/40 = 850\ cycle/sec$

Time period, $T = 1/v$

$T = 1/850 s$

or

$\boldsymbol{T = 0.001176s.}$

Example 2. A tuning fork of frequency 500 sends longitudinal wave in air. Distance between a compression and the next rare faction is found to be 34cm. Find the velocity of sound.

Solution. Since, distance between a compression and the next rare faction is λ/2,

$\lambda/2 = 34$

$\lambda = 2 \times 34 = 68 cm$

$V = v\lambda$

Since v=500(given)

$V = 500 \times 68$

or,

$V = 34000 cm/s = \mathbf{340 m/s}$.

32.5 REFLECTION OF SOUND

Sound waves are reflected from surfaces of the substances. Echoes are well-known examples of reflection of sound. Just like light, sound gets reflected and obeys the same laws of reflection. The main difference between reflection of light and that of sound is that light is reflected from a smooth surface (even if the surface is not large enough), however, sound gets reflected from large surfaces which may not be necessarily smooth. This is due to difference in the wave length of sound ($\approx 65 cm^{-1}$) and light ($\approx 10^{-5} cm^{-1}$). In the figure given here, let a source of sound be placed in front of a plastic tube 'A'. Sound wave, travelling through a pipe 'A', gets reflected from 'O', on the surface of a hard ply board. The reflected sound wave travels through another plastic tube B.A burning candle is placed at the mouth of B. Sound, being a mechanical wave should disturb the flame of candle. If the flame of candle disturbs, it indicates the reception of sound. Generally, the flicker in the flame occurs when the axes of two pipes A and B are inclined equally to the normal ON at O, thus, verifying the laws of reflection.

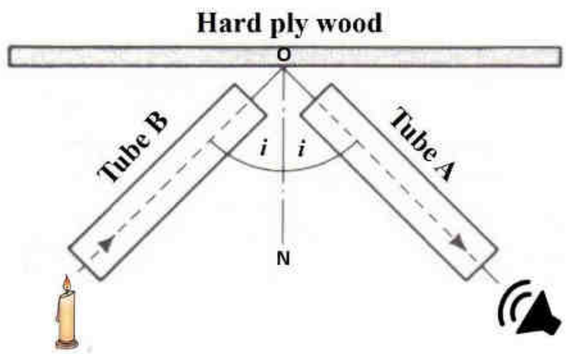


Figure 5: Experimental set up for verifying reflection of sound

ECHO

In a big hall or on a mountain area, when we shout loudly, observe that a portion of speech is heard back. "This is due to reflection of sound from some distant objects like the wall of the hall or a distant mountain. The repetition of the words of a speaker, caused by the reflection of sound from a distant object, is called an echo. The sensation of sound persists in our brain upto1/10th of a second (0.1 *s*). This property of ear/brain is called persistence of hearing. For production of an echo it is essential that the reflected sound must reach back after 0.1*s*. If it

Comes earlier it will merge with the continuing impression and shall not be distinguishable. Echoes may be heard more than once due to successive or multiple reflections.

(a) **Echo of articulate sound**. Articulate sound is one which requires negligible time for its production. Let the reflecting obstacle be situated at a distance "x" from the source and ear. Echo of the sound will be heard only if the reflected sound reaches the ear after a time of 0.1second, since the ear retains the compression of sound for that time.

Therefore, for going from source and coming back, $2x = V \times t$,

where, $V = 340$m/s (velocity of sound)

&

$t = \frac{1}{10}$ second

Therefore, $2x = 340 \times \frac{1}{10} = 34$

or

$x = 17m$

Thus, *minimum distance of reflecting obstacle for production of ech of articulate sound is* **17*m*.**

Examples of articulate sound includes firing of a pistol, bursting of crackers, striking of hammer etc.

(b) **Echo of one syllable.** One syllable is a sound which takes 1/5 second for its production. Therefore echo of one syllable will be heard only if the sound reaches back after 1/5 *second*. Let' y be the distance of reflecting obstacle in this case.

$2y = 340 \times \frac{1}{5} = 68$

y=34m

Thus, minimum distance of reflecting obstacle for production of echo of one syllable is 34 *m*. Similarly, it can be proved that echo of sound comprising of 2, 3...syllabii will be producedonlyifthereflectingobstacleissituatedataminimumdistanceof68*m*.102*m*respectively.

Example 3: A man shouts while standing in front of a hill and hears echo of his own soundafter2.5*second*. Find the distance of man from the hill. Velocity of sound= 340*m/s*.

Solution: Let x = distance of the man from the hill

Distance covered by the sound = 2x

We know, distance =velocity× time

So 2x = V ×

tV=340*m/st*

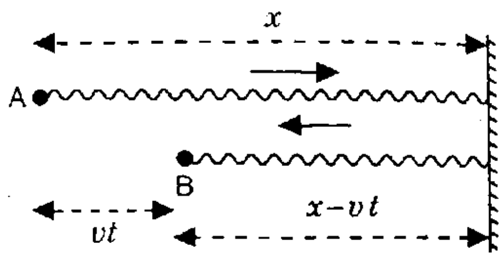
=2.5*s*

$2x$=340 × 2.5 = 850

***x*=425*m*.**

Example 4. A tank, travelling at the rate of 72 *km/h*, towards a hill fires a shot and its driver hears the echo after 4.5 *second*. Find the distance of tank from the hill when the shot was fired Velocity of sound= 340 *m/s.*

Solution. Let A be the position of the tank when shot was fired and B be its position when its echo was received.



AB= V ×t

Where, v = velocity of tankt = time for echo

Distance travelled by sound $x + x$ -vt = 2x-vt.

Therefore, $2x - vt = V \times t$

Where, V = velocity of sound.

Here, v= 72 *km/h*

$= 72 \times \frac{5}{18} = 20$ *m/s*

$V = 340\ m/s t{=}4.5\ sec.$

$$2x-(20\ \times 4.5) = 340\ \times 4.5$$

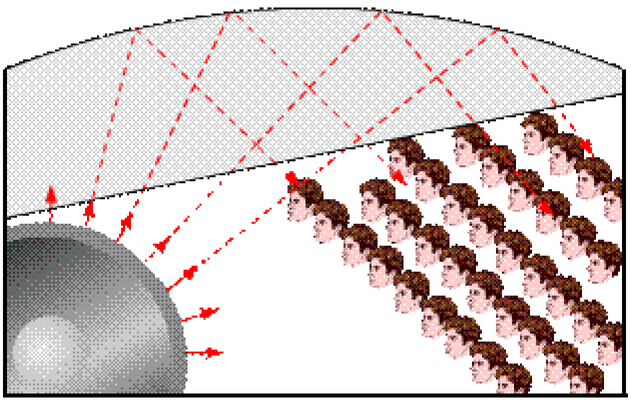
$$2x = \frac{360\times 4.5}{2} m$$

$$\boldsymbol{x = 810m}$$

REVERBERATION

A sound created in a big hall will persist by repeated reflection from the walls until itis reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation.

- In an auditorium or big hall, excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound-absorbent materials like compressed fibre board, rough plaster etc. Concave reflectingsoundboardsarefittedascurvedceilingsinsideauditoriumsandthespeakersareplaced at
- the focus of the sound board as shown in the figure 6. This prevents the spreading out of sound waves in different directions. Rather sound after reflection from the curved surface



reaches all corners of the hall evenly.

Figure 6: Curved ceiling of the auditoriums.

- Speaking tube or megaphone: Megaphone or loud speakers have horn-shaped tube to confine the air in the tube and prevent the sound waves from spreading out by successive reflections.
- Ear trumpet or hearing aid: It is a device which is used by the persons who are hard of hearing, shown in figure 7. The sound waves received by the wide end of the trumpet are reflected into a much narrower area, leading it to the ear. This enhances the amplitude of

vibrating layer of air inside the ear and helps in improving hearing.

Figure 7: Modern day hearing aid.

32.6 RANGEOF HEARINGIN HUMANS

Our ears are sensitive to both the amplitude and the frequency of sound wave. Some sounds appear loud whereas others appear faint to the ear. In other words, loud ness is the degree of sensation and depends upon the sensitivity of the ear (varies from person to person). In general, human ear is sensitive to frequency of sound/vibrations extending from about 20 Hz (1Hz=1cycle/s) to 20kHz (1kHz = 1000Hz). Toddlers and some animals, such as dogs can hear up to 25k Hz. Our ears become less sensitive to higher frequencies with increase in age.

Sounds of frequencies below 20 Hz are called infrasonic sound or infrasound. Rhinoceroses communicate using infrasound of frequency as low as 5 Hz. Whales and elephants produce sound in the infra sound range.

ULTRASONICS

Sounds of frequencies higher than 20 kHz are called ultra sonic sound or ultrasound or **ultrasonics**. **Ultrasonics** is produced by animals such as dolphins, bats and rats. There are various applications of ultrasounds in our day-to-day life.

APPLICATIONS OF ULTRASONICS

- Bats use ultrasonic waves to navigate and to detect insects in the surroundings. The bat sends out the waves and receives waves that are reflected by the insect's body. These waves and their reflections help the bat to know the exact location of the insect. Dolphins use ultrasound to find fish and to detect sharks that may attack them. They also use ultrasonic waves to communicate with each other. The ultrasonic waves have a variety of applications in many fields.
- The ultrasound waves are used in medical science (radiology) to take pictures of the interior of the human body. The ultrasound scanning technique helps in examining any defects present inside the abdomen area. Laproscopic surgery (bloodless surgery) these

days uses ultrasonic waves to create images of the inside body.

- The vibrations of the ultrasound waves are used in physiotherapy these days for relaxing muscles and joints and in relieving neuralgic pains.
- Ultrasonic waves are use dinsterilising water and milk since they are capable of destroying bacteria.

SUPERSONICS

You may have watched the republic day (26^{th} January) parade on the Raj path New Delhi, either personally or on Television screen. On every 26^{th} Jan, there is an Air show organised by our Indian Air Force, on the skies of New Delhi. Different fighter aircrafts with various formations used to fly high at very high-speed creating sounds like thunder.

Figure 8: Supersonic light combat air craft (LCA) TEJAS manufactured in India by Hindustan Aeronautics limited (HAL).

When an object travels with speed greater than that of sound, it is said to have supersonic speed. When supersonic air craft travels in air with velocity greater than the velocity of sound in air, a shock wave results. The supersonic aircraft produces shock waves in air. These shock waves generated by a supersonic aircraft, travelling at supersonic speed, carry a great amount of energy. The pressure variation associated with this type of shock wave produces a burst or cracking sound called 'sonic boom'. Remember that as long as the aircraft moves with a supersonic speed, it continues to send the sonic boom in the surrounding medium.

SONAR

SONAR stands for Sound Navigation and Ranging. Sonar is a device that uses ultrasonic waves to measure the depth of a sea. It is also used to calculate the direction and speed of underwater objects. This is used by ships to locates a rocks, ice bergs, underwater submarines etc.

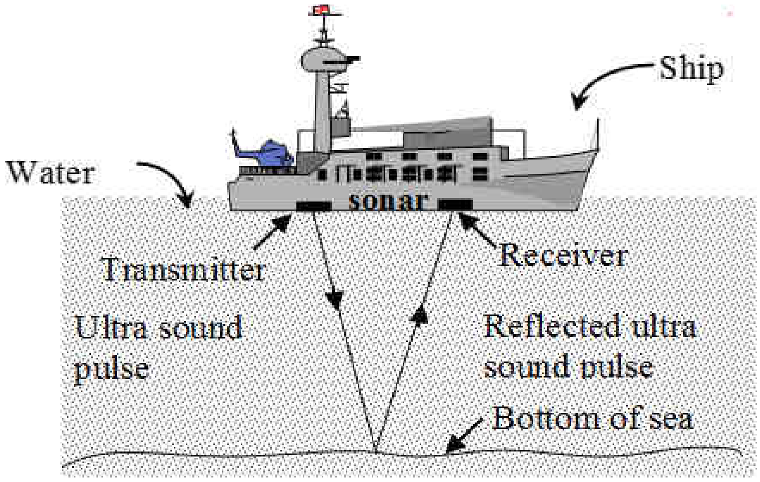


Figure 9: Ultrasound sent by transmitter and received by receiver.

SONAR is based on the principle of the reflection of sound wave (i.e. echo). It can be used to find the ocean depth accurately. Powerful pulses of ultrasound are sent out at regular intervals from a transmitter mounted on the ship. When these pulses are intercepted by a distant objector even the sea bottom, they get reflected. The reflected sound or echo is detected by an underwater receiver which is also mounted on the ship. The time interval between transmission and reception of the ultrasonic signal is recorded. By knowing the speed of ultrasound in sea water and the elapsed time between the transmission and the reception of the ultrasound signal at a point, these a depth of the sea at that point can be computed. The principle of SONAR is also used in industry for detection of flaws in metal bar can hear blocks or sheets without damaging them. This technique can be used for finding the level of a liquid in a huge metallic tank.

CHECK YOUR PROGRESS 32.3

1. What is persistence of hearing? What is its value?
2. What should be the minimum distance of the reflecting object, for production of echoo fan articulate sound?
3. What is meant by one syllable? What is its duration?

32.7 STRUCTUREOFHUMANEAR

An ear is one of the most important sense organ of the body that helps us to hear some sound. It allows us to convert pressure variations in air with audible frequencies into electric signals that travel to the brain via the auditory nerves. It is divided into three parts-the outer ear, middle ear and inner ear. Outer ear is otherwise called as ‘Pinna’. When sound waves reach the pinna, some waves pass directly down the middle of the tube called the auditory canal. Some waves which strike the outer part of the ear are reflected into the auditory canal. At the end of the auditory canal, there is a thin membrane which stretches across it. This is called the eardrum. When sound waves reach the eardrum, the ear drum gets stretched and relaxed (to and fro vibration).

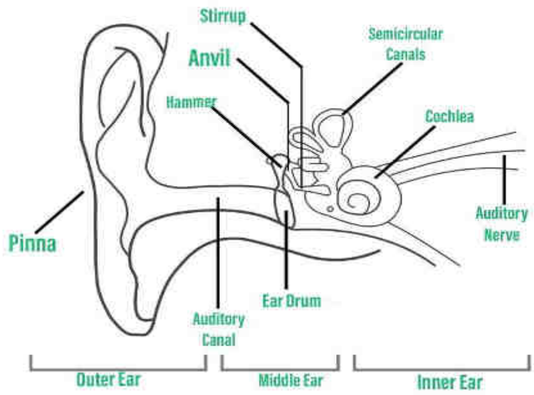


Figure 10: Internal structure of a human ear

The Middle Ear

In the cavity of the middle ear are three bones. They are called the hammer anvil and stirrup, which are named after their shapes. The ear bones form a system of levers. When the ear drum vibrates its movements are amplified by the lever system. The oval window on which the stirrup bone vibrates has a much smaller area than that of the eardrum. This difference in area between the eardrum and the oval window causes the vibrations of the eardrum to be amplified as they enter the inner ear and setup vibrations in the fluid here. The middle ear also has a tube called Eustachian tube, which is connected to the throat. When we swallow, the tube opens and the air in the middle ear is connected to air outside the body. This brief connection allows the air pressure in the ear to adjust to the air pressure outside the body. This balancing of air pressure allows the ear drum to vibrate as freely as possible.

The Inner Ear

The inner ear is filled with a fluid. The vibrations of the stir up setup waves in the fluid. There is a membrane with delicate fibres in the cochlea. Each fibre only vibrates in response to a sound wave with a particular pitch. When a fibre vibrates it stimulates a nerve ending and a nerve impulse or message is sent to the brain where we become aware of sound. The semicircular annals are part of inner ear but are not concerned with hearing. The information received by the brain from their sense organs enables us to stand upright when still and to keep up your balance when moving around. A hearing aid can be used to send an amplified sound to the eardrum when someone can hear only quite loud sounds. If the eardrum of middle ear has worse damage, anaid can pass on vibrations to the cochlea directly through the skull bones. Deafness occurs if the cochlea or auditory nerve is damaged.

32.8 NOISEPOLLUTION

Noise is an unpleasant sound that irritates people. The presence of a large amount of unwanted noise can upset the balance of the environment and lead to noise pollution. Noise levels are measured in decibels (dB) by a noise metre. The sound level the average human ear can just detect, called the threshold of hearing, is taken as 0dB. Normal conversation is about 60dB, a jet plane overhead is100dB.High-pitched noises are usually more annoying than low-pitched ones. Noise can damage the ears, cause tiredness and loss of concentration and, if it is very loud, result in sickness and temporary deafness. There are generally two types of noise pollution, namely; environmental noise pollution and man-made noise.

- **Environmental Noise:** The kind of noise produced from the wide-range of environmental happenings refers to environmental noise. It can include thunder storms, the mating calls of animals, and many more.
- **Man-made Noise:** The sound created due to man-made activities refers to man-made noise and serves as the major reasons for noise pollution. It can include noise from loud speakers, vehicles, construction work, household noise, and many more.

There are several ways of reducing unwanted noise. For example, silencers are used in vehicles exhaust system for noise control. Rotating shafts in machinery can be balanced better so that they do not cause vibration. Car engines are often mounted on metal brackets via rubber blocks which absorb vibrations and do not pass them on to the car body. Sound-insulating materials, such as carpets and curtains, and double gazed glass windows are used in offices/homes. The farther away the noise originates the weaker it is, so distance is a natural barriers, as are trees between houses and a noisy road. Tractor drivers, factory workers, pneumatic drill operators and others exposed regularly to noise often have to wear ear protectors.

RECAPITULATION POINTS

- Sounds are produced by vibrating objects.
- Sound travels through materials as waves of vibrating medium.
- Sound waves are longitudinal in nature.
- Sound waves produces compressions and rare factions.

- Sound waves can be characterized by its wave length, frequency and velocity.
- The velocity of sound depends upon factors such as, the nature of the medium, density, temperature and air pressure etc.
- Hearing range or audible range of sound waves is 20Hz to 20,000Hz.
- A sound wave whose frequency is less than 20 Hz is known as infra sonic.
- The sound waves having frequencies higher than 20,000 Hz are called ultrasonic waves or Ultrasound.
- Sound travel sat 332m/sin air at 0°Cand344 m/s in air at 20°C.
- Echo is a repetition or bouncing back of sound due to the reflection of original sound by a large and hard obstacle.
- SONAR stands for Sound Navigation and Ranging.
- External ear acts like a receiver of sound energy.
- The sound energy then travels along the ear canal.
- At the end of the ear canal, an area of tight muscles present is called the eardrum.
- Sound energy causes the ear drum to vibrate.
- The vibrations of the ear drum cause the ear bones to vibrate.
- The vibrations are passed on from the ear bones to the inner ear.
- In the inner ear is a nerve that detects these vibrations and sends electrical signals to the brain. The brain interprets these signals as sound.
- Hearing aid can be used to send an amplified sound to the ear drum when someone can hear only quits loud sounds.

TERMINAL EXERCISE

1. What type of wave-motion is setup in the medium when a tuning fork is set into vibrations2 What are compressions and rarefactions?
2. How do you define wave-length of a wave in terms of compressions and rare factions?
3. Give four example illustrating that the source of sound producing sound must be in the state of vibrations.
4. Describe an experiment to show that a material medium is necessary for the propagation of sound.
5. How would you show that sound can be reflected?
6. What are the uses of ultrasonic?
7. Describe an experiment to determine the velocity of sound in air. How would you determine the velocity of sound in solids?

8. Describe an experiment to determine velocity of sound in water.
9. What do you mean by echo? Obtain the necessary condition for production of echo of an articulate sound.
10. What is the function of an Eustachian tube?
11. Draw an eat labelled diagram of the internal structure of a human ear.
12. Discuss about the parts of a human ear.
13. Write various uses of ultrasound.
14. Write a note on noise pollution.
15. A battle tank is moving towards a mountain at 54 km/h fires an artillery and the officer in charge of the tank hears its echo after 5.3 s. What was the distance of the tank from the hill when the artillery was fired? Velocity of soundis345 m/s(Ans. 954 m).
16. Echo of an articulate sound is heard after 1.75 s, due to reflection of sound from a wall. What is the distance of wall from the source of sound? Velocity of sound is 342m/s. (Ans.299.25 m).
17. A man claps his hands in front of wall which is at a distance of 500m. After what time will heart heecho? Velocity of sound is340 m/s. (Ans. 2.94 s).
18. An Army officer standing at distance from a hill fires a gun and hears its echo after 4.7 s. He, then moves 300m closer to the hill and again fires a gun. Echo of this sound is heard by him after 2.9.s. What was his original distance from hill and what is the velocity of sound? [Ans.783.3m, 333.3 m/s].
19. An engine is approaching a tunnel surmounted by a cliff and emits a short whistle when 1km away. The echo reaches the engine after 5 second. Calculate the speed of engine assuming the velocity of sound to be340m/s. [Ans.23.6 m/s]
20. A man is located between wo cliffs, separated by a distance of 850m from each other. He fires a gun and hears first echo after 1.5 sec & second echo after 3.5 sec. Find (i) his distances from the two cliffs (ii) velocity of sound and (iii) time when he hears the third echo (Ans. (i)255 m, 595 m (ii) 340m/s(iii) 5 sec).
21. How do you define wave length of a wave?
22. How does velocity of sound in air depends upon its (i) density (ii) pressure and (iii)temperature?
23. What is meant by echo?
24. What are ultra sonic, infrasonic and supersonics.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 32.1

1. Sound Waves, Seismic Waves.

2. The transfer of energy and momentum from a point in a medium to another point in the medium without the actual transfer of matter between the points is defined as wave motion.

3. Transverse and Longitudinal are the two types of wave motion. When the particles of the medium vibrate in a direction perpendicular to the direction of propagation of the wave, it is called as transverse wave. However, when the particles of the medium vibrate about their equilibrium position in a direction parallel to the direction of propagation of the wave is called a longitudinal waves.

4. Longitudinal waves require a medium for its propagation. In this type of wave motion, the waves travel through a medium in the form of compression and rarefaction. The region of high pressure is called compression and the region of low pressure is called rarefaction. For example, Sound waves in the tube.

CHECK YOUR PROGRESS 32.2

1. The time taken by the particle of the medium to complete one oscillation is called as the time period of the sound wave. SI unit is seconds.

2. The number of vibrations or oscillations completed by a particle in one second is the frequency of the sound wave. SI unit of frequency is Hz.

3. $T = 1/v$.

4. 322 m/s

CHECK YOUR PROGRESS 32.3

1. The sensation of sound persists in our brain up to 1/10th of a second (0.1*s*). This property of ear/brain is called persistence of hearing. For production of an echo, it is essential that the reflected sound must reach back after 0.1*s*.
2. Minimum distance of reflecting obstacle for production of echo of articulate sound is 17m.
3. One syllable is a sound which takes 1/5 second for its production. Therefore, echo of one syllable will be heard only if the sound reaches back after 1/5 *second.*

33 LIGHT AND IT'S REFLECTION

INTRODUCTION

Our eyes are sensitive to visible light. Visible light is all the colors (red, yellow, blue, etc.) that we can see. But there are many other kinds of radiation that we cannot see. Radio waves, X-rays etc. Doctors use a special kind of film to see X-rays when they shine through your body. Some animals, like bees can see ultraviolet light.

Light is a kind of wave, somewhat like ocean waves or sound waves. Waves carry energy from one place to another. But light waves don't need water or air or anything to travel. They can move even in empty space (unlike sound waves). Light waves are made of a mixture of electricity and magnetism so they are called electromagnetic waves. They have properties like reflection, refraction etc.

33.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Define reflection of light
- Understand the laws of reflection with ray diagrams
- Write mirror formula and
- Gain knowledge about magnification
- Apply the knowledge about lenses in day-to-day life

33.2 LIGHT, REFLECTION AND SPHERICAL MIRRORS

33.2.1 DEFINITION OF LIGHT

Light is a form of electromagnetic radiation that enables the human eye to see or make things visible. It is also defined as radiation that is visible to the human eye. Light contains photons, which are minute packets of energy.

Important properties of light

- Light travels in a straight line.
- The speed of light is faster than sound. Light travels at a speed of 3 x 10^8 m/s.
- Reflection of light
- Light is a transverse wave and does not need any medium to travel.
- Light does not need a material medium to travel. That is, it can travel through a vacuum too. Scientists have assigned a value of 299, 792, 458 m/s to the speed of light in a vacuum.
- The wavelength (λ) of light changes when it goes from one medium to another.
- Light undergoes refraction (bending) when it travels from one transparent medium to another.

33.2.2 REFLECTION

Light is something that enables us to see objects around us from the point or source through which it gets reflected or appears to come from. For example, during daytime when sunlight falls on the tree, the tree reflected the light to the observer and so the tree is visible to the observer. However, during the night when there is no light falling on the tree, the tree is not visible properly or in other words, it appears darker. Therefore, it is concluded that sunlight or any other form of light is necessary to view the tree.

Some terms related to Light

1. **Ray of light:** The light traveling in any one direction in a straight line is called a ray of light. A ray of light is a path followed by light energy in a transparent medium. A ray of light is represented by a straight line having the sign of an arrow on it in the direction of propagation of light as shown in the figure.
2. **Beam of Light**: A group of parallel rays of light emitted by the source of light is called a beam of light.

33.3 REFLECTION OF LIGHT

The process of returning or bouncing back of the light rays to the same medium after striking a surface is called *reflection of light*. The surface which reflects the light is known as a *reflector*. The polished metal surfaces are *good reflectors*. However, *silver* metal is the best reflector. Even water surfaces, waxed surfaces, and glazed paper act as reflectors. The most commonly used reflector is a looking glass or a plane mirror.

Consider a ray of light AO incident on the plane mirror MM' at O, which after reflection from the mirror bounce back in the same medium followed the path OB. The ray OA and OB are called the *incident ray* and the *reflected ray*. Suppose ON is the *normal* of the plane mirror, then the angle between AO i.e incident ray, and the normal is called the *angle of incidence* while the angle between OB i. reflected ray and the normal is called the *angle of reflection*. Each of the terms related to the reflection located on the figure shown below:

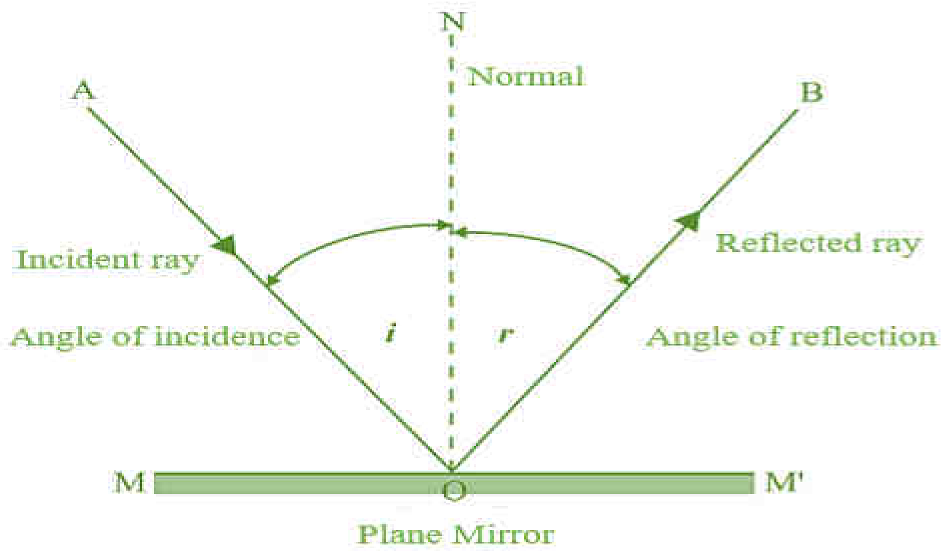


Fig 33.1: Reflection of light throw plane mirror

Normal: A perpendicular drawn to the reflecting surface at point O (known as the point of incidence) is called the *normal to the reflecting surface*.

Incident Ray: A ray of light that falls on the reflecting surface from a light source or an object is called the *incident ray*.

Reflected Ray: A ray of light that arises from the reflecting surface after reflection from it is called a *reflected ray*.

Angle of incidence: The angle between the incident ray and normal to the point of incidence on the reflecting surface is known as *incident angle*. It is denoted by 'i'.

Angle of reflection: The angle between the reflected ray and the normal to the point of incidence on the reflecting surface is known as the *angle of reflection*. It is denoted by 'r'.

33.3.1 Laws of Reflection

The reflection of light from a surface obeys certain laws called *Laws of reflection,* stated as:

First Law of reflection: The incident ray, the reflected ray and the normal to the reflecting surface at the point of the incident, all lie on the same plane.

Second Law of reflection: The angle of reflection is always equal to the angle of incident.

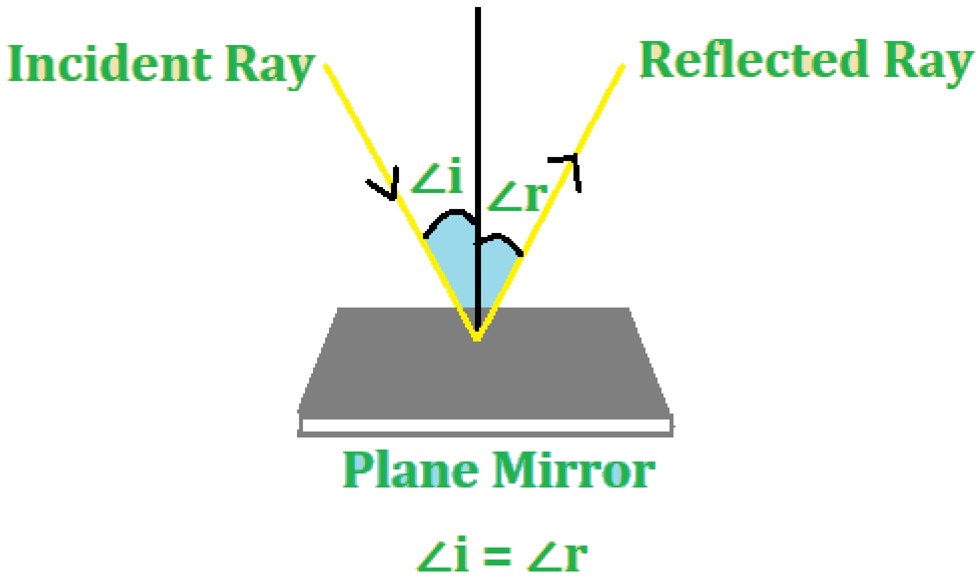


Fig 33.2: Law of Reflection

Nature of Light: The following are the two theories that help to understand the nature of light:

Wave theory of light: According to wave theory light, light consists of electromagnetic waves and does not require a medium to travel. The speed of light waves is very high (being about 3 x 10^8 meters per second in vacuum).

Particle theory of light: According to particle theory of light, light is composed of particles that travel in a straight line at a very high speed. The elementary particle that defines light is called a photon.

Two types of reflection such as:

33.3.2 Regular Reflections

This type of reflection occurs when the incident light ray falls on a polished, smooth and uniform surface such as a plane mirror. The incident beam of light rays is parallel to one another, and even the reflected light rays are parallel and fixed in one direction. The beam of reflected light rays is only visible from a particular direction or angle. Thus, the use of this reflection is simply for seeing our image in a plane and a uniform mirror.

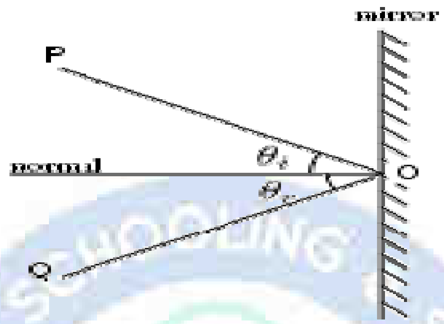


Fig 33.3: Regular Reflections

Regular reflection is a mirror-like reflection of rays of light. Here the rays of light which are reflected from a smooth and shiny object such as a mirror, are reflected at a definitive angle and each incident ray which is reflected along with the reflected ray has the same angle to the normal as the incident ray.

33.3.3 Diffused reflection

This type of reflection occurs when the incident light ray falls on a rough or non-uniform surface, such as a wall in a room. The incident beams of light rays are parallel to one another. However, these rays fall on different points in the rough surface after striking the surface, leading to a different and independent reflection of rays for every point. The irregular reflection results in every reflected ray travelling in different directions.

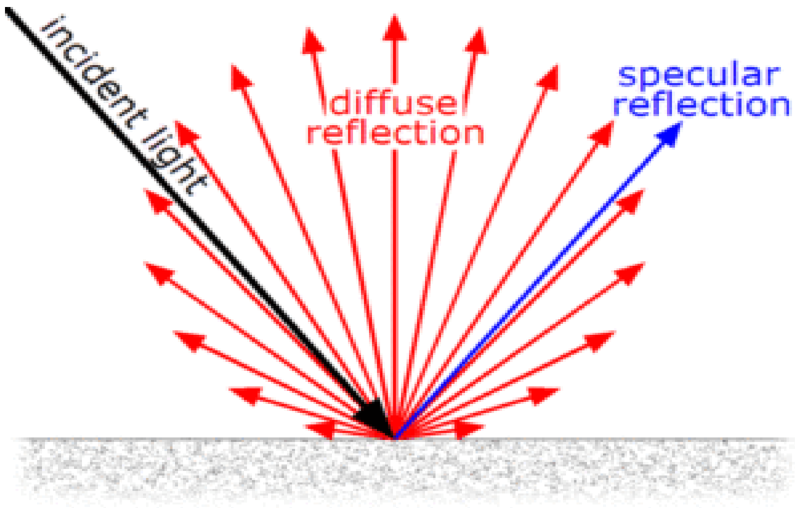


Fig 33.4: Diffused Reflection

33.4 TWO TYPES OF IMAGES

The product of these reflections takes place in the formation of an image. An image is what we see after the phenomenon of reflection of light. There are mainly two types of images that the reflection of the light waves can produce.

- **Real image-** A real image is formed when the rays of light intersect in a real sense. Such an image can be obtained on a screen, and the image obtained is inverted in nature. A real image is formed when the reflection of light rays is done on a concave mirror.
- **Virtual image**- A virtual image is formed when light rays appear to diverge from the image. They do not authentically intersect. Such an image cannot be obtained on a screen, and the produced image is erect in nature. A virtual image is formed when the reflection of light rays is done on a plane mirror or a convex mirror.

Solved Problem

Example: If angle of incidence of a ray of light is 35°, calculate angle of reflection.

Solution:

Given, angle of incidence=35°

According to law of reflection,

$\angle i = \angle r$

$\angle r = 35^{\circ}$

Hence angle of reflection is 35°.

33.5 PLANE MIRROR AND LATERAL INVERSION

Every one of us would have seen our image in a mirror. The image formed in the mirror will be the same as we do in front of it. But, if you have noticed closely, there is a difference in the image left unnoticed. Now, when we lift our left hand, it is seen that the right hand is raised on the mirror. Likewise, when we touch the right ear using the left hand, it appears as the right hand is touching the left ear.

It is noted that the 'left side' appears as 'right side' and 'right side' appears as 'left side'. When we take a closer look, the image of our head will be at the top as it is. Here, the image does not appear upside down, but only the sides are interchanged.

Similarly, the image of a letter written on a piece of paper will be different in the plane mirror by interchanging the sides. This type of reversal where the right appears left, and vice-versa is known as lateral inversion.

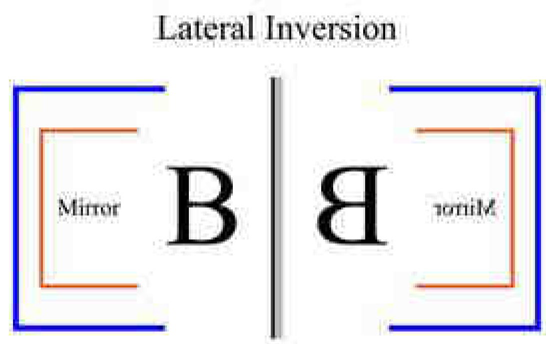


Fig 33.5: Lateral Inversion

The word 'AMBULANCE' is written backwards in an ambulance van due to lateral inversion.

Fig 33.6: Use of Lateral inversion in ambulance

This is because the drivers of other vehicles moving ahead of the ambulance can see the word 'AMBULANCE' in the right way around in their rear-view mirror and allow the vehicle to pass without blocking its path.

Fig 33.7: Image in rear-view mirror

Whenever we look at a plane mirror, we see the image by the phenomenon of lateral inversion.

Image properties of a plane mirror

1. The image is always virtual and erect.
2. The image is laterally inverted.
3. The image size on the mirror will be the same as the object size.

4. The object's distance from the mirror is equal to the image's distance from the mirror.

33.5.1 CONVENTION SIGNS

Before, we start further; it is very important to know the convention signs

Sign Conventions for Mirrors

Quantity	Positive When	Negative When
Object location (p)	object is in front of mirror REAL OBJECT	object is in back of mirror VIRTUAL OBJECT
Image location (q)	Image in front of mirror REAL IMAGE	Image is in back of mirror VIRTUAL IMAGE
Image height (h’)	image is upright	image is inverted
	CONCAVE MIRROR	CONVEX MIRROR

33.6 MIRRORS

What is a Mirror? A mirror is basically a shiny polished object which reflects most of the light falling on it. To make one side reflective, the other side is polished with a particular kind of material.

Types of Mirrors

One is plane mirror (more so, called the looking mirror), a flat, shining reflecting object.

The other is called spherical mirrors, which are that have curved reflecting surfaces are known as spherical mirrors. A Spherical mirror is formed when you cut out a piece from a sphere and make either of the surfaces reflective.

They are of two types of spherical mirrors:

Concave mirror like a spoon curved inside in the middle (Converging mirror)

Convex mirror like the balloon curved outside or bulges out. (Diverging mirror)

TERMS USED IN SPHERICAL MIRRORS

Understanding ray diagrams will become easier if you learn more about terms used in ray diagram and image formed by concave and convex mirror.

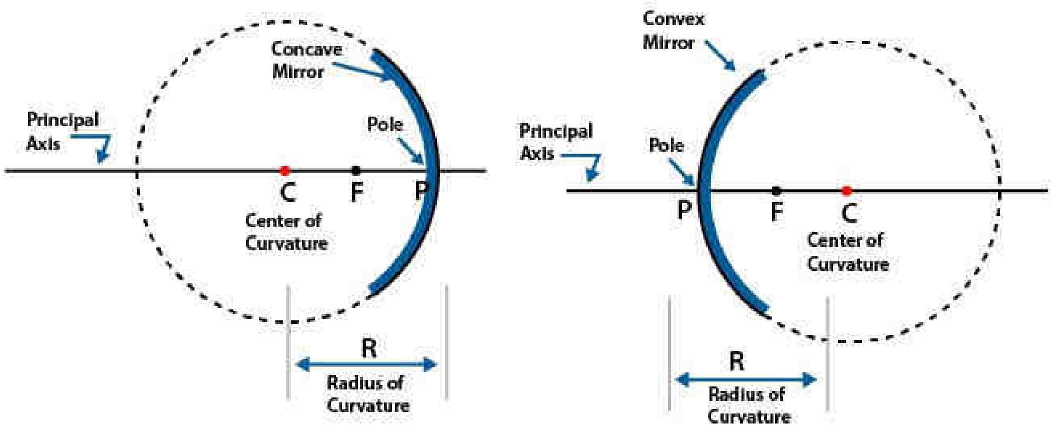


Fig 33.8: Spherical Mirror

1. Pole: It is the midpoint of a spherical mirror. It is represented by the letter 'P'.

2. Centre of Curvature: It is the center of the sphere of which the mirror is a part. The center of curvature is denoted by "C'.

3. The radius of Curvature: It is the distance between the pole of a spherical mirror and the center of the curvature. The radius of curvature is denoted by "R'.

4. Principal Axis: The straight line passing through the pole of a spherical mirror and the center of curvature.

5. Aperture: It is the diameter of the reflecting surface of a spherical mirror.

6. Focus: It is a point on the principal axis where the light rays parallel to the principal axis converge (if it is a concave mirror) or appear to diverge (if it is a convex mirror) after getting reflected from the mirror.

7. Focal Length: It is denoted by the letter 'f'. It is the distance between the center of the mirror and the focal point of the mirror. It is the point where a parallel beam of light converges or diverges.

33.7 IMAGE FORMATION OF CONCAVE MIRROR

Learn about the different types of images formed by a concave mirror. We can obtain different types of images by changing the placement of the object from a concave mirror. The formation of the images varies when the object is placed at:

1. At the Infinity
2. Beyond the center of curvature
3. At the center of curvature
4. Between the center of curvature and focus
5. At the focus
6. Between the principal focus and pole

Define the principal focus of a concave mirror**:** A concave mirror's principal focus is a location on its principal axis where all parallel light rays will converge following reflection from the concave mirror. The rays of light arriving from an object positioned at an indefinite distance from the mirror will be parallel to the principal axis, as illustrated in the figure. The rays will converge to the focal point of the mirror, which is denoted by point F in the image, after reflection from a concave mirror.

(a) **At the infinity**: A real, point-sized, inverted, and the highly diminished image is formed at the focus when the object is placed at the infinity.

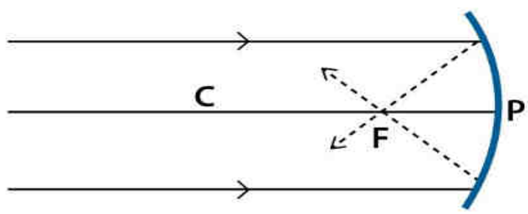


Fig 33.9: (a) Image when object is placed at infinity

(b) Beyond the center of curvature: A diminished image is formed between the center of curvature and focus when the object is placed beyond or behind the center of curvature. The nature of this image formed by concave mirror is real and inverted.

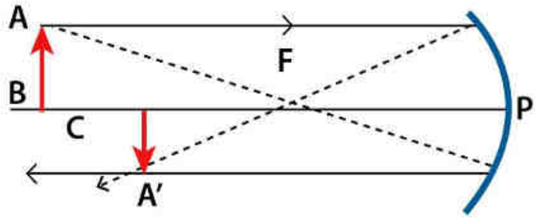


Fig 33.9: (b) Image when object is placed beyond the center of curvature

(c) At the center of curvature: Same size image is formed at the center of curvature when the object is placed at the center of curvature. The nature of this image formed by concave mirror is real and inverted.

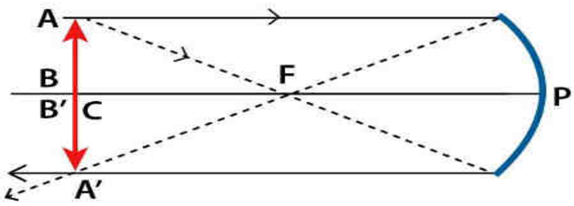


Fig 33.9: (c) When the image at C

(d) Between the center of curvature and principal focus: An enlarged image is formed behind or beyond the center of curvature when the object is placed in between the center of curvature and principal focus. The nature of this image formed by concave mirror is real and inverted.

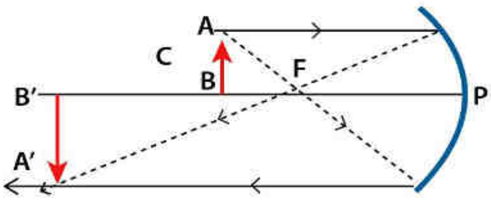


Fig 33.9: (d) When the image between C and P

(e) **At the principal focus**: A highly enlarged image is formed at infinity when the object is placed at the focus. The nature of this image formed by a concave mirror is real and inverted.

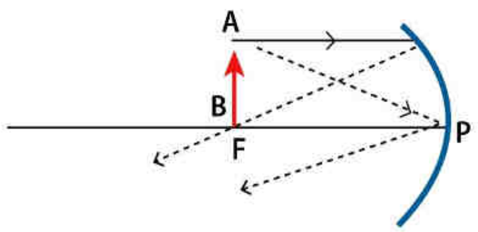


Fig 33.9: (e) When the image between C and P

(f) **Between the principal focus and pole**: An enlarged image is formed when the object is placed between the principal focus and pole. The nature of this image formed by concave mirror is virtual and erect.

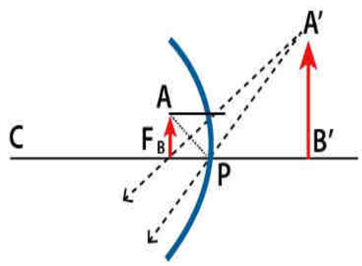


Fig 33.9: (f) When the image between principal focus and pole

33.7.1 Applications of Concave Mirrors

- Make-up Mirrors: Mirrors with a slight inward bulge help form a slightly enlarged image of the face, helping to figure out the issues with make-up or missed portions.
- Dental Mirrors: Dentists use concave mirrors to see the cavity hidden beyond the human sight in the jaw. These mirrors also help enlarge the damaged or infected area to analyse the extent of the damage.
- Solar Furnace: These mirrors help bring solar energy and concentrate it on a single point. This phenomenon helps in the generation of electricity at a large scale. It is also used in cooking, melting of metals and other applications.
- Headlights: Concave Mirrors are used in the car's headlights to provide a focused beam of light, aiding in better illumination of the path.

- Telescope: Light coming from the far-off planets is similar to the light from infinity. The concave mirror focuses the image on a plane mirror, and the image formed in the plane mirror is visible through the eyepiece.
- Medical Optical Instruments: An ophthalmologist focuses light in the patient's eye using a concave mirror. The retina gets illuminated, which can be seen from behind the concave mirror using a small hole in it.
- Microscope: Concave mirrors converge light on the specimen to make the surroundings darker and illuminate the specimen better to accentuate the results.
- Aircraft Landing Aid: The aircraft landing aid uses concave mirrors, and it plays an important role in helping the pilot land the aircraft correctly.
- Shaving Mirrors: This is similar to the use of concave mirrors in make-up mirrors. Shaving mirrors render an enlarged image, which helps the user effectively see any missed spots while shaving.

33.7.2 Convex Mirror

The reflective surface in convex mirror is on the bulge or outer side. Whatever be the distance between the mirror and the object, the image formed by a convex mirror is always diminished, erect and virtual. Convex mirrors reflect the light incident on them and therefore convex mirrors are also known as diverging mirrors.

The light gets diverged from the reflecting surface of a convex mirror which is why it is also known as a diverging mirror. The images formed by the convex mirrors are always erect, virtual, and diminished regardless of the distance between the mirror and the object.

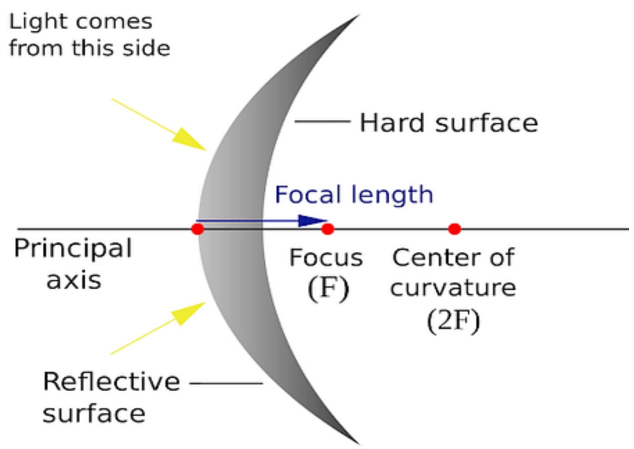


Fig 33.10: Convex Mirror

Convex Mirror: Image Formation

There are two possibilities of image formation depending on the position of the object in a convex mirror

- When the object is at infinity and
- When the object is between the infinity and the pole.

When the Object is at Infinity

When the object is placed at the infinity of a convex mirror, a point-sized image is formed behind the convex mirror at the principal focus. The image thus formed will be highly diminished, virtual and erect.

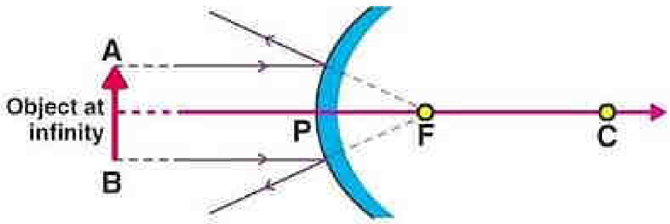


Fig 33.11: Image when the Object is at Infinity

When the Object is placed between Infinity and Pole

When the object is placed between the infinity and pole of a convex mirror, the image formed will be diminished, virtual and erect, and will be formed in between the pole and the focus, that is, behind the convex mirror.

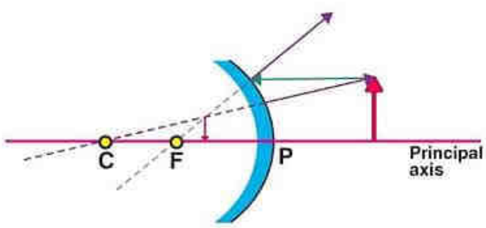


Fig 33.12: When the Object is placed between Infinity and Pole

33.7.3 Applications of Convex Mirror

Convex Mirrors have a number of applications in day-to-day life. Here are some of the important functions of a concave mirror.

In Automobiles

It is important to have a good overview of the vehicles that are around us while we are driving. Automobiles have rear view and side-view mirrors that help the drivers with the same. Convex mirrors are used as rear view mirrors in automobiles to help the drivers get a good view of the road and the vehicles behind them. This helps them foresee risky situations and thus avoid accidents.

Fig 33.13: Image in Rear view mirror

Convex mirrors have broader fields of view when compared to concave and plane mirrors. The concave mirrors are capable of providing a fish-eye view to the person who is driving an automobile and this feature helps them get a clear rear view of the roads and the different vehicles around them. The virtual image that is formed by the convex mirror will also be smaller than the actual size thus providing a wider field view for the driver.

In Mobile Cameras

Mobile cameras that have selfie cameras built into them use a convex mirror to capture self-portrait shots.

Fig 33.14: In Mobile Cameras

Automated Teller Machines

Convex mirrors are placed close to ATM or automated teller machines so as to permit the customers if there is anyone standing behind them. This helps in ensuring the security of the customers while they are using the ATM. It helps in avoiding the issue of theft of the withdrawal money of the customers and also keeps the identity of the ATM user safe.

Fig 33.15: Convex Mirror placed at ATM

In Telescope

Telescopes are made using convex mirrors so as to view farther objects clearly as point-sized images.

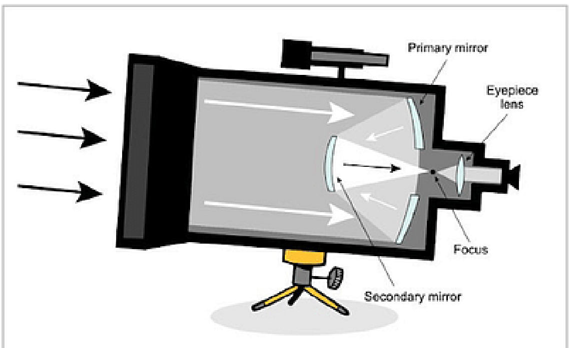


Fig 33.16: Uses of Convex mirror in telescope

33.7.4 Differences Between Concave and Convex Mirrors

As with the image formation, definition and uses, there are a large number of differences between concave and convex mirrors.

Convex Mirror vs. Concave Mirror		
Property	Convex Mirror	Concave Mirror
Other names	Diverging mirror, fish-eye mirror	Converging mirror
Reflecting surface	Curved outwards	Curved inwards
Center of curvature	Lies on the opposite side of the reflecting surface	Lies on the same side of the reflecting surface
Focus and focal length	Lies behind the mirror and focal length is negative	Lies in front of the mirror and focal length is positive
Image	Virtual, upright, and diminished	Real and inverted, except when the object is placed between the pole and the focus. In that case, the image is virtual, upright, and enlarged.
Image size	Smaller than the size of the object	Can be smaller, equal to, and bigger than the object depending on the position of the object
Image position	Always within the focus	Can be anywhere on principle axis depending on the position of the object
Image projection	Cannot be projected on a screen	Only real image can be projected on a screen
Uses and applications	Side view mirrors in vehicles and as security mirrors in grocery stores and supermarkets	Reflecting telescope, headlamp, searchlight, and torchlight

CHECK YOUR PROGRESS 33.1

1. Define light.
2. Give two properties of light.
3. Tell about reflection and laws briefly.
4. Tell three uses of Concave Mirrors.
5. What are the two differences between a concave and convex mirror?

33.7.5 Mirror Formula, Magnification

Let us first know about the terms used in the mirror formula of spherical mirrors.

- Object distance (u) : The distance of the object from the pole 'P' of the spherical mirror is called the object distance. It is denoted by the letter 'u'
- Image Distance (v) : The distance of the image from the pole 'P' of the spherical mirror is called the image distance. It is denoted by the letter 'v'.
- Focal length (f) : The distance of the principal focus (F) from the pole (P) of the spherical mirror is called the focal length. It is denoted by the letter 'f '.

The relationship between the image distance (v), object distance (u) and focal length (f) of a spherical mirror is known as the mirror formula. The Mirror formula can be written as :

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

where the symbols have their usual meaning.

(a) Magnification

Physically, we all understand what magnification is. It can be defined as the extent to which the image appears bigger or smaller in comparison to the object size.

It is represented as the ratio of the height of the image to the ratio of the height of the object. Magnification is denoted as the letter 'm'. Were, Magnification (m) = h/h’

And h’ is the image height and h is the object height.

Magnification can also be related to the image distance and object distance; therefore it can also be written as:

m = -v/u

Where v is the image distance and u is the object distance.

Hence, the expression for magnification (m) becomes:

m = h’/h = -v/u

Mirror formula in terms of Radius of Curvature:
Since, the radius of curvature (R) is two times its focal length (f), that is

$$R = 2f$$

or

$$f = R/2$$

Hence, the Mirror Formula can be written as:

$$1/u + 1/v = 1/f = 2/R$$

Numericals

(a) The radius of curvature of a spherical mirror is 20 cm. What is its focal length?

Solution:

Given: radius of curvature (R) = 20 cm

The focal length of the mirror is $f = R / 2 = 20 / 2$

= 10 cm

CHECK YOUR PROGRESS 33.2

1. Give mirror formula.
2. Define magnification of mirrors.
3. Describe the equation for radius of curvature to the focal length of mirror.
4. A Concave mirror produces three times magnified real image of an object placed at 10cm in front of it. Where is the image located?
5. An object is placed at a distance of I0 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

RECAPITULATION

- Light is a form of energy which makes the objects visible to us.
- When light falls on a smooth and rigid surface and comes back to the same medium, the phenomenon is called reflection.
- In reflection, the angle of incidence is equal to the angle of reflection. Also the incident ray, reflected ray and normal drawn at the point of incidence all lie in the same plane.
- In plane mirror, the virtual image of the size of object and at equal distance from the mirror is formed.
- Spherical mirrors are of two types (i) concave and (ii) convex.
- In spherical mirrors radius of curvature is double of the focal length.
- Concave mirrors are used in make-up mirrors, dental mirrors, solar furnace, headlights, telescope, medical optical instruments, microscope, aircraft landing aid, shaving mirrors
- Convex mirror are used in automobiles, mobile cameras, automated teller machines, telescope.
- Magnification can be defined as the extent to which the image appears bigger or smaller in comparison to the object size

TERMINAL EXERCISE

1 Give four differences between concave and convex mirrors.

2 Describe in detail, reflection, it's laws with diagrams.

3 Draw image formation of convex mirror.

4 Tell five uses of convex mirror.

5 What is mirror formula and magnification?

6 An incident ray makes an angle of 45° with the surface of a plane mirror, calculate angle of reflection.

7 The radius of curvature of a spherical mirror is 10cm. What is its focal length?

8 A dentist uses a spherical mirror that produces an upright image that is magnified four times. What kind of mirror is it? What is its focal length in terms of the object distance?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 33.1

1. Light is a form of electromagnetic radiation that enables the human eye to see or make things visible. It is also defined as radiation that is visible to the human eye

2. Two properties of light (a) Light travels in a straight line. (b) Light is a electromagnetic wave and does not need any medium to travel.
3. Refer to the text
4. Three uses of Concave mirror Make-up Mirrors, Dental Mirrors, Headlights
5.

Convex Mirror vs. Concave Mirror		
Property	Convex Mirror	Concave Mirror
Other names	Diverging mirror, fish-eye mirror	Converging mirror
Reflecting surface	Curved outwards	Curved inwards
Center of curvature	Lies on the opposite side of the	Lies on the same side of

	reflecting surface	the reflecting surface

CHECK YOUR PROGRESS 33.2

1. Mirror Formula

Let us first know about the terms used in the mirror formula of spherical mirrors.

- Object distance (u) : The distance of the object from the pole 'P' of the spherical mirror is called the object distance. It is denoted by the letter 'u'
- Image Distance (v) : The distance of the image from the pole 'P' of the spherical mirror is called the image distance. It is denoted by the letter 'v'.
- Focal length (f) : The distance of the principal focus (F) from the pole (P) of the spherical mirror is called the focal length. It is denoted by the letter 'f '.

The relationship between the image distance (v), object distance (u) and focal length (f) of a spherical mirror is known as the mirror formula. The Mirror formula can be written as:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

where the symbols have their usual meaning.

2. Magnification

Physically, we all understand what is magnification. It can be defined as the extent to which the image appears bigger or smaller in comparison to the object size.
It is represented as the ratio of the height of the image to the ratio of the height of the object. Magnification is denoted as the letter 'm'. Where,
Magnification (m) = h/h'
And h' is the image height and h is the object height.
Magnification can also be related to the image distance and object distance; therefore it can also be written as:
m = -v/u
Where v is the image distance and u is the object distance.
Hence, the expression for magnification (m) becomes:
m = h'/h = -v/u

3. Mirror formula in terms of Radius of Curvature:

Since, the radius of curvature (R) is two times its focal length (f), that is

R = 2 f OR f = R/2

4. Magnification = 3

object distance u=10 cm and we know,

Magnification m = -v/u

-v = m x u

= 3×−10 = -30

-v = -30

V = 30 , v=30 cm . Thus the image is formed at distance of 30 cm.

5.

Ans. Convex mirror

f = +15 cm, u = – 10 cm.

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

$$\frac{1}{15} = \frac{1}{v} + \frac{1}{(-10)}$$

$$\frac{1}{v} = \frac{1}{15} + \frac{1}{10}$$

$$\frac{1}{v} = \frac{5}{30} \qquad v = +6 \text{ cm}$$

The image is formed 6 cm behind the mirror, virtual image is formed.

34

REFRACTION OF LIGHT

INTRODUCTION

Why does pencil partly immersed in water in a glass tumbler, appears to be displaced at the interface of air and water? Why does bottom of a tank or a pond containing water appears to be raised? Why does a thick glass slab when placed over printed page, the letters appear to be raised when viewed through the glass slab? In this chapter we would get to know the science behind these phenomena and other such related natural events that we observe if we are keen observers.

Figure 34.1: A pencil immersed in water appears to be bent.

34.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Understand how light bends when travelling through different media
- Know the meaning of refractive index of a medium
- Identify examples of refraction taking place in nature
- Learn about various types of lenses
- Explain images formation by convex and concave lens with the help of ray diagrams
- Use lens formula and define magnification
- Gain knowledge about power of lens and define dioptre
- Explain how white light disperse through a prism and
- Describe scattering of light in nature with examples

34.2 REFRACTION OF LIGHT

Light appears to travel along straight-line path in a transparent medium. Have you ever thought What happens when light moves from one transparent medium to another? Does it still move along a straight-line path or change its direction. Let us explore this enquiry with an activity.

ACTIVITY 34.1

- Take a transparent, disposable plastic water bottle/ empty Dettol bottle and fill it half with water.
- Add 2-3 drops of Dettol.
- Fill the remaining half with smoke of incense stick(agarbatti). Close the bottle.
- Now throw a beam of light from toy laser in the setup (preferably in a dark room). What do you observe?
- Throw the beam from different angles and try to observe the path of light.

Figure 34.2: Light is seen bending at the interface

You will observe that light does not travel in the same direction in all media. It appears that when travelling obliquely from one medium to another, the direction of propagation of light in the second medium changes. This phenomenon is known as refraction of light. Let us now consider the case of a pencil immersed in water appearing to be bent (figure 34.2). The light reaching us from the portion of the pencil inside water seems to come from a different direction, compared to the part above water. This makes the pencil appear to be displaced at the interface (figure 34.3). Will the pencil appear to be displaced to the same extent, if in place of water, transparent liquids like kerosene or turpentine are used?

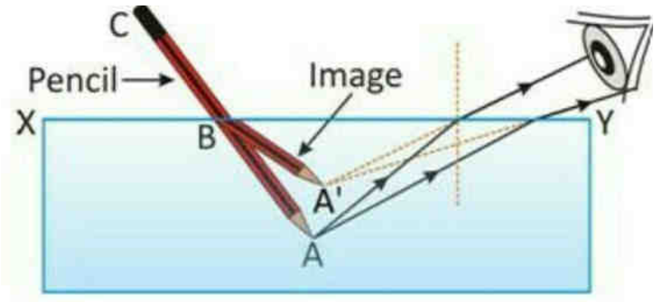


Figure 34.3: light from pencil in water appears to come from different direction.

ACTIVITY 34.2

• Place a coin in a large shallow bowl on a table.

• Step away from the bowl slowly. Stop when the coin simply vanishes from your sight.

•Request that a friend gently pour water into the bowl without disturbing the coin.

• Continue looking for the coin from your current location.

• Does the coin reappear from your vantage point? How could this be?

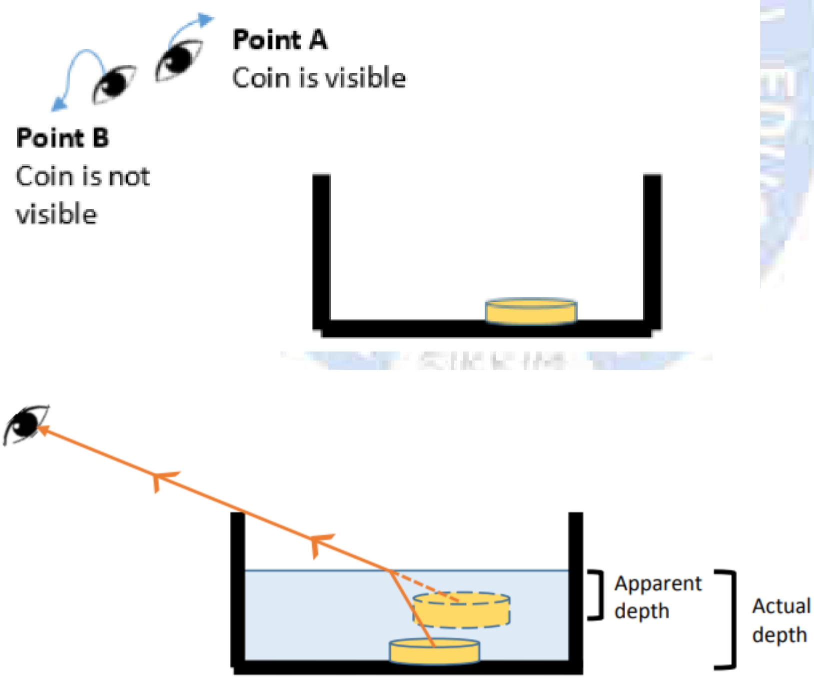


Figure 34.4 Coin re-appearing activity

Pouring water into the bowl reveals the coin once more. Because of light refraction, the coin appears slightly raised above its actual position.

Light bends away from the normal as it travels from denser medium to rarer medium. It bends towards the normal as it moves from rarer to denser medium.

34.3 REFRACTION THROUGH GLASS SLAB

To understand the phenomenon of refraction of light through a glass slab, let us do an Activity

ACTIVITY 34.3

- Place a glass slab on a white sheet of paper fixed to a wooden drawing board and draw a pencil boundary around it.
- Draw an OC line that intersects the boundary line obliquely. Connect pins A and B to that line.
- Locate these pins on the other side of the glass slab.
- Place a pin on the sheet so that A, B, and E form a straight line. Now align another pin F in a straight line with pins A, B, and E.
- Take out the slab and the pins. Draw a line from points F and E to the boundary at D. The line ABC gives the direction of incident ray on the glass slab while the line DEF gives the direction of emergent ray.
- The CD line indicates the refracted ray's direction within the glass slab.
- To the boundaries, draw normal N1CN2 at C and N3DN4 at D.

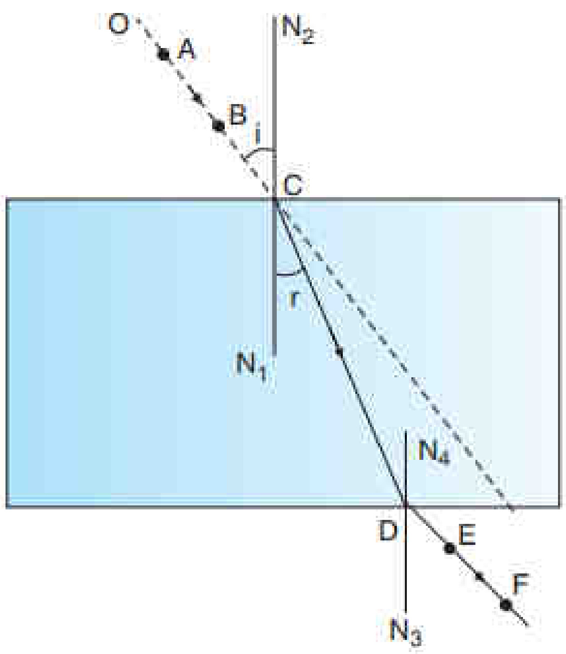
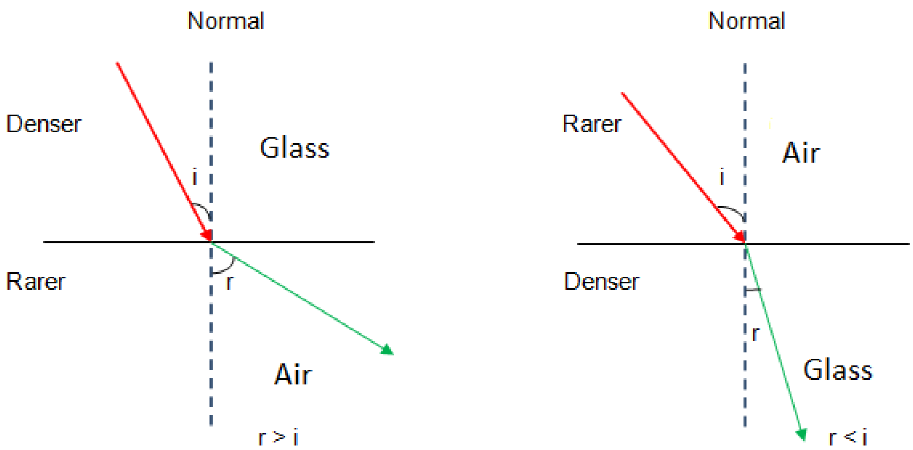


Figure 34.5 Refraction through a glass slab

Now you can see how the light ray bends towards the normal as it travels from a rarer (air) medium to a denser (glass) medium (Figure 34.6b). Furthermore, as a light ray moves from a denser to a rarer medium, it bends away from the normal path (Figure 34.6a).



(a) (b)

Figure 34.6: Bending of light when travelling through different medium

34.4 LAWS OF REFRACTION

How much a light ray would bend depends not only on the refractive index of medium, but it also depends on the angle of incidence. Scientist have devised laws through experimentation that light rays follows while undergoing Refraction, which are as follows:

1. The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane
2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant and equal to the refractive index of that medium. This law is also called Snell's law.

$$\frac{\sin i}{\sin r} = constant \qquad ...(34.1)$$

This constant value is called the refractive index of the second medium with respect to the first.

The extent of bending of light or refraction caused depends on the nature of the medium.

34.5 REFRACTIVE INDEX OF THE MEDIUM

Have you thought that why does light bends when ravelling from one medium to another. Scientists observed that a light ray travelling from one medium to another under goes changes in speed, a ray of light from a rarer medium to a denser medium slows down and bends towards the normal. On the other hand, the ray of light going from a denser medium to a rarer medium is speeded up and bends away from the normal. It shows that the speed of light in different medium varies. Different medium has different abilities to bend or refract light. This bending ability of a medium is known as the index of refraction or refractive index. It is defined as the ratio of the speed of light in vacuum to that in the material medium. Therefore, refractive index of a medium

$$n \approx \frac{\text{speed of light in vaccum}}{\text{speed of light in medium}} \quad ...(34.2)$$

TABLE 34.1 REFRACTIVE INDEX OF SOME MATERIALS

Material	Refractive index	Material	Refractive index
Air	1.0003	Canada balsam	1.53
Ice	1.31	Rock salt	1.54
Water	1.34	Dense flint glass	1.65
Alcohol	1.36	Ruby	1.71
Kerosene	1.44	Sapphire	1.77
Turpentine oil	1.47	Diamond	2.42

34.6 SOME EVENTS IN NATURE DUE TO REFRACTION

We are familiar that when light travels from one medium to another, refraction takes place. In atmosphere, different layers have different refractive index as the upper atmosphere is rarer as compared to lower atmosphere which is denser. Therefore, when light from sun, moon, stars passes through air, refraction takes place.

34.6.1 ATMOSPHERIC REFRACTION

Refraction of light due to different layers of earth atmosphere is called Atmospheric Refraction. Various phenomena we observe in nature like twinkling of stars, advanced sunrise and delayed sunset are caused due to Atmospheric refraction.

34.6.2 TWINKLING OF STARS

The stars twinkle, reason being atmospheric refraction of starlight. The starlight, when enters the earth's atmosphere, go through refraction continuously before it reaches the earth. The atmospheric refraction occurs in a medium of gradually changing refractive index. The apparent position of the star is not stationary but keeps on changing slightly, as the physical conditions of the earth's atmosphere is not stable Fig. 34.7. As the path of rays of light coming from the star goes on changing slightly, the apparent position of the star shifts and the amount of starlight entering the eye flickers – the star sometimes appears brighter, and at some other time, fainter, which is the twinkling effect.

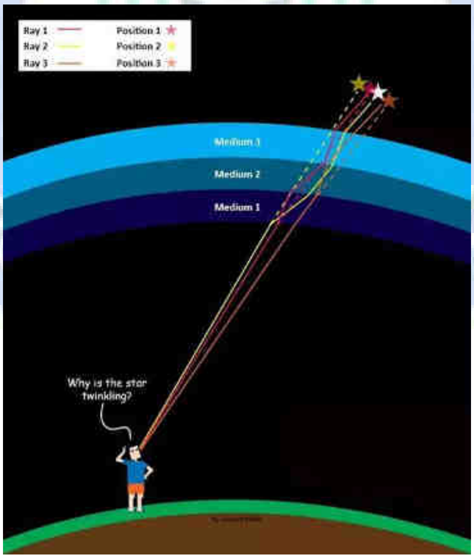


Figure 34.7 Twinkling of stars

34.6.3 Advanced Sunrise and Delayed Sunset

Do you know that in reality we actually see the sunrise about 2 minutes before the sun is actually at that perceived position? Did we ever know that the sunset that we actually see is of a sun that has already set? So why do these different perceptions occur.

During the process of sunrise, the light rays bend due to our atmosphere and we see the sun early even though the sun is just below the horizon. Similarly at the time of sunset (Fig.34.8) due to the same bending of light rays we can see the apparent position of the sun which is not the actual position, even after the actual sunset.

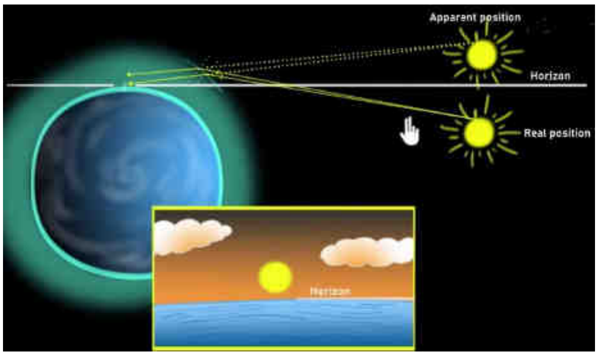


Figure 34.8 Delayed sunset

34.7 REFRACTION OF LIGHT THROUGH GLASS PRISM

We have explored how light gets refracted through a rectangular glass slab. What would happen to light rays when travelling through a transparent prism? Consider a triangular glass prism. It has two triangular bases and three rectangular lateral surfaces. These surfaces are inclined to each other. The angle between its two lateral faces is called the angle of the prism

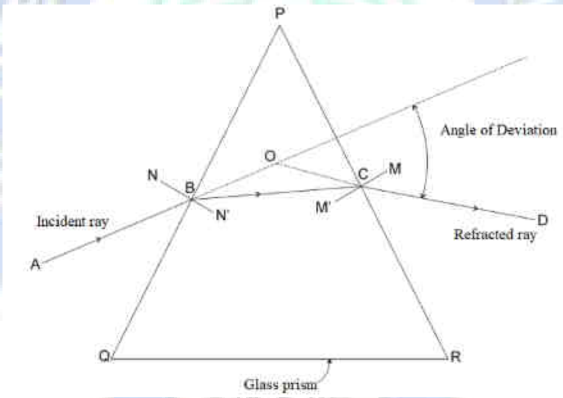


Figure 34.9 Refraction of light ray through glass prism

- A glass prism PQR has been kept on its base QR. A ray of light AB is incident on the face PQ of the prism. Here AB is an incident ray.
- The incident ray AB is going from air (rarer medium) to glass (denser medium), so it bends towards the normal BN’ and goes along the direction BC inside the glass prism.
- Thus BC is the refracted ray of light which bends towards the base QR of the prism.
- When a ray of light passes through a prism, it bends towards the base of the prism.
- When the ray of light BC travelling in the glass prism comes out into air at point C, refraction takes place again.

- Since the ray BC is going from the glass (denser medium) to air(rarer medium), the ray bends away from the normal MC and goes along the direction CD in the form of emergent ray.

34.8 DISPERSION OF WHITE LIGHT THROUGH A GLASS PRISM.

You must have been amazed by the spectacular colours in a rainbow. You must have thought how the white light of the Sun give us various colours of the rainbow? Before we get to this question, we shall first perform an activity.

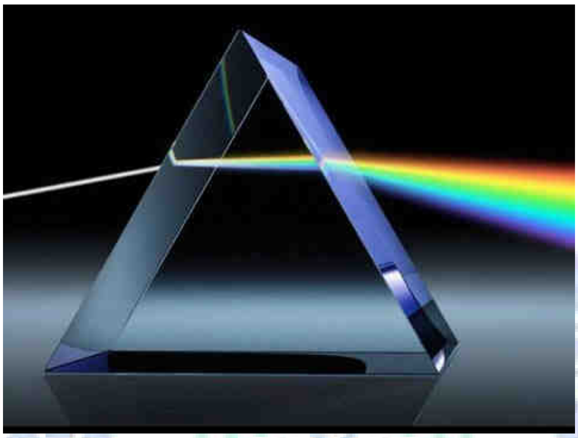


Figure 34.10 Splitting of white light into seven colours (dispersion).

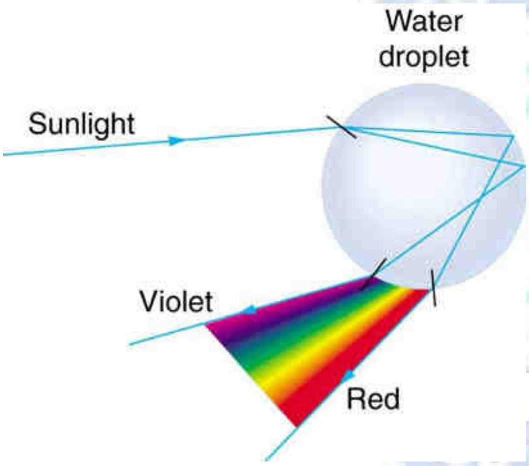
ACTIVITY 34.4

• Cut a small hole or narrow slit in the centre of a thick sheet of cardboard.
• Allow light to shine through the narrow slit. This produces a narrow white light beam.
• Take a glass prism and place it on one of its faces, allowing the light from the slit to fall on one of its faces.
• Slowly rotate the prism until the light it emits appears on a neighbouring screen.
• What do you notice? You'll see a lovely strip of colours. What causes this to happen?

The incident white light was most likely split into a band of colours by the prism. Take note of the colours at the two extremities of the colour band. What is the colour sequence that you see on the computer screen? Colors that can be seen include violet, indigo, blue, green, yellow, orange, and red, as illustrated in Fig.34.10. The acronym VIBGYOR can assist us in remembering the colour sequence. The Spectrum is a band of colours that depicts the components of a white light beam. Dispersion is the separation of light into its individual component's colours.

What causes these colours to appear? This is due to the fact that as light passes through a prism, various colours bend at various angles with respect to the incident ray. Red bends the greatest, whereas violet bends the least. As a result, the rays of each colour deviate and emerge along different paths, allowing us to distinguish between them. White light is a term used to describe any light with a spectrum resembling that of sunlight.

Rainbows are examples of light dispersion found in nature. Rainbows are the result of a combination of sunlight refraction and reflection. If you're a good observer, you're probably aware that we can only see a rainbow when we're gazing away from the sun. Figure (34.11a) shows how Light enters a drop of water and is reflected off the drop's back. Both as it enters and leaves the drop, light is refracted. The light is spread, and a rainbow is seen, as illustrated in Figure (34.11b), because water's index of refraction varies with wavelength. The rainbow of colours that an observer sees is made up of an infinite number of rays refracted and reflected toward the observer's eyes by multiple drops of water. When the background is dark, as in stormy weather, the effect is most spectacular, although it may also be seen in waterfalls and lawn sprinklers.



(a)

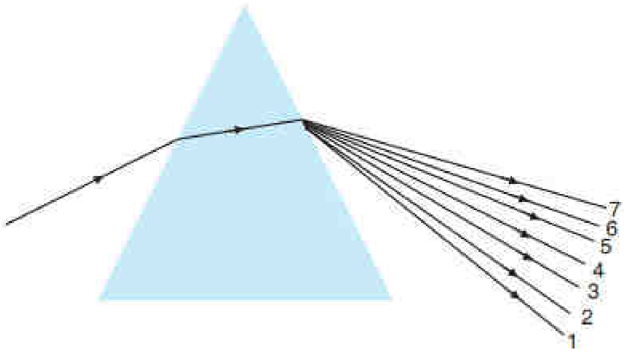
(b)

Figure 34.11: (a) Dispersion through rain drop(b)Rainbow formation

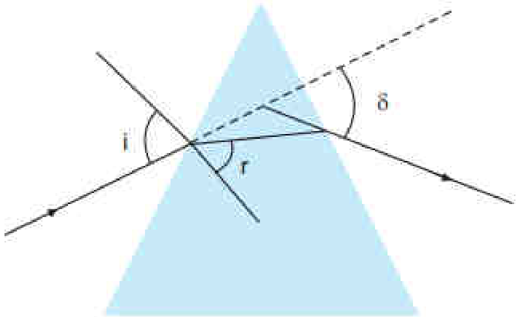
CHECK YOUR PROGRESS 34.1

1. When light passes from air to a medium its speed reduces to 40%. The velocity of light in air is 3×10^{-8} ms^{-1}. What is refractive index of the medium?

2. When sunlight is passed through prism, it splits into seven colours as shown in Fig. By numbers write corresponding colours.



3.If the prism shown in the Figure below is immersed in water, how do angles 'r' and ‘δ’ change for the same angle of incidence i.



4. Give reasons for when white light passes through a prism, it splits into seven colour.

5. Give an example of dispersion of light in nature

34.9 SCATTERING OF LIGHT

Scattering of light occurs when light rays collide with an obstruction such as dust, gas molecules, or water vapours and divert from their straight course. The Tyndall effect and the "red hues of sunrise and sunset" are examples of stunning light scattering phenomena.

34.9.1 Tyndal Effect

The earth's atmosphere is a diverse collection of microscopic particles. Among these particles is smoke, tiny water droplets, suspended dust particles, and air molecules. The path of a light beam becomes visible when it encounters such small particles. After being diffusely reflected by these particles, the light reaches us. The Tyndall effect or the light scattering effect, which you learned about in previous classes, is caused by colloidal particles. This phenomenon occurs when a fine beam of sunlight enters a smoke-filled room through a small aperture. As a result of light scattering, the particles become visible. The Tyndall effect is visible when sunlight passes through a dense forest canopy. Small water droplets in the mist scatter light. The colour of the scattered light is determined by the size of the scattering particles. Shorter wavelength light is scattered by very small particles, while longer wavelength light is scattered by larger particles.

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34.9.2 BLUE COLOUR OF SKY

The size of air molecules and other fine particles in the atmosphere is smaller than the visible light wavelength. These are more effective at scattering light with shorter wavelengths at the blue end (Violet, Indigo, and Blue) than light with longer wavelengths at the red end (Violet, Indigo, and Blue) (Orange, Red). The wavelength of red light is about 1.8 times that of blue light. As a result, as sunlight passes small particles in the atmosphere scatter the blue end (shorter wavelengths) of the spectrum more strongly than the red end (longer wavelengths).

Because our eyes are more sensitive to blue colour, the scattered blue end of light enters our eyes and appears primarily blue, even though violet is the most scattered. If the earth had no atmosphere, there would have been no scattering. In that case, the sky would have appeared gloomy. Passengers flying at very high altitudes see the sky as dark because scattering is minimal. You may have noticed that the 'danger' signal lights are red. Do you understand why? The red is scattered the least by fog and haze. As a result, it can be seen in the same colour from a distance.

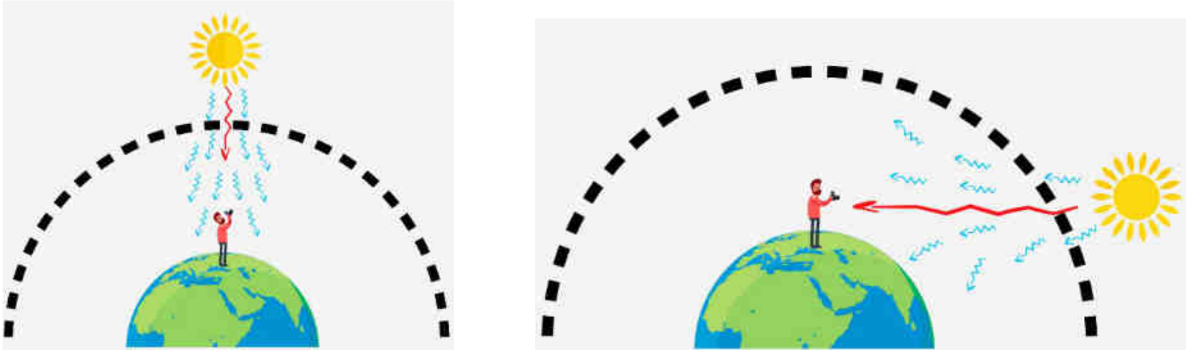
34.9.3 Colours of Sky and Sun at Sunrise and Sunset

Have you ever seen a sunset or sunrise with the sky and the Sun? Have you ever wondered why the Sun and the surrounding sky appear red?

Let us now examine the science behind it. The Sun's light rays must travel through a significant portion of the atmosphere near the horizon before reaching our eyes at Sunrise and Sunset.

The light from the Sun, on the other hand, would travel a shorter distance. The Sun appears white at noon because only a small amount of blue and violet light is scattered; the majority of the light reaches us intact.

Much of the blue light and shorter wavelengths are scattered toward the horizon by the particles. As a result, the wavelengths of light that reach our eyes are longer. The Sun takes on a crimson hue as a result of this.



(a) (b)

Figure 34.12: (a) Negligible scattering (b) Blue light getting scattered

34.10 REFRACTION THROUGH SPHERICAL LENSES

You may have seen watchmakers using a small magnifying glass to inspect minor parts. Have you ever placed your palm on a magnifying glass's surface? Is the surface flat or curved? Is the centre thicker than the sides? Lenses include spectacle lenses and those used by watchmakers. What is a lens, exactly? What is the mechanism of light ray bending? We'll go over them in this section. A lens is made of a transparent substance that is held together by two surfaces, one or both of which are spherical. In this case, a lens is confined by at least one spherical surface. Such lenses' other surface would be planar.

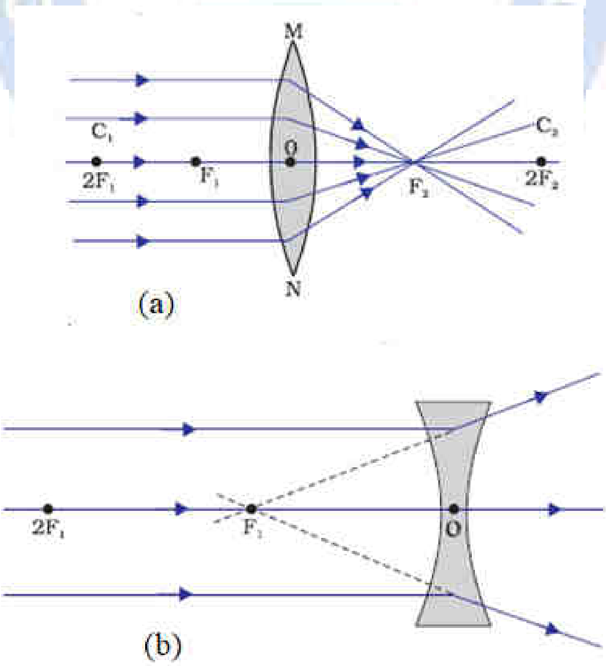


Figure 34.13 (a) Converging convex lens (b) Diverging concave lens

Two spherical surfaces bulging outwards are possible in a lens. A double convex lens is one that has two convex surfaces. It's simply referred to as a convex lens. In comparison to the edges, it is thicker in the middle. Light beams are converged by convex lenses, as depicted in Fig34.13(a). As a result, convex lenses are also known as converging lenses.

A double concave lens is similarly confined by two inwardly curved spherical surfaces. It's thicker at the edges than in the centre. As indicated in the diagram 34.13(b), concave lenses diverge light beams. Diverging lenses are a type of lens that does exactly that. A concave lens is simply referred to as a concave lens when it has two concave surfaces.
There are two spherical surfaces on either a convex or concave lens. A sphere is made up of all of these surfaces. The lens's centres of curvature are the spheres' centres.

The letter C is commonly used to signify the centre of curvature of a lens. We can refer to them as C1 and C2 because there are two centres of curvature.
The primary axis of a lens is an imaginary straight line that passes through both of its centres of curvature. An optical centre is the focal point of a lens (O).

ACTIVITY 34.5

1. Take a paper cup. Invert it and place some clay on it. Take a small convex lens of focal length 10-15 cm approximately. Insert it into the clay.
2. Take another paper cup. Invert it and fix a candle on it.
3. Place both the setups on a long scale. Keeping the lens fixed in between, place a sheet of paper as a screen. Mark on the ruler, the focus(F), 2F on both sides of the lens.
4. Attempt to obtain a picture of a burning candle on a piece of paper.
5. Using the ruler, adjust the distance between the lens, the candle, and the screen, and observe the image of the candle (object) from various positions. The object can be kept at F, 2F, between F and 2F, beyond 2F, at infinity (very far), or between the lens and F. You can tabulate your observations as follows

No.	Distance of object from the lens (cm)	Distance of image (paper) from the lens (cm)	Nature of image (real or virtual)	Size of image compared to the object.(Enlarged or diminished)
1				
2				
3				
4				
5				
6				

34.10.1 Sign Convention for Spherical Lenses

In the case of spherical lenses,

(i) all distances within the lens must be measured from the optical centre of the lens, and

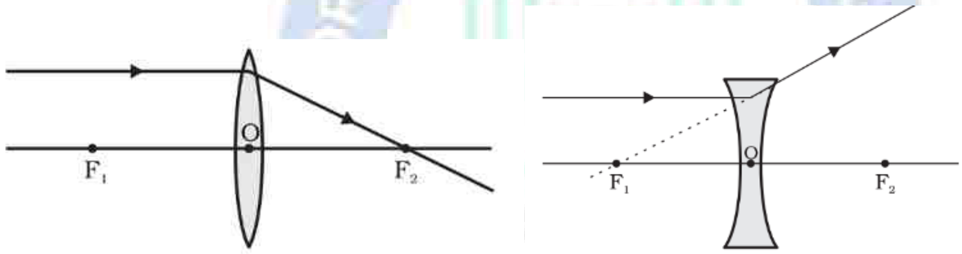
(ii) distances measured in the direction of the incident ray must be positive.

(iii) distances measured in the opposite direction of the incident ray are considered negative.

(iv) heights measured above the principal are considered positive, while heights measured below it are considered negative.

34.10.2 Rules for Ray Diagrams

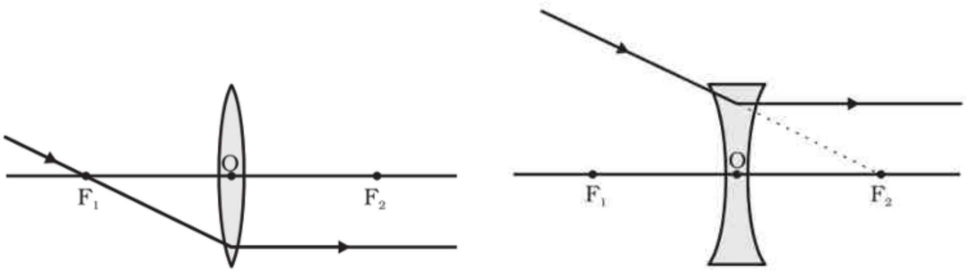
1. A ray of light from the object, parallel to the principal axis, passes through the principal focus on the other side of the lens after refraction from a convex lens, as shown in Fig 34.14. (a). As shown in Fig 34.14(b), the ray appears to diverge from the principal focus located on the same side of the lens in the case of a concave lens.



(a) **(b)**

Figure 34.14 Ray parallel to principal axis

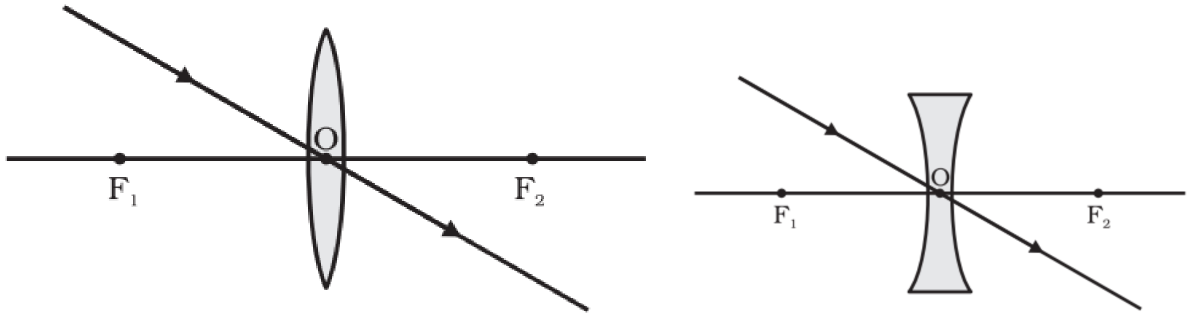
1. A ray of light passing through a principal focus will emerge parallel to the principal axis after refraction from a convex lens. This is depicted in Fig. 34.15. (a). After refraction, a ray of light that appears to meet at the principal focus of a concave lens will emerge parallel to the principal axis. This is depicted in Fig. 34.15. (b).



(a) **(b)**

Figure 34.15 Ray passing through focus

1. A ray of light passing through the optical centre of a lens will emerge with no deviation. Figures 34.16(a) and 34.16(b) show this.



(a) **(b)**

Figure 34.16 Ray passing through optical centre

34.10.3 Image Formation in Lenses

Only two rays are required to draw the image formed by any lens. These are the two rays:
(i) After refraction, a ray parallel to the principal axis of the lens converges at the principal focus of a convex lens. In the case of a concave lens, it appears to diverge. (ii) A ray directed toward the optical centre falls symmetrically on the lens and, after refraction, passes through it undeviated. Figure 1 depicts the image formations in a convex lens.

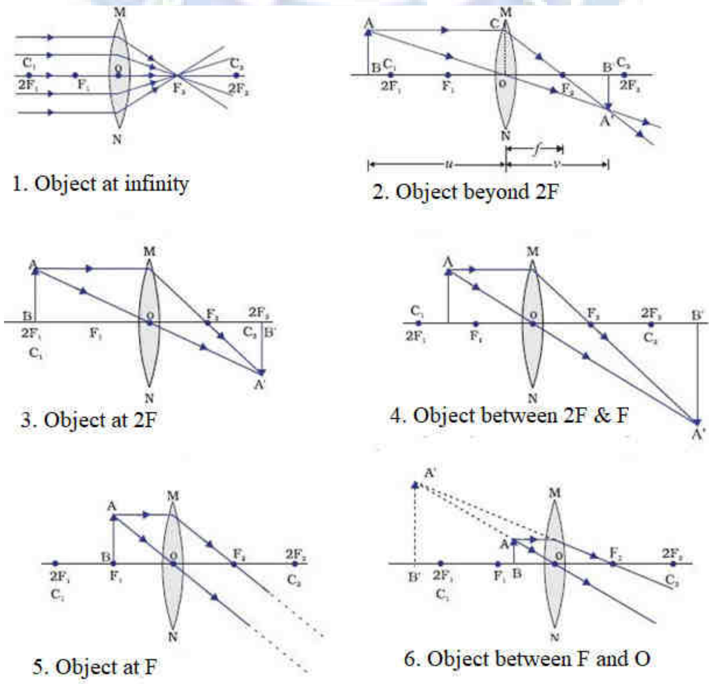


Figure 34.7: Ray diagrams for convex lens

TABLE 34.2 Nature, position and relative size of the image formed by a convex lens for various positions of the object.

Position of the object	Position of image	Size of the image	Nature of image
At infinity	At focus F_2	Very small, point size	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Highly enlarged	Real and inverted
Between focus F_1 and optical centre O .	On the same side of the lens as the object	Enlarged	Real and inverted

TABLE 34.3 Nature, position and relative size of the image formed by a concave lens for various positions of the object

Position of the object	Position of image	Size of the image	Nature of image
At infinity	At focus F_2	Very small, point size	Virtual and erect
Between infinity and optical centre O.	Between focus F1 and optical centre O	Diminished	Virtual and erect

34.10.4 Lens Formula

Assuming that the distance of the object from the optical centre of the lens is 'u,' the distance of the image from the optical centre is 'v,' and the focal length of the lens is 'f,' the relationship between u, v, and f for the lens can be shown as follows:

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u} \qquad \text{……. (34.3)}$$

34.11 MAGNIFICATION

You would have notice that in case of some lenses, the size of the image of an object is enlarged where as in some other cases it is diminished. If we take the ratio of the size of the image to the size of the object for a particular lens it remains constant for that lens. The magnification of the lens is the ratio of the size of the image to the size of the object.

$$\text{Magnification} = \frac{\text{size of image } (h_i)}{\text{size of object } (h_o)}$$

$$m = \frac{h_i}{h_o} \quad \ldots(34.4)$$

Magnification is also related to image distance 'v', and object distance 'u' as

$$m = \frac{v}{u} \quad \ldots(34.5)$$

Therefore, $m = \frac{h_i}{h_o} = \frac{v}{u}$ …(34.6)

Example 34.1 A concave lens has focal length of 20 cm. At what distance should the object from the lens be placed so that it forms an image at 15 cm from the lens? Also, find the magnification produced by the lens.

Solution

A concave lens always forms a virtual, erect image on the same side of the object.

Image-distance v = –15cm;

Focal length f = –20 cm;

Object-distance u =?

Since, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Or,

$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f}$$

$$\frac{1}{u} = \frac{1}{-15} - \frac{1}{-20} = -\frac{1}{15} + \frac{1}{20}$$

$$\frac{1}{u} = \frac{-4+3}{60} = \frac{-1}{60}$$

Or, $u = -60\ cm$

Therefore, object distance is 60cm

Magnification $m = \frac{v}{u} = \frac{-15}{-60} = \frac{1}{4} = +0.25$

The positive sign signifies the image is erect and virtual. The image is one-fourth the size of the object.

Example 34.2 A 1 cm object is placed perpendicular to the principal axis of a convex lens of focal length 15 cm. The distance of the object from the lens is 20 cm. Find the nature, position and size of the image. Also find its magnification.

Solution

Height of the object $h_o = +1$ cm;

Focal length f = + 15 cm;

Object-distance u = –20 cm;

Image-distance v =?

Height of the image h_i =?

Since, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Or,

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{-20} + \frac{1}{15}$$

$$\frac{1}{v} = \frac{-3+4}{60} = \frac{1}{60}$$

Therefore, $v=+60$cm

The positive sign of v shows that the image is formed at a distance of 30 cm on the other side of the optical centre. The image is real and inverted.

Magnification $m = \frac{h_i}{h_o} = \frac{v}{u}$

Or, $h_i = h_o \times \frac{v}{u} = (+1) \times \frac{60}{-20} = -3$ cm

Height of the image is 3 cm

Magnification m $= \frac{v}{u} = \frac{60}{-20} = -3$ or, −The negative signs of 'm' and h′ show that the image is inverted and real. It is formed below the principal axis. Thus, a real, inverted image, 3 cm tall, is formed at a distance of 60 cm on the other side of the lens. The image is three times enlarged.

CHECK YOUR PROGRESS 34.2

1. Name the type of lens which always produces virtual image.

2. Draw the ray diagram for image formation in concave lens.

3. An object of size 10 cm is placed in-front of a convex lens of focal length 20 cm. Find the size of the image formed.

34.12 POWER OF LENS

You've already learned that a lens's ability to converge or diverge light rays is determined by its focal length. A convex lens with a short focal length, for example, bends light rays through large angles by focusing them closer to the optical centre. Similarly, a concave lens with a very short focal length produces more divergence than one with a longer focal length. A lens's power is defined as the degree of convergence or divergence of light rays it achieves. A lens's power is defined as the reciprocal of its focal length. It is symbolised by the letter P. The power P of a lens with focal length f is given by

$$P = \frac{1}{f}$$

The SI unit of lens power is 'dioptre.' It is represented by the letter D. If 'f' is measured in metres, then power is measured in 'dioptres.' As a result, 1 dioptre is the power of a lens with a focal length of 1 metre. $1D = 1m^{-1}$. It is worth noting that the power of a convex lens is positive while the power of a concave lens is negative. Opticians prescribe corrective lenses with power ratings. Assume the prescribed lens has a power of + 2.0 D. This means the lens prescribed is convex. The focal length of the lens is + 0.50 m. Similarly, a lens of power – 2.5 D has a focal length of – 0.40 m. The lens has a concave shape.

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RECAPITULATION POINTS

- When light goes from one medium to another its speed changes and the light ray bends. This phenomenon is called refraction of light.
- In refraction, the ratio of sine of angle of incidence to the sine of angle of refraction is constant called refractive index.

- When light goes from rarer to denser medium it bends towards the normal and angle refraction remains less than the angle of incidence.
- When light goes from denser to rarer medium it bends away from the normal and angle of refraction remains greater than the angle of incidence.
- A transparent medium bounded by two well defined surfaces is called lens. There are two types of lenses (i) which converges light (convex lens) and (ii) which diverges light
- The focal length of a mirror f is given as:

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$

- The reciprocal of the focal length is called power of the lens. Its unit is diopter.

$$P=\frac{1}{f}$$

TERMINAL EXERCISE

QI. Choose the correct answer:

1. Which of the following can make a parallel beam of light when light from a point source is incident on it?
   (a) Concave mirror as well as convex lens
   (b) Convex mirror as well as concave lens
   (c) Two plane mirrors placed at 90° to each other
   (d) Concave mirror as well as concave lens
2. A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. The focal length of this mirror is
   (a) – 30 cm (b) – 20 cm (c) – 40 cm (d) – 60 cm

3. Under which of the following conditions a concave mirror can form an image larger than the actual object?
   (a) When the object is kept at a distance equal to its radius of curvature
   (b) When object is kept at a distance less than its focal length
   (c) When object is placed between the focus and centre of curvature
   (d) When object is kept at a distance greater than its radius of curvature

4. Which of the following statements is true?

(a) A convex lens has 4 dioptre power having a focal length 0.25 m

(b) A convex lens has –4 dioptre power having a focal length 0.25 m

(c) A concave lens has 4 dioptre power having a focal length 0.25 m

(d) A concave lens has –4 dioptre power having a focal length 0.25 m

5. Rays from Sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object?

(a) 15 cm in front of the mirror

(b) 30 cm in front of the mirror

(c) Between 15 cm and 30 cm in front of the mirror

(d) More than 30 cm in front of the mirror

QII. Answer the following questions:

1. What happens to the speed of light as it travels from a denser medium to a rarer medium (and vice versa)?

2. Is it possible for the angle of incidence to be identical to the angle of refraction? Justify.

3. Is it true that light is always converged by a convex lens? Explain.

4. Write down the characteristics of the image created by a concave lens.

5. What would the image generated by a concave lens with a focal length of 30 cm and an object at a distance of 15 cm look like?

6. When an object is positioned 20 cm away from the mirror, find the position of the image created in a concave lens with a focal length of 12 cm. Magnification is also available.

7. The greatest and minimum speeds of light are found in which of the following media?

Media	Refractive index
A	1.6
B	1.5
C	1.4
D	1.3

8. A screen is used to display the image of a candle created by a convex lens. If the lower half of the lens is painted black and entirely opaque, will the image be full size? Use a ray diagram to illustrate your answer.

9. Is it possible to create a real and erect image with just one lens?

10. What is light dispersion? What is the cause of light dispersion?

11. What causes distant objects to appear smaller and closer to one another?

12. Know the difference between visible, ultraviolet, and infrared light.

13. During light refraction, which of the following quantities remains constant?

I Light speed (ii) Light frequency (iii) Light wavelength

14. A planar mirror produces a magnification of +1. What exactly does this imply?

15. Determine the focal length of a lens with a power rating of 2.0 D. I'm not sure what kind of lens this is?

ANSWER TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 34.1

1. 5/3
2. (1) Violet (2) Indigo (3) Blue (4) Green (5) Yellow (6) Orange (7) Red
3. Water is denser than air, r and δ both will decrease.
4. Material of the prism has different value of refractive index for different colours of light.
5. Rainbow in the sky

CHECK YOUR PROGRESS 34.2

1. Concave lens.
2. Convex lens 40 cm.
3. -20 cm

SUPPLEMENTARY STUDY MATERIAL

1. NIOS SCIENCE BOOK FOR CLASS 'X'
2. NCERT SCIENCE BOOK FOR CLASS 'X'

35 HUMAN EYE

INTRODUCTION

A human eye is the most advanced optical instrument designed by nature. It is one of the most essential sense organs of human body, which detects light and sends signals via the optic nerve to the brain. We can view our colourful surrounding via an eye. An eye helps us to differentiate between different colours, read newspapers, distinguish objects situated on distant as well as nearby objects etc. This can be called as the finest photographic camera designed so far.

35.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

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The interior structure of a Human eye is shown inthefigure1.

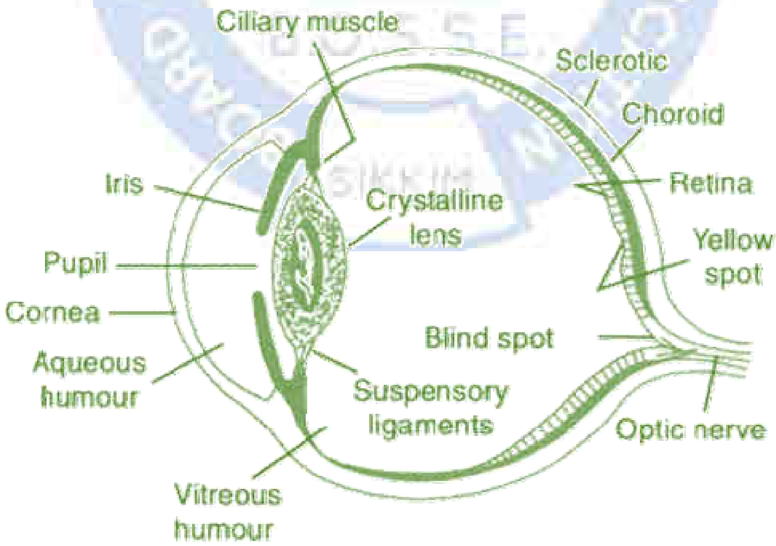


Figure1: Anatomical structure of a human eye

Cornea is the outermost part of a Human eye through which the light enters. It is a thin, transparent bulge membrane on the front surface of the eyeball. At the outer surface of the cornea, maximum refraction of the light rays incident on the eye takes place. Iris is the coloured tissue present behind the cornea, which forms around black opening called the

pupil. There is muscles control the pupil. As the iris muscles relaxes or squeezes, the size of pupil changes and the amount of light that enters the eye gets regulated. Eye consists of a crystalline, clear biconvex **lens** which is placed just behind the iris. The eye lens is composed of a fibrous, jelly-like material. The lens bends light and focuses it on a photo-sensitive screen called the **retina** to help us see clear images. The ciliary muscles helps the lens to bend or stiffen to transmit light from the cornea to the retina. The ciliary body produces a transparent fluid called **aqueous**

humor and bends the lens to refract light. The elasticity of the lens helps modify or change the focal length and thus the light from the objects at different distances are focussed on the retina. An inverted and real image is formed on the retina. The brain performs an image processing and turns the image back to normal. Thus we see things the way they are. The retina is a delicate membrane consisting of a large number of light-sensitive cells. These Photo-sensitive cells are activated when they are illuminated with light and thus generate electrical signals. These signals pass to the brain through the **optic nerves** (nerves present inside the eye). The brain receives and processes these signals, so that we view the objects as they are. There is a yellow spot on the retina, which consists of densely packed photosensitive cell and detects maximum light. This region is mainly responsible for colour vision or colour detection.

Do You Know: Cornea contains no blood vessels and very much sensitive to pain. Lens of an eye don't possess any direct blood or nerve connections. It depends on a clear fluid between the lens and the cornea, called the aqueous humor, to obtain essential energy and carry away waste products. The colour of Iris is very unique in nature, just like the fingerprint of a person. Eye scanners these days actually exploit this unique and distinct property of human eye. Every human eye colour is unique in nature due to Iris.

The elasticity of the crystalline lens allows us to focus on images at different distances with minimum deviation. The ability of the eye lens to fine-tune its own focalleng this called **power of accommodation** of an eye. However, its focal length cannot be reduced below a certain minimum limit. If we bring a book very much close to our eyes, we may see blurred (unable to distinguish) letters and feel strain in the eyes. The minimum distance from the eye, from where we a person can see and read something comfortably and distinctly is about 25cm. This minimum distance is called the least distance of distinct vision or the near point of the eye. The extreme point up to which a person can see objects clearly is called the far point of his/her eye. It is infinity for a normal eye. Thus, a normal eye can see objects clearly between 25 cm and infinity. However, this near point and far point of vision changes from person to person, based on health conditions, age factor etc. Or in other words, the power of accommodation varies from person to person. The flexibility of lens decreases with the increase in age. In such conditions, the person cannot see the objects distinctly and comfortably. Some of the common defects of vision and their correction are extensively discussed in the next section. In some cases, lenses become clouded or milky in old age and the vision become shazy. This condition is called cataract. This condition results in partial or complete loss of vision and then cataract surgery is performed. In this procedure, an artificial lens called an intraocular lens replaces the defective natural lens. A condition where a person cannot see some particular colours or distinguish between some colours clearly is called as colour blindness. In such conditions, yellow spot of the eye is generally affected.

CHECK YOUR PROGRESS 35.1

1. Define the terms magnification and resolution of a lens or an optical device?
2. What is the focal length of an eye lens?
3. What are anti-glare glasses and why are they used?

35.1 DEFECTS OF VISION AND THEIR CORRECTION:

There are primarily three refractive effects of vision.

These are:

(i) Myopia or short sightedness,

(ii) Hypermetropia or long-sightedness, and

(iii) Presbyopia.

(i) Myopia: Myopia is otherwise called as short/near sightedness. A person having myopia would have a clear nearby vision but the distant vision is affected. For patients with myopia, the far point of their eye is shifted closer than infinity. In such disorders, the image of a distant object is not formed exactly on the retina, rather in front of retina. This defect may arise when(i) the eye ball gets elongated or (ii) extreme curvature of the eye lens. A concave lens of suitable power can be used to focus the image back on to the retina as shown in the figure (Myopia correction).

Do you know? There is a blind spot on the retina which lacks any photoreceptor cells.

Figure2: Image showing myopia condition and its correction using concave lens.

(ii) Hypermetropia: Hypermetropia is also known as long-sightedness. A person suffering from hypermetropia can see distant objects easily but unable to distinctly see objects which are closer. In such defects, the near point of an eye, is shifted farther from the normal near point.

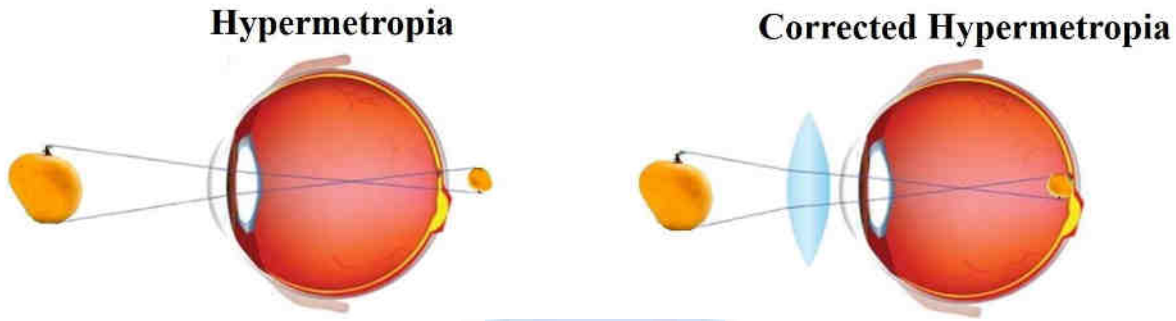


Figure3: Image showing Hypermetropia condition and its correction using convex lens.

Thus, while reading newspapers or books, a person has to hold it beyond the normal point of his/her eye for reading at ease. This is due to the fact that the light rays from a near object are focused at a point behind the retina. The schematic diagram of this effect is shown in figure 3. This defect may arise when (i) the size of the eyeball decreases and (ii) the focal length of the eye lens increases. This defect can be corrected by using a convex lens of appropriate power as shown in figure 3. Converging lenses are used in the eye glasses to provide extra focusing power necessary for forming the image on the retina.

(ii) Presbyopia: When the eye lens becomes hard and loses its elasticity, close-up vision is impacted. This condition is called as presbyopia. This is common for persons over age of40 years. Under such disorder ness, people require reading glasses or glasses with bifocals to view images clearly up close.

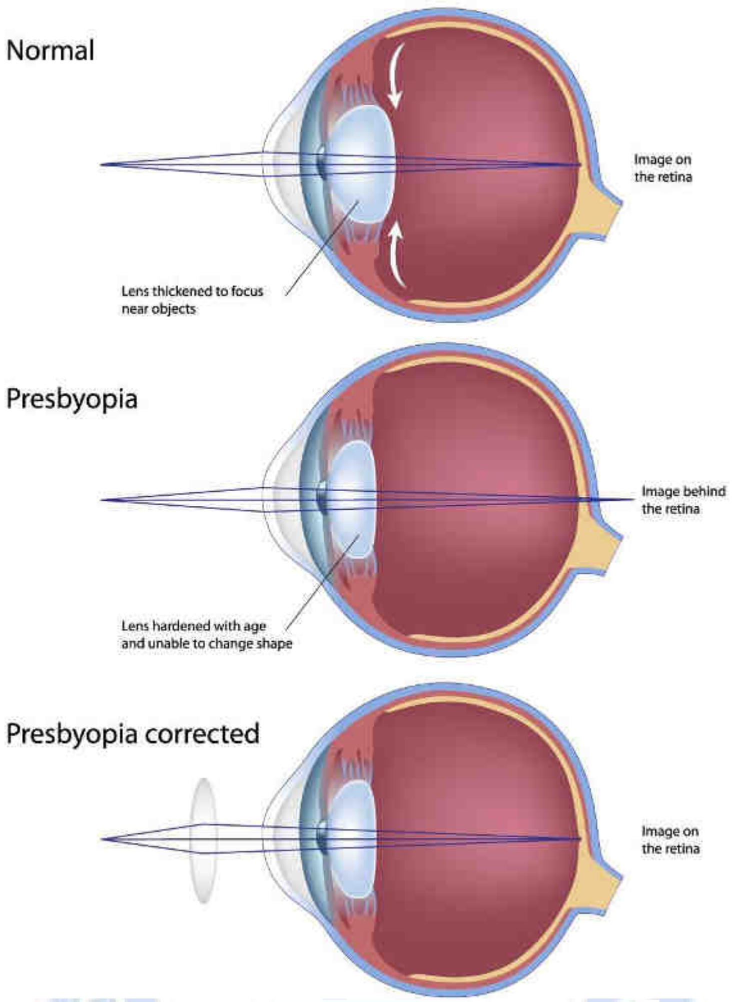
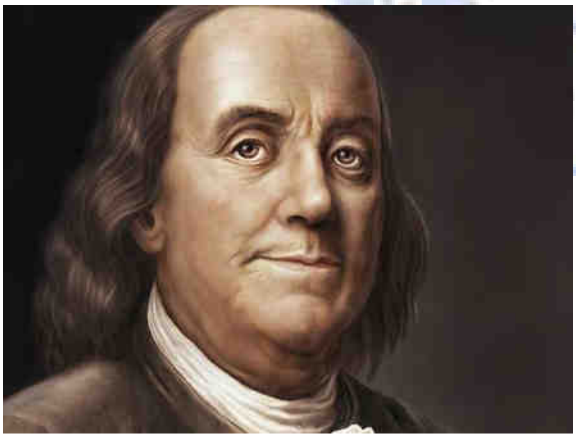


Figure 4: Presbyopia and its correction



Do you know: Benjamin Franklin *invented bifocals in the year 1784. He developed them because he was facing problems in switching eyeglasses for far and near vision. So, he joined the two lenses by cutting them and then uniting the segments into one glass with a sharp adjustment switch between the lower and upper lenses.*

CHECK YOUR PROGRESS 35.2

1. What is meant by accommodation of an eye?
2. What is the distance of clear vision for a normal human eye?
3. What is colour blindness?

RECAPITULATION POINTS

- Human eye is one of the sense organs of our body which helps us to visualize things.
- The lens of an eye is a biconvex lens which focusses light on the retina.
- Image of an object is produced on the retina, which is the most photo sensitive part of an eye.
- Area land inverted image is for me don the retina, which is flipped by the brain to show us the actual image of an object.
- Myopia is an eye defect in which near objects are clearly seen but the distant objects is blurred. It is rectified by the use of concave lens.
- Hypermetropia is long sightedness where distant objects is clearly seen but near objects is blurred. Convex lens is used to rectify this eye disorder.
- Presbyopia is a condition that occurs when the biconvex lens of eye get sharder and unable to change shape.

TERMINAL EXERCISE

1. What are the common defects of human eye?
2. Draw a labelled diagram of a Human eye
3. What are the basic differences between Myopia and Hypermetropia?
4. How can Myopia be corrected. Explain with the help of a diagram
5. How can Hypermetropia be corrected. Explain with the help of a diagram.
6. What is the function of a pupil?
7. What is presbyopia?
8. What is meant by accommodation of an eye?
9. What is the distance of clear vision for a normal human eye?
10. What is colour blindness?
11. Difference between yellow spot and blinds pot?
12. Which type of lens is used to correct myopia?
13. Which type of lens is used to correct long sightedness?
14. What type of optical phenomena occurs through the lens of an
15. eye?
16. Write about different parts of an eye and discuss their applications.

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 35.1

1. Resolution or resolving power of an optical device is the ability of the instrument to distinguish two points distinctly. Magnification refers to how far the image of an object's size can be enlarged.
2. 2.5 cm
3. Anti-glare glasses come with an anti-reflective coating, i.e. a fine layer on the surface of the glasses which helps reduce the amount of glare that reflects off the lens. These glasses are used to eliminate the excess brightness and its impact on our eyes.

CHECK YOUR PROGRESS 35.2

1. The ability of the eye lens to fine-tune its own focal length is called **power of accommodation** of an eye.
2. 25 cm
3. A condition where a person cannot see some particular colours or distinguish between some colours clearly is called as colour blindness.

36 ELECTRICAL ENERGY

INTRODUCTION

The January of 1879 is a hallmark year in the history of modern civilization as Thomas Alva Edison, invented the light bulb and with a flick of a switch, we moved from darkness into light. Electricity plays a vital role in our everyday life although it is easy to take it for granted. Would our life be paralyzed without electricity? Actually electricity and magnetism which are two sides of the same coin are all around us and not just available for gadgets of daily use. The colours of rainbow are there because of electricity, our nervous system is driven by electricity, we see because of electricity, our hearts beat because of electricity, atoms, molecules, all chemical reactions exist because of electricity.

The understanding of electricity and electric energy is based on charges, the fundamental property of matter. So to comprehend electricity, we need to zoom into at the atomic level.

The keys to unlocking the world of electrical energy needs an understanding of potential, electric current, resistance and power. As we appreciate and understand these concepts, we will be able to understand and venerate electricity and electric energy.

36.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Describe, identify, list and appreciate the importance of electrical energy in our life.
- Compare and contrast static and current electricity.
- Enquire about the contribution of Edison and Nikola Tesla in the field of electricity and thus deliberate the difference between AC and DC
- Find out “how” and “why” of electric current, potential difference and resistance and measuring devices- ammeter and voltmeter.

- Plan and conduct investigations/ experiments and audits to determine the relationship between potential difference, current and resistance, factors on which resistance depends and power.
- Draw, analyze and interpret data/ graphs/ circuit diagrams.
- Recognize the process and phenomena associated with effects of electric current with focus on heating effect and relate them to causes and effects.
- Derives formulae /equations /laws in order to demonstrate mathematical thinking skills and understanding of Joule's law of heating and net resistance in series and parallel combination.

36.2 THE DISCOVERY

Rub a plastic comb with your hair and hold it above small pieces of paper. You will observe that the papers jump and stick to the comb. Rub two balloons with a woolen cloth and suspend them freely, close to each other, they move away, or repel.

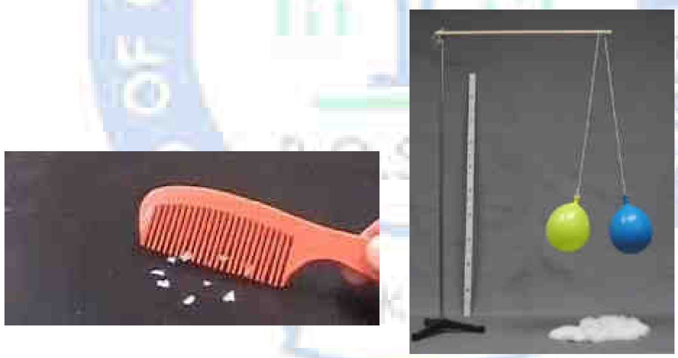


Fig 36.1: Balloon and comb showing presence of electric chargers

In both the above cases, a force must be exerted. The force is non-contact force termed as electric force. The force of attraction in first case and repulsion as in the second case may remind us of another non-contact force, the gravitational force. But while gravitational force arises due to mass, this force arises due to another fundamental property of matter termed as charge.

We know that matter is made of atoms. As per the modern picture, atom encompasses nucleus at the center with positively charged protons and neutrons, and negatively charged electrons in a cloud around it. While objects are generally neutral, they have same number of electrons and protons, so despite having charge, the net charge is zero.

However, they can gain electrons and acquire a net negative charge or lose electrons and thus acquire a net positive charge and are then said to possess electricity.

The objects can develop a net charge by primarily three ways- Friction, Conduction and Induction. In the above cases, as the two objects were rubbed, one gained and the other lost electrons acquiring equal negative and positive charge respectively. This method is called as charging by Friction.

Actually, electricity is not a new phenomenon but was discovered by the Greeks in 600 BC, when they observed that amber (a fossilized resin formed from tree sap) when rubbed could attract pieces of dry leaves. As amber is called as electric in Greek, this property was termed as electricity.

The word atom, comes from a Greek word which means indivisible and initially atoms were considered as the elementary particles. Later discoveries proved that atoms comprise of protons, electrons and neutrons which were in turn considered as undividable. However, thanks to the quantum theory we now have standard model of particle physics which explains that quarks (which make protons and neutrons) and leptons (which make electrons) are the basic building block of the universe. The standard model also explains how the force carrying particles called as bosons influence quarks and leptons.

CERN near Geneva, is the leading organization where the study of fundamental particles is carried out in particle accelerators.

36.2.1 Properties of Electric Charge

Some important properties of electric charges include-

1. Bodies which have a net like charge repel, while those which have a net unlike charge attract each other. **Repulsion is the sure test of a body being charged.**

2. Charges are conserved, they cannot be created nor destroyed but they can be moved from one body to another
3. Charge is a scalar quantity. Thus, total charge is the sum of individual charge.
4. The SI unit of charge(Q) is coulomb (C)
5. Both the electron and a proton have same charge, which is equal in magnitude but opposite in nature. The charge is equal to 1.6×10^{-19} C. This is termed as fundamental charge (e) and charge less than this cannot exist freely.
6. An object can acquire charge only in integer multiple of fundamental charge, that is, $Q = \pm ne$ where n= 1,2,3……Thus charge is quantized, it cannot exist as a fraction of fundamental charge e.
7. Charles Augustine Coulomb succeeded in accurately measuring the force between two charged objects which is given by-

$$F \alpha \frac{q_1 q2}{r^2}$$

Here q_1 and q_2 are the magnitude of charge on two objects while the distance between them is represented by r.

36.2.2 Types of Electricity

If an object has a net charge accumulated on its surface and the charges are at rest, this is static electricity or **Electrostatics.** If charges are moving in a material, this constitutes **Current electricity** or electrodynamics.

While static electricity arises due to the transfer of charges from one object to another, current electricity is due to motion of charges in the same material. Current electricity is used for performing mechanical work like running machines, static electricity too has many applications including in photocopiers, pollution control machines etc.

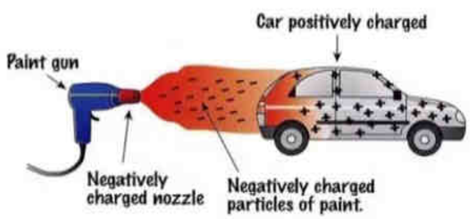


Fig 36.2: Types of Electrostatics

36.2.3 Conductors and Insulators

Metals are conductors while non-metals like rubber, glass, paper are classified as insulators. If we could peek into these materials at the atomic level, we shall find that metals have electrons which free to move as they are not held to the atoms tightly and are termed as free electrons or conduction electrons. Metals can thus be envisioned as material comprising of free electrons and positive ions. On the other hand, insulators do not have free electrons as electrons are tightly bound to the atoms. The free electrons can be made to move in an orderly manner, constituting electric current.

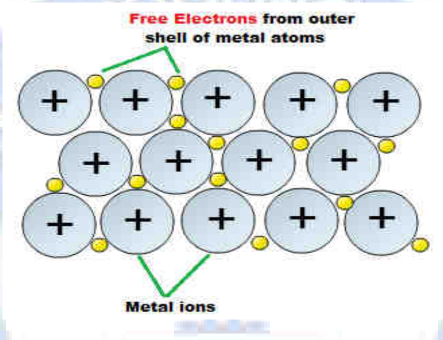


Fig 36.3: Conductors and insulators

Static electricity can be developed in both conductors and insulators, although conductors will need to be held with an insulator like a wooden handle to exhibit static electricity. This happens as human body is a good conductor and the charge will flow through our hand and into the earth if we touch a conductor which has acquired static charge. This process of transfer of charge to the earth is termed as earthing. Do remember, charge cannot be created, nor destroyed but can be transferred from one object to another, or charge is always conserved.

Insulators are incapable of exhibiting current electricity under normal circumstances. There is a third category of materials like silicon and germanium which have very few free electrons and hence allow very little current to flow. These are called as semiconductors and they have ushered in the electronic revolution. While we generally recall metals as conductors of electricity, presence of acids, base or salt in a liquid makes it a good conductor. Normally, gases are insulators.

Both conductors and insulators of electricity find many applications in our everyday life. In our discussion we shall concentrate on electric current and metals as conductors.

CHECK YOUR PROGRESS 36.1

1. Sakshi rubs a glass object and a velvet cloth together and the glass becomes positively charged. Which of the following statements are true?

a. When the glass rod was rubbed, it gained protons

b. The velvet cloth became charged negatively during this rubbing process.

c. Charge is created during the rubbing process; it is then grabbed by the more charge-hungry object.

d. If the glass rod acquired a charge of +7 units, then the velvet cloth acquired a charge of -5 units.

e. This observation does not support the law of conservation of charge.

f. Electrons are transferred from glass to velvet; protons are transferred from velvet to glass.

g. Once charged in this manner, the glass object and the velvet cloth should attract each other.

36.3 ELECTROSTATIC POTENTIAL

Let's assume you have an uncharged sphere. You bring a positive charge from a large distance and put it on the sphere, thus making it positively charged. As the charge on the sphere increases, would it not be more and more difficult to add charge? After all, like charges repel each other. You will have to do more work, and this work is stored as energy of the charge. Or, now the charges on the sphere will have energy due to their position. This energy is termed as electric potential energy. (Does this remind you gravitational potential energy, wherein the object possesses energy because of its position above the surface of earth?)

Electric potential is defined as the amount of work done in transferring the charge from infinity (point where its potential energy was zero) to that point.

Electric potential is thus defined as work done per unit charge.

$V = W/Q$

volt= joule/ coulomb

You may wonder, what is the role played by the concept of electric potential in the study of electricity?

To understand this, let's consider an analogy-

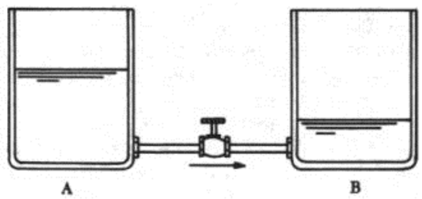


Fig 36.4: Flow of water for tank A to B

Would the water flow from tank A to B or vice versa when the tap connecting the two tanks is opened?

Ofcourse, water will flowfrom tank A to B. But why, one may wonder. Ofcourse fluids flow from high pressure to low pressure. Another question, will the liquid continue to flow from A to tank B and tank A will empty out? Intutively we know that the liquid will stop flowing once the pressure in both tanks is same. (level of water in both tanks is same)

Let's take another example.

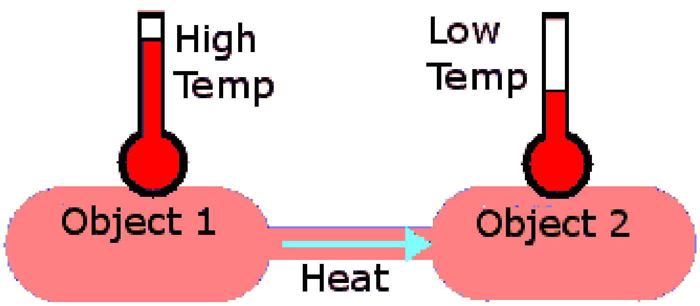


Fig 36.5: Flow of heat form object 1 to 2

It is clear from the above example that heat will flow from object 1 to object 2, from object which is at a higher temperature to the object that is at a lower temperature. The heat flow will stop when both the objects will acquire the same temperature.

To infer will it appropriate to say that-

- Fluids only flow if there is a pressure difference
- Heat will flow if there is a temperature difference

It is not just the pressure ot temperature that causes flow of fluid or heat but the difference!

Likewise, for the current to flow there has to be a potential difference.
(after all, current too is the flow of charge)

36.3.1 Potential difference

Potential difference can be expressed as difference in potential between two points, or work done in bringing a unit charge from one point to another.

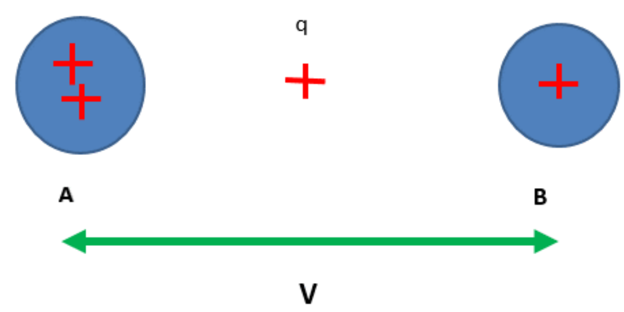


Fig 36.6: Potential Difference

As we refer to the above figure, we can understand that the amount of work done in moving a unit positive charge q from infinity to A is more than the amount of work done in moving the charge from infinity to B.
Thus A is said to be at a higher potential than B. The work done in moving a unit charge from B to A is said as the potential difference between A and B.
Potential difference too is measured as V=W/Q
Its SI unit is volt and it is a scalar quantity.
Let us now define the unit of potential difference.
Potential difference between two points is said to be 1 V if I J of work is done in moving 1 C of charge from one point to another.

By convention a positively charged body is always at a higher potential as compared to a negatively charged body. If positive charges like protons or positive ions are free to move they would move from higher potential point to lower potential point. The electrons would move in the opposite direction, that is from lower to higher potential. Thus charges will flow (hence current will flow) only if there is a potential difference.

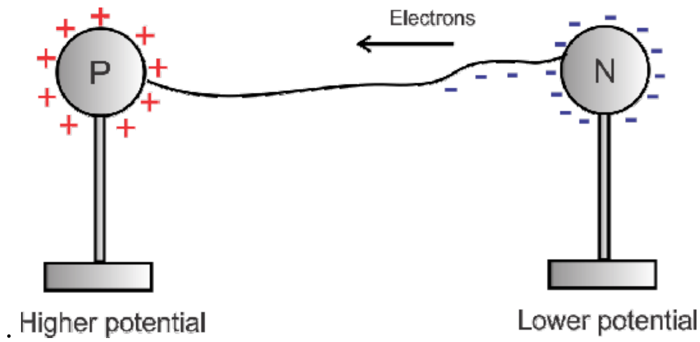


Fig 36.7: Flow of Charge

The movement of charges or, the flow of current will continue as long as there is a potential difference between the two ends of a conductor. In normal circuit, the potential difference is maintained by a cell or a battery.

Potential difference can be measured with a device called as voltmeter. The voltmeter is connected in a certain way between the two points the potential difference is to be measured, which we shall discuss shortly.

Always determine the least count of the measuring device

Fig 36.8: Voltmeter

NUMERICALS

1. How many electrons constitute 2 C of charge?

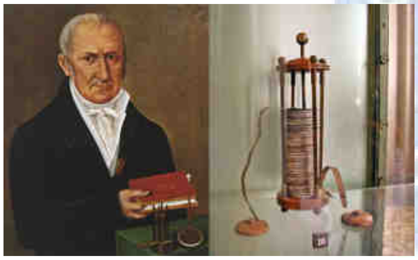
   Charge on 1 electron = 1.6×10^{-19} C
   Charge Q= n e
   n= Q/e

$n = 2/ 1.6 \times 10^{-19}$
$n = 12.5 \times 10^{18}$

2. What will be the work done in moving 5C of charge from point B to point A if the potential at point A is 5 V while potential at point B is 2 V?
   $V_A = 5$ V
   $V_B = 2$V
   $V_A - V_B = W_A - W_B/Q$
   $V=W/Q$
   $W=V \times Q$
   $W=3 \times 5$
   W=15 J

Alessandro Volta

The SI unit of Potential Difference, that drives current is named after Italian physicist Alessandro Volta (1745- 1827) He was the first to invent electric battery, which was called a voltaic pile, thus inspiring many experiments using electric current including the decomposition of water (electrolysis) which created the field of electrochemistry. He is also credited with the isolation and discovery of methane gas.



CHECK YOUR PROGRESS 36.2

1. An ebonite rod rubbed with wool acquires -2 micro coulomb of charge. How many electrons were transferred from wool to the ebonite rod? (hint: 1micro= 10-6)
2. If 20 J of work is done in moving a certain amount of charge from potential of 4 V to that of 6V, determine how much of charge was moved?
3. Determine the potential difference between two points if 10 J of work is done to move 3 C of charge between the points.

4. Two metallic spheres A which has a charge of 4 C and B which is not charged are touched and then separated. Will the sphere B acquire any charge in the process, if yes what will be the magnitude of charge on it?

36.4 CONCEPT OF CURRENT

The word "current" means motion. When water flows, we call it as water current, flow of air is termed as air current and likewise, flow of charges is termed as electric current. As discussed, metallic conductors which find wide applications in our life have a large number of free electrons. These electrons move in random directions, just like the molecules in a gas. If we apply a potential difference across the conductor, that is one end of the conductor is maintained at a higher potential and the other at a lower potential, the free electrons would now move in an orderly manner. They would drift (their speed is very low) in an orderly manner and thus constitute current.

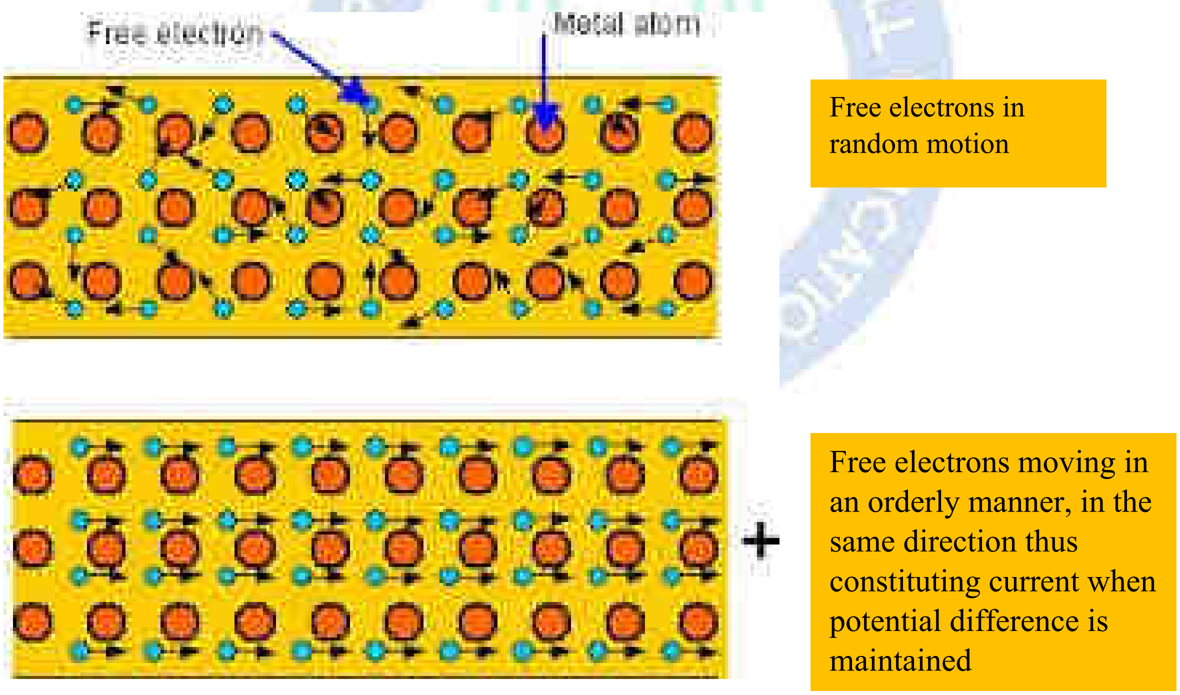


Fig 36.9: Current

There are certain points we should make a note of-

- The speed at which the electrons drift is very small, about 0.0001m/s. The speed does not impact the magnitude of current. For the current to flow what is required is that the electrons simply move in a methodical fashion.

- As discussed earlier, positive charges move from higher potential to lower potential. We generally use a cell/ battery to provide a potential difference, so positive charge would move from positive to the negative terminal of the battery. As the behavior of negative charged electrons will be opposite to that of positive charges, they actually would move from the negative to the positive terminal. (this is also evident in the figure)
- Current (I) is a scalar quantity and it SI unit is ampere (A)
- However, the direction of current is to be shown in a circuit diagram. The current is always represented to be moving from positive to the negative terminal of the battery.
- This might confuse us as, while we have established that electrons flow from the negative to the positive side of the battery, the direction of current is represented in the opposite direction!
- When we talk of the direction of electric current, we usually refer to
  - Conventional current
  - Electron current
- Conventional current is the flow of positive charges from positive to negative terminal of battery, electron current is the flow of electrons from negative towards positive terminal of the battery.
- However, while representing the direction of current, we still use the direction of conventional current. (this is a rule used worldwide)

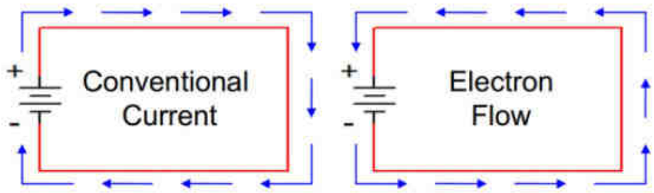


Fig 36.10: Direction of current (Conventional)

36.4.1 Quantitative concept of electric current

Electric current flowing through a conductor is equal to amount of charge flowing per second through it.

If a charge Q flows through a cross section of a conductor in time t, electric current is given by-

I= Q/t

If 1 coulomb of charge flows through a cross section of a conductor in 1 s, the current through it is said to be 1 ampere.

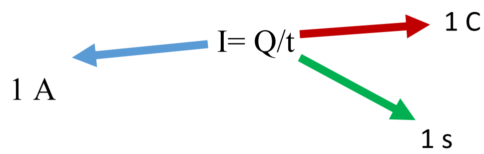


Fig 36.11: 1 ampere current

Current is also measured in smaller units

milli ampere (mA)= 10^{-3} A

micro-ampere (μ A) = 10^{-6} A

The device used for measuring electric current in the circuit is called as ammeter.

Both ammeter and voltmeter are to be used in circuits that use a cell/battery. (In DC circuits)

The red knob is the positive terminal of the device and is to be connected to the positive terminal of the battery, while the black knob is to be connected to the negative terminal of the battery

Fig 36.12: Ammeter

While in metals it is the movement of free electrons that constitute current, in electrolytes and ionized gases, both positive and negative ions move and constitute electric current.

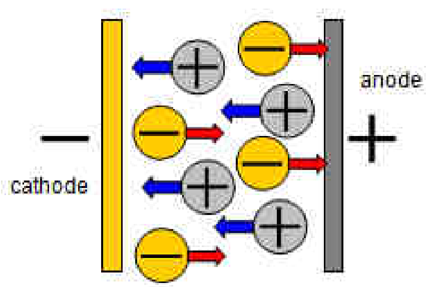


Fig 36.13: Current

Suppose there are n electrons that pass through the cross section of a conductor in time t.

As discussed then, the total charge flowing through the conductor will be

Q= ne

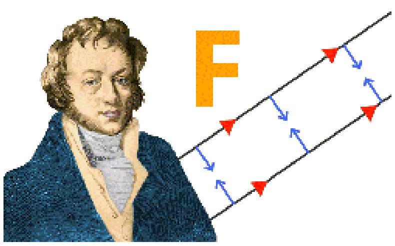
Thus I= ne/t

NUMERICALS

1. A current of 0.2 A is drawn by a device for 2 hours. Determine the amount of electric charge flowing through the circuit.
   I=0.2 A
   t= 2 hours= 2 X 3600= 7200 s (Remember, if current is in SI unit, time too should be in SI unit)
   as I= Q/t so, Q= I x t
   Q= 0.2 X 7200= **1440 C**
2. If a conductor carries a charge of 40 mA determine the amount of charge that will flow through the cross section of the conductor in 1 minute. Also calculate the number of electrons that will flow in this time period. (given; charge on 1 electron is 1.6 X 10^{-19} C)
   I= 40mA= 40 X 10^{-3} = 0.04 A
   t= 1 minute= 60 s
   Q= I x t
   Q= 0.04 x 60= 2.4 C

   Let the number of electrons be n
   Q=ne
   n= Q/e
   n= **1.5 x 10^{19} electrons**

André-Marie Ampère (1775-1836) was a French physicist and mathematician who had keen interest in astronomy and chemistry. He discovered that current carrying wire could attract or repel, and this force was magnetic in nature although there were no magnets involved! He also proposed the existence of particle which we recognize as electron and discovered the element fluorine.



CHECK YOUR PROGRESS 36.3

1. Give 2 examples each of liquid that will conduct electricity and not conduct electricity.
2. Calculate the current in the circuit if 1200 C of charge flows through it in 15 minutes?
3. If 500 J of work is done for the flow of charge across a potential difference of 2 V, determine the current flowing through the device.
4. If 3×1017 electrons flow through an area per minute, determine the value of electric current.

36.4.2 Types of electric current

When we insert a cell/ cells in the TV remote, charge our cellphone or flick a switch to switch-on the tube light in our room, we know that current flows in the device. What we also intuitively know is that while cell will provide less current, the current supplied to our homes is of a greater magnitude and is generated in a power plant. You must have wondered whether there is a difference in the two currents.

Actually, there is. The current supplied by the cell is called as Direct Current or DC and the one we get from the power plant is called as AC or alternating current.

In DC the charge carriers drift in one direction only while in AC the charge carriers change their direction periodically. In a way, the charge carriers seem to be oscillating. Remember, current is the flow of charge. Charge has to move and, in the process, transfer the energy to the device in use which is called as the load. It just does not matter in which direction the charge carriers are moving.

In our discussion in this chapter, we shall limit out discussion to DC.

The cell or a combination of cells (called as battery) comprise of chemicals and electrodes. Due to the chemical reaction that takes place, the carbon rod in the cell acquires a positive charge while the zinc can acquire a negative charge. Thus, there exists a potential difference between the terminals of the cell. For an ordinary cell, this potential difference is 1.5 The cell now has chemical energy stored in it. When the cell is connected across a device like a bulb (in case of a torch, or in the TV remote) the current moves from the positive to the negative terminal. This delivers the energy to the device or the load. This in turn will reduce the potential difference between the two terminals.

With constant use, when the terminals of the cell; acquire the same potential, the cell is said to be dead. It has utilized all its chemical energy and no longer delivers energy to the load.

Both the ammeter and voltmeter are DC devices. There positive terminal is connected to the positive terminal of the battery and the negative to the negative terminal.

Fig 36.14: Cell

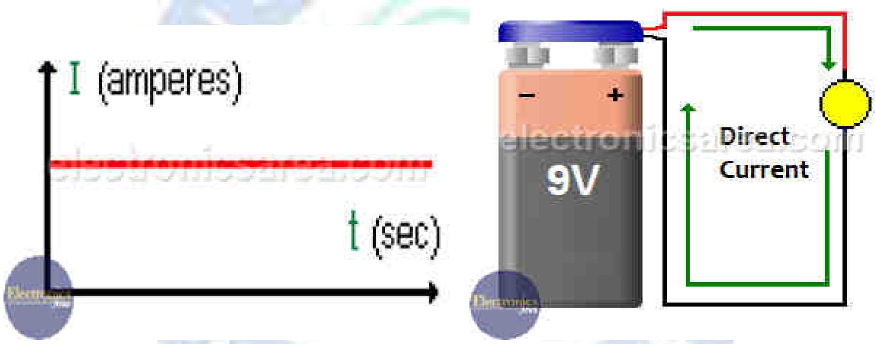


Fig 36.15: Battery

The other type of current is which runs the refrigerator and TV in our homes, the one that is supplied by the power stations through electric wires, the AC current.

In AC the charges vibrate, or in other words, the current changes direction periodically and also changes in magnitude. You may wonder how does only the oscillation of charge result in current? But remember, the current is the orderly movement of charge, the charge is not required to move from one point to another. In this type of current, the current is zero, to begin with, then it increases, reaches a certain maximum value, then begins to decrease, and reaches zero again. Then the charges begin to move in the opposite direction, causing the current to now flow in the opposite direction and the same cycle is repeated.

The figure of AC given below comprises one complete cycle of current.

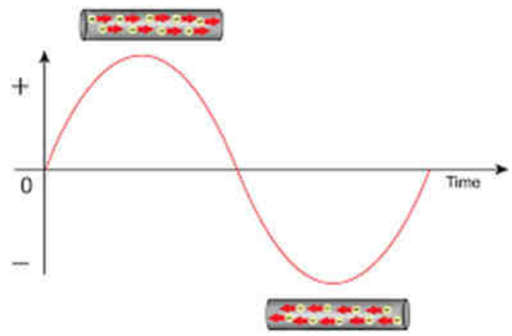
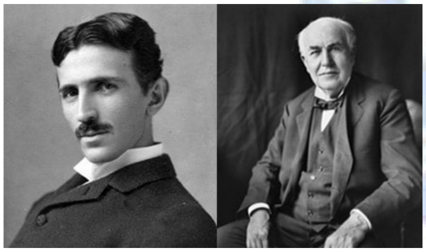


Fig 36.16: One complete Cycle of current

AC has a frequency. In India, the frequency of AC is 50 Hz, to this means that 50 cycles are completed in 1 second, or in other words the current changes direction 100 times in 1 second!

The epic battle of current

Nilkola Tesla and Thomas Edison are the two pioneers of the field of electrical engineering. While Edison was the supporter of DC current, the futuristic inventor, Tesla is credited with the invention of AC. The two titans clashed over which current was better.



36.5 RESISTANCE

From our experience, we know that if an object moves on a surface, it experiences an opposition by the surface, which we term friction. In a similar way, do you think that free electrons moving in a conductor will also feel some kind of opposition? If we could somehow peek inside a conductor, we would see that the free electrons constantly undergo collisions with other free electrons and positive ions as they move randomly inside the conductor. When a potential difference is applied across the ends of the conductor, as the electrons begin to drift from the negative to the positive potential, they collide with the positive ions. Such collisions obstruct the motion of electrons and this property of material offers opposition to the flow of free electrons and hence current is called resistance.

In fact, the word “resistance” means opposition, and in the context of electricity, it is the property of a material to oppose the flow of current.

Do you think that we can give the difference between good and bad conductors of electricity based on the property of resistance of the material?

Materials that offer less resistance to the flow of current are good conductors and those which offer greater resistance to the flow fall in the category of bad conductors.

Resistance (symbol R) is also a scalar physical quantity and its SI unit is also represented as Ω.

Now if we know that for an electric device to work-

- We need to provide a potential difference across its ends.
- This will enable the free electrons to drift in an orderly fashion thus constituting the electric current.
- However, as the free electrons flow, they will experience resistance.
- If the same potential difference is provided to two different devices, it is not necessary that they will have the same current flowing through them. The device having less resistance will have a greater current through it and the one with more resistance will have less current.

So, it is clear that V, I, and R seem to be the primary electrical terms, there should be a relation between them.

This relation can be explored in the laboratory by conducting a simple experiment. But before that, as we would be connecting different electrical elements with the help of wires to provide a closed path for the current to flow (or make an electric circuit) it would be appropriate to revise the electric symbols of the different electrical elements. With the help of a drawing using these symbols, we can show how the electric elements are connected to make the circuit. Such a drawing is called a circuit diagram or a schematic diagram.

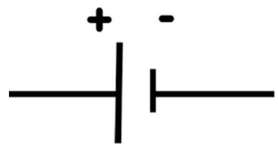
36.6 ELECTRIC CIRCUIT AND ITS ELEMENTS

The various electric elements/ components used in making a simple electric circuit include-

1. **Cell/ Battery**

   The cell provides the potential differences in the circuit.

The electric symbol for the cell comprises two vertical lines, one long and the other short. The short line represents the negative terminal and the long one represents the positive terminal.



When two or more cells are joined together, this forms a battery.

Cells can be joined in two ways (in fact all electrical elements can be joined in two ways)

- Series connection
- Parallel connection

When cells are connected such that the positive terminal of one cell is connected to the negative terminal of the next cell, such a combination is called a series connection of cells.

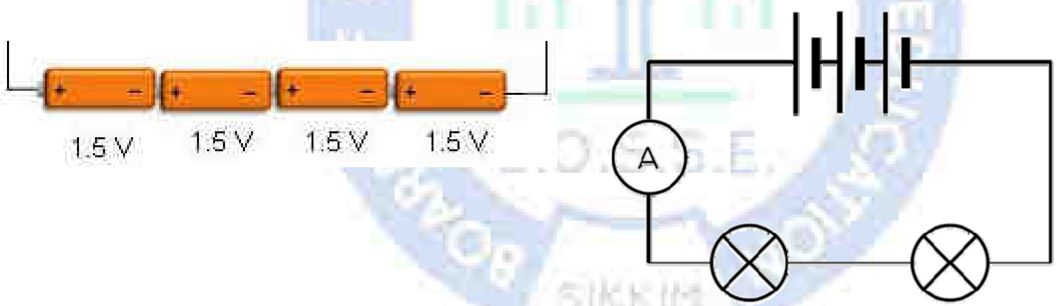


Fig 36.17: Series connection of cell

You must have noticed this kind of connection of cells in a normal torch. In such a connection the potential difference provided by individual cells gets added up and we now have a battery that provides a greater potential difference across the conductor.

If each of the cells is 1.5 V and if 3 such cells are connected in series, now the available PD (potential difference) will be 4.5 V

The figure given below shows the parallel combination of cells.

Fig 36.18: Parallel combination of cells

As can be seen, the positive terminals of all cells are joined together and likewise, the negative terminals are joined together.

If all the cells in such a combination are 1.5 V each, then the net PD obtained by such a battery remains 1.5 V however, the battery will last longer.

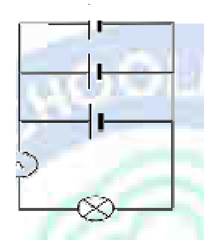


Fig 36.19: Parallel combination

2. Resistor

It is an electric component that opposes the flow of current, Resistors are usually made of alloys such as manganin and constantan

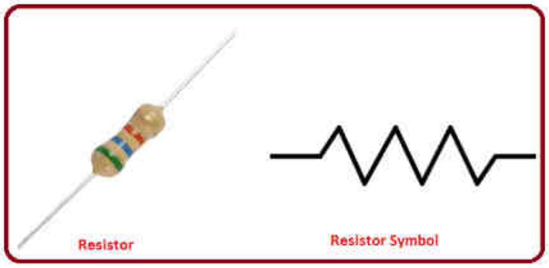


Fig 36.20: Resistor

A resistors are color coded to indicate their value. They are two terminal devices.

The opposition offered by the resistor to the flow of current is termed as resistance and depends on physical features of the resistor, its length, area of cross-section, material and also temperature.

3 Variable resistance

A variable resistor is an adjustable resistor, comprising of two terminals, where one of the terminals is a sliding or moving contact often known as a wiper. These are primarily used to adjust the value of current or voltage in the circuit.

The appliance we use which involve tuning of TV, radio stations, dimming lights, controlling the speed of devices such as fan, mixer grinders etc. uses variable resistors. **Rheostats and potentiometers** are categorized as variable resistors.

Fig 36.21: Variable resistance

Rheostate

Fig 36.22: Rheostate

4. A plug key/ switch

We should be able to switch on- close the circuit or switch off- open the circuit as per our need. A plug key is thereby an essentisl part of the circuit.

Fig 36.23: Plug key

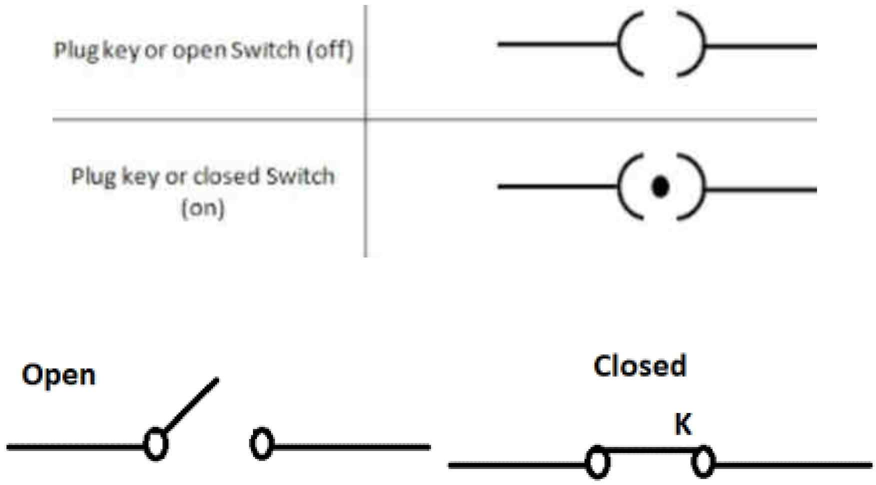


Fig 36.23: Plug key

5. Ammeter

It measures current in the device

It is a two-terminal device

It is always connected in series with the device in which current is to be measured.

It a low resistance device

It has to be connected in a circuit such that its positive terminal is connected to the positive terminal of the battery and negative terminal to the negative terminal of the battery

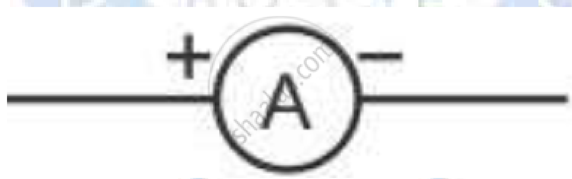


Fig 36.24: Ammeter

6. Voltmeter

It measures potential difference across a device

It is a two-terminal device

It is always connected in parallel with the device across which PD is to be measured.

It a high resistance device

It has to be connected in a circuit such that its positive terminal is connected to the positive terminal of the battery and negative terminal to the negative terminal of the battery

Fig 36.25: Voltmeter

7 Galvanometer

It is a two terminal device used to detect or measure current in the circuit. It does not have positive/ negative terminal as in the case of ammeter. Its needle is positioned at the centre of the device, thus enabling detection of flow of current in either direction.

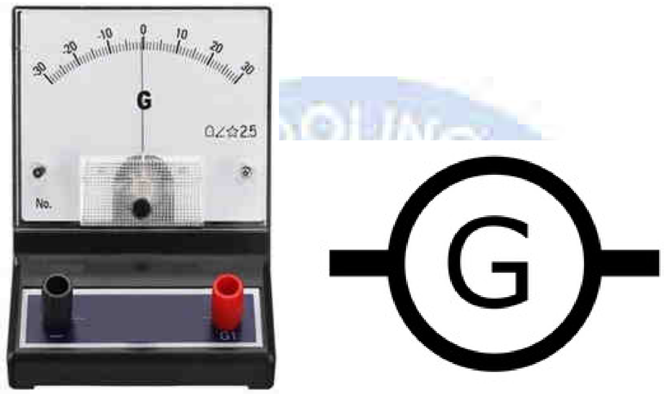


Fig 36.26: Galvanometer

8. Wires are used in the circuit

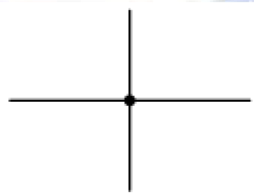


Fig 36.27: Connected wires

this is the symbol if the wires are connected and if the wires are not connected, the symbol is

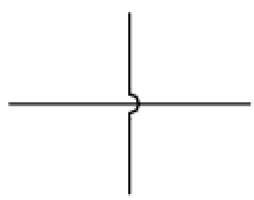


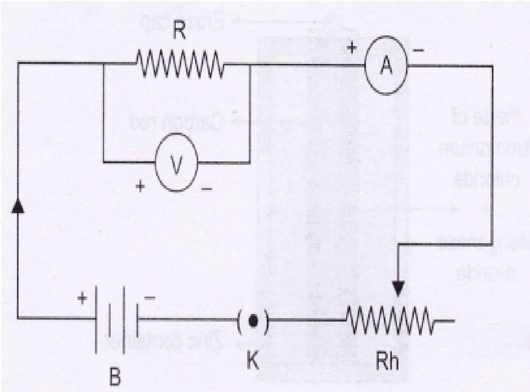
Fig 36.28: Wires not connected

This is digital multimeter.
The device can be used to measure current, voltage and resistance in the circuit directly when connected appropriately in the circuit

36.7 OHM'S LAW

In the field of electricity Ohm's law is a fundamental relation between voltage, current and resistance.
The law is somewhat intuitive, from experience we know that if voltage across a device increases, current flowing through a device also increases. Over a period of time the remote of our TV stops working as efficiently and we say that the cells are weak. Translating this in the language of science means that the chemicals in the cells are being consumed, the potential difference provided by the cell has become less, so the current in the remote too has become less thus adversely impacting the functioning of the remote. When we change the cells, the PD increases, current increases and the remote again functions efficiently.
A simple activity can help us understand this law.

- Set up the circuit as shown



- Take the reading of the ammeter and voltmeter and tabulate the result.

S. No	Reading of the Voltmeter (V)	Reading of the Ammeter (I)	V/I
1.			
2			
3			
4			
5			

Note:
Rheostat (variable resistance is used in series in the circuit and it changes the overall resistance and thus current and voltage across the given resistance.
Within experimental errors, the ratio of V/I will be constant. When we plot a graph of I vs V, the graph comes out to be a straight line.

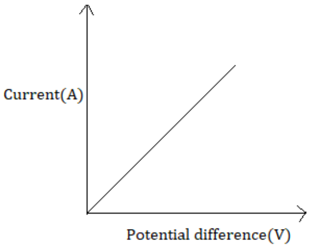


Fig 36.29: Ohms law V/I constant

This proves that current flowing through a metallic element is directly proportional to the potential difference across it, provided temperature and other physical conditions remain constant. This is termed as Ohm's Law.

$$I \propto V$$

$$\text{Or, } V=IR$$

Here, R is the constant of proportionality and is actually the resistance of the conductor. The slope of the I/ V graph gives the reciprocal of resistance, called as conductance.

If we have a V/I graph, its slope will give us resistance.

Georg Simon Ohm was a noted German physicist and mathematician who made remarkable contribution in the field of electricity, most noticeable being Ohm's Law.

Ohmic and non- Ohmic conductors

While in metals the graph between V and I is a straight line, which implies that resistance does not vary (provided the temperature does not change) in devices such as p-n junction diode, transistor (used in electronic circuits) the graph will be a curve. Such devises are termed as non-ohmic conductors.

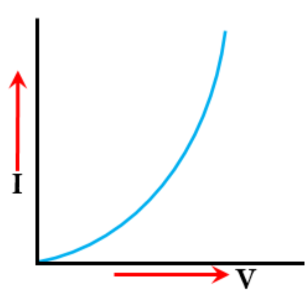


Fig 36.30: V= IR

However, V=IR is always valid

36.7.1 Factors on which resistance of a conductor depends

As we know resistance of a conductor is the opposition provided by the conductor to the flow of current.

Value of R is conductor specific and at a given temperature depends on-

1.length of conductor
2. Area of cross section of the conductor (thickness)
3. Material of the conductor

Activity

- Take two wires of Nichrome A and B such that the length of A is double of that of B
- Take a third wire C, which has the same length as A but double the area of cross section.
- Take a fourth wire D of same length and thickness as A but is of a different material
- Construct a circuit using ammeter, voltmeter, a battery of 2V, and connecting wires as used in case of verifying Ohm's law.
- Close the circuit and tabulate the result in the table given-

S. No	Voltmeter reading	Ammeter Reading for wire A	Ammeter Reading for wire B	Ammeter Reading for wire C	Ammeter Reading for wire D	R of the wire
1	2 V					

We shall find that resistance offered by the conductor will be

$R \alpha\ l/A$

Or, R is directly proportional to length of conductor, more the length more the resistance

R is inversely proportional to the thickness of the conductor; a thin conductor offers more resistance than a thick conductor of the same length

The proportionality sign in the expression for R is replaced by a constant ρ.

$R= \rho\ l/A$

ρ is termed as resistivity or specific resistance and is material specific, that is its value depends on the nature of the material. Its SI unit is Ωm. Resistivity of a material is its characteristic property; and can be likened to density of a material.

Each material has a fixed value of resistivity at a given temperature.

More the value of resistivity, more is the resistance and vice-versa.

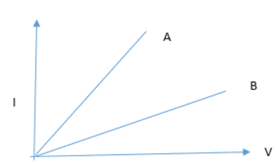
Thus conductors have less resistivity which will increase with an increase in temperature.

Insulators have a high value of resistivity which decreases with an increase in temperature.

In the case of alloys, resistivity is more than that of conductors and less than insulators and does not vary with temperature. This property of alloys finds many practical applications in our day to day life.

NUMERICALS

1. Determine the resistance offered by an electric device when it is operated at 200 V and consumes 2mA of current
   V=200 V
   I= 2mA= 0.002 A
   R=?
   V=IR
   Or, R= V/I
   R= 200/ 0.002= 1×10^5 Ω
2. When a bulb is cold it has a resistance of 2Ω and when it is operated at 10 V it consumes 0.5 A of current. What is its resistance when it is glowing? What might be the reason for different resistance when the bulb is cold and when it is glowing?
   V= 10 V
   I= 0.5A
   R= V/I= 10/0.5= 20 Ω
   As the bulb glows. The filament becomes hot and due to increase in temperature, the resistance increases.
3. Study the I/V graph given below. Which of the two wires is longer if both of them are made of the same material and are of same thickness?



As slope of I/V graph gives conductance (reciprocal of resistance) so B has greater R

As R= ρ l/A, and A and ρ are the same for wires A and B, so R is directly proportional to length. So, B is the longer wire.

36.7.2 Difference between resistor, resistance and resistivity

Resistor is an object; resistance is its electrical property. Resistance of two conductors of the same material may be different while resistivity of the conductors will be same. Resistance is measured in ohm (Ω) resistivity is measured in Ωm.

CHECK YOUR PROGRESS 36.4

1. If the potential difference across the terminals of a room cooler is 100V, it draws 2 A of current. How much of current will be drawn by the cooler if the potential difference is increased to 220V?
   (hint: the resistance of a device is fixed)
2. Determine the specific resistance(resistivity) of a wire of length 150 cm, diameter 0.06 mm and resistance as 20Ω?
   (hint: determine the area of cross section using A=πr2
3. If the resistance of wire of a given material of length l and area of cross section A is 12Ω, determine the resistance of a wire of the same material of length 3l and area of cross section A/4?
4. A wire has a resistance of 10Ω. What will be the resistance of the wire if it is stretched to 4 times its length? (hint: if a wire is stretched to increase its length, its area of cross section reduces by the same measure)
5. Study the I/V graph and determine which of the wires should be used as a connecting wire if both are of the same length and same thickness.

36.8 COMBINATION OF RESISTORS

In many electrical devices such as TV, laptops, heaters etc. to get desired value of current more than one resistors are used. Resistors can be connected in-

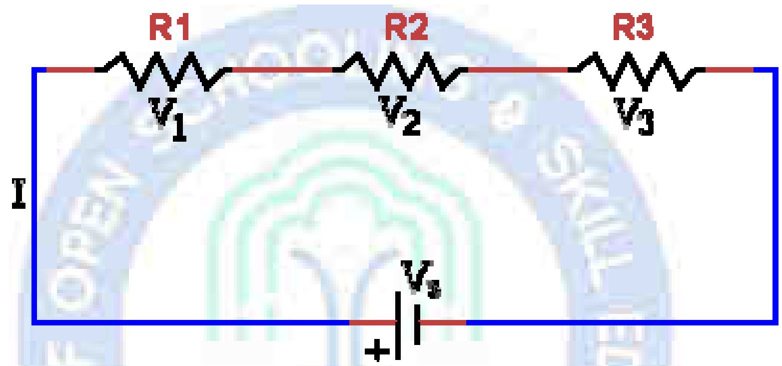
1.series
2. Parallel
3. Series and parallel combination

36.8.1 Joining the resistors in series

In this combination two or more resistors are joined end-to -end.

Activity:

- Take 3resistors R1, R2.and R3 and join them end-to end
- Complete the circuit using an ammeter, a voltmeter, a battery and a key
- Keep the battery at 4V
- Connect the voltmeter across the resistors one at a time and change the position of ammeter connected in series in the circuit
- Note the reading of both the ammeter and voltmeter and record
- Tabulate the readings as per the following table



Voltmeter connected across resistor	Voltmeter Reading	Ammeter reading (I)
R1	V1=	
R2	V2=	
R3	V3=	

As we record this reading we shall find that the reading of ammeter will remain the same, while V1, V2 and V3 will be different.

In fact, V1+V2+V3= V (applied potential difference, in this case 4V)

In such circuits it is essential to determine equivalent resistance. If in place of all the resistors, a single resistor was used such that the current in the circuit would remain same, such a resistor is termed as equivalent resistor.

In series combination, equivalent resistors can be determined by keeping in mind-

- Current through the circuit remains the same

- Voltage across each resistor is different

Thus, V1= IR1, V2= IR2, V3=IR3

V= V1+V2=V3

V= I (R1 +R2+ R3)

IR= I (R1 +R2+ R3), where R is the equivalent resistance

Thus R=R1 +R2 +R3

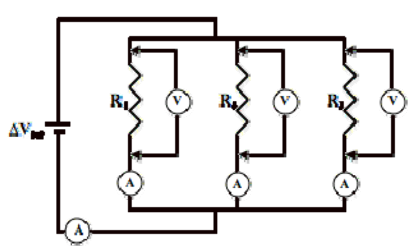
In series combination of resistors, net/ equivalent resistance is the algebraic sum of the individual resistance. Or, the total resistance in the circuit increases so the total current in the circuit decreases.

36.8.2 Joining of resistors in parallel

In this combination two or more resistors are joined such that one end of each of the resistors is connected to a common point and the other end of each resistor too is connected at a common point.

Activity:

- Take 3 resistors R1, R2.and R3 and join them in parallel
- Complete the circuit using an ammeter, a voltmeter, a battery and a key
- Keep the battery at 4V
- Connect the voltmeter across the resistors one at a time and change the position of ammeter connected in series in the circuit with each of the resistors as shown in the diagram
- Note the reading of both the ammeter and voltmeter and record
- Tabulate the readings as per the following table



Voltmeter connected across resistor	Voltmeter Reading	Ammeter reading (I)
R1	V1=	I1=
R2	V2=	I2=
R3	V3=	I3=

We shall find that the reading of the voltmeter would remain the same in each case while the current in each of the resistors will be different.

In parallel combination of resistors, equivalent resistance can be determined by noting-

- Voltage across each resistor is same
- Current in each resistor is different

Total current I= I1 + I2 + I3

As V across each of the resistor is same, I1= V/R1, I2= V/R2 and I3= V/R3

Thus I= V (1/R1 + 1/R2 + 1/R3)

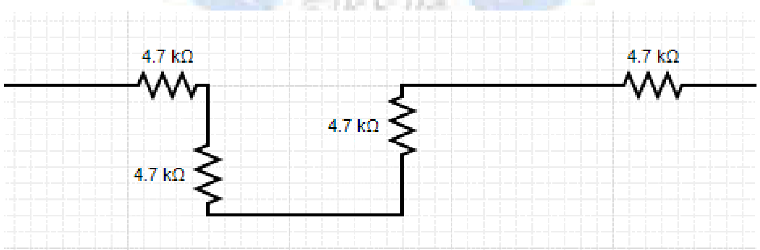
V/R= V (1/R1 + 1/R2 + 1/R3)

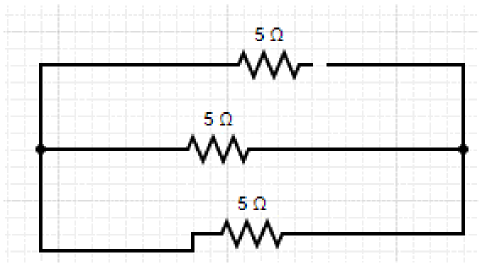
Or, 1/R= 1/R1 + 1/R2 + 1/R3

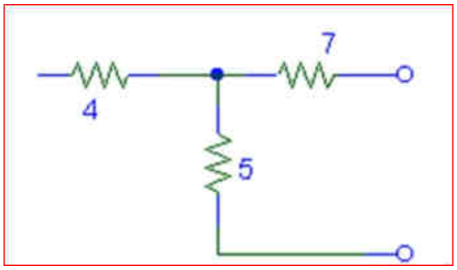
Thus to increase current in a circuit, resistors are connected in parallel.

CHECK YOUR PROGRESS 36.5

1. Determine the equivalent resistance in the following cases







2. In the circuit diagram given in Fig. suppose the resistors R1, R2and R3have the values 5 Ω, 10 Ω, 30 Ω, respectively, which have been connected to a battery of 12 V. Calculate (a) the current through each resistor, (b) the total current in the circuit, and (c) the total circuit resistance.

3. An electric lamp, whose resistance is 20 Ω, and a conductor of 4 Ω resistance are connected to a 6 V battery. Calculate

a. the total resistance of the circuit,

b. the current through the circuit, and

c. the potential difference across the electric lamp and conductor

36.8.3 Advantages of Parallel connection in domestic circuits

All electrical appliances in our homes are connected in parallel except for the fuse.

The main advnatges of this type of connection is-

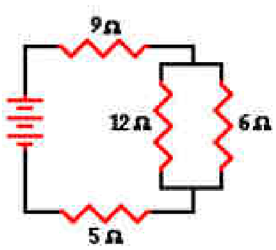
1 All devices can run on same voltage but use different current as per its resistance. (Domestic appliances are designed to operate at 220 V)

2 Each device can be swirched off/on independently

3 if one device stops working, the other devices keep working efficiently

This is unlike series connection in which if one device stops working the circuit is broken and all devices stop working. Also in series all devices get the same current but different voltage which adversely impacts their working.

36.8.4 Combination circuits’



1.Study the circuit given above. If the applied potential difference in the circuit is 36 V determine-
a) net resistance in the circuit
b) total current in the circuit

Here 6Ω and 12 Ω are in parallel
Net resistance will be= 4Ω
Now, 9Ω, 5Ω and 4Ω are in series
Total resistance in the circuit is= 18 Ω

If the potential difference in the circuit is 36 V, total current in the circuit= 2 A

To determine Potential difference across 9Ω we shall use Ohm's law
V=IR, voltage across 9Ω will be current in 9Ω and resistance
V= 2 x 9= 18 V (as 9Ω is in series in the circuit, current will be 2 A)

Likewise, voltage across 5 Ω will be: 2 x 5= 10 V

Thus voltage across both 6Ω and 12 Ω will be 36- (10 + 18) = 8 V

Now current in both 6Ω and 12 Ω can be determined

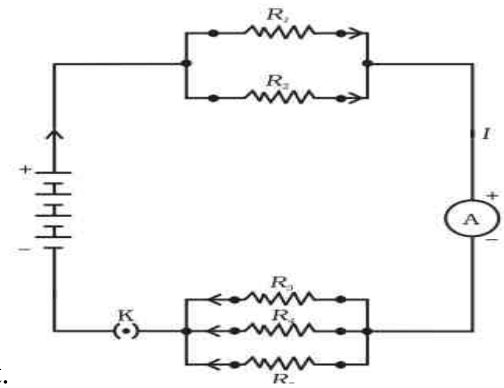
I in 12Ω; I= V/R
I= 8/12= 0.66

Many a times circuit may comprise of resistors in connected in the combination of series and parallel circuits.

- Identify the resistors in series and parallel
- Make the circuit primarily a series circuit by replacing the parallel resistors by an equivalent resistor
- Use Ohm's law to determine the unknown value

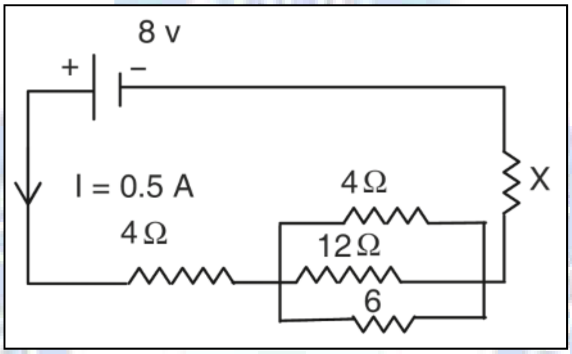
CHECK YOUR PROGRESS 36.6

1.If in Fig., R1= 10 Ω, R2= 40 Ω, R3= 30 Ω, R4= 20 Ω, R5= 60 Ω, and a 12 V battery is connected to the arrangement. Calculate a.the total resistance in the circuit, and b.the total current flowing in the



circuit.

2.In the given circuit, calculate the value of X



36.9 HEATING EFFECT OF ELECTRIC CURRENT

Electrical energy like all other forms of energy cannot be seen but its effects can be studied. Electrical energy primarily has three effects, heating effect, magnetic effect and chemical effect.

If you speak on the cellphone for a long time, it will become hot. When laptop is used continously for some time, it too becomes hot. In fact it is a common observation that when electrical energy is consumed by a device, besides doing the desired work some heat is also generated in the device. Some electrical energy is converted into heat. This is the heating effect of electric current.

Heating effect of current is desirable in some devices like electric iron, toaster , bulb and undesirable in many cases as in mixer grinder, motor etc, where excess heat may damage the device. While devices which do not work on heating effect are provided with a fan, grills etc. to dissipate heat, heating devices comprise of heating element made of nichrome which converts electrical energy to heat.

We know that free electrons drift from high potential to low potential when potential difference is appied across the ends of a conductor. But the motion of free electrons is obstructed due to collisions with ions in the conductor, a proprty which is recognozed as resistance. Thus work needs to be done to overcome resistance. This workdone is converted to heat energy in the conductor.

It has been verified experimentally that heat produced in the conductor is-

- Directly proportional to current flowing through the conductor
- Time for which the current flows
- Resistance of the conductor

36.9.1 Expression for electrical energy

Let current I flow through the conductor for t seconds

We know, current= charge/ time; I= Q/t

Q= It (i)

Also, done in moving a charge Q through potential difference V is W= VQ (ii)

From (i) & (ii)

W= VIt (iii)

Putting the value of V=IR in (iii)

$W= I^2Rt$ (iv)

In heating devices as work done is converted to heat, equation (iv) may be written as

$H= I^2Rt$

Equation (v) is termed as Joule's law of heating in a conductor is

Thus as per this law Heat produced

- directly proportional to square of current
- directly proportional to the resistance of the conductor
- directly proportional to the time for which the current passes through the conductor

Also, I=V/R can be substituted in equation (iii)

Thus $H= V^2 t/R$ (v)

SI unit of Heat energy is joule (J)

Heat can also be measured in calorie,

1 calorie= 4.186 J

36.9.2 Practical applications of Heating effect of current

1. Electric Fuse

Electric fuse helps to prevent fires which may be caused due to short circuit or over loading. It is a small wire made of an alloy of lead and tin having a low melting point. It is connected in series to the live wire (the wire that carries the current in the circuit) It has a much higher resistance as compared to copper connecting wires. Fuse wires of different ratings are available in the market like 1A, 2 A 5 A etc.depending on the current requirements of the device/ circuit. When the current in the circuit exceeds the current rating of the fuse wire, it heats up and melts thus breaking the circuit. This saves the device from electricity hazards.

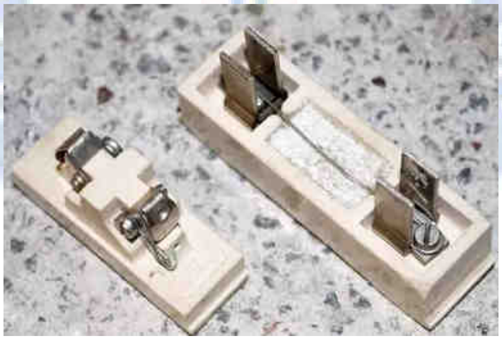


Fig 36.31: Fuse wire

2. Heating applinces

Electric toaster, electric heater, electric kettle are some of house hold devices that work on heating effect of current. All such appliances comprise of a heating element, a long, thin wire made of nichrome(an alloy of nickle, chromium and iron). This has a high resistance and high melting point and does not oxidise (burn) even at very high temperatures.

When curretnis passed in the device, due to its high resistance, the heating element becomes red hot and glows, as it converts the electrical energy into heat energy effectively. Although the same current passes through the heating element and the connecting wires which are made of copper (these are in serries) the copper wire does not glow as it has a very low resistance and the heat produced is very less.

3. Electric bulb

An incadescent bulb comprises of a filament which is made of thin wire of high resistance made of tungsten. When current passes through the bulb, due to heating effect the tungsten filament becomes white hot and emits light. It has a very high melting point but reacts with air and burns. To avoid this the bulb is filled with gas like argon or nitrogen which are chemically inactive and thus make the bulb last longer. However bulbs are not energy efficient as most of electrical energy is converted to heat and only a small fractioon of it is converted to light.This is the reason that electric bulbs have been replaced by more efficient and cost effective LED's.

Electric fuse has been replaced by Miniature Circuit Breakers (MCB) in most devices and circuits. These work on magnetic effect of current and switch off when the current exceeds the safety limit. While the fuse wire needs to be replaced, the MCB just needs to be switched back to the on position when it trips and restores the circuit.

Excess current in a circuit may be due to overloading or short circuit. We often use extension cords and as a result the current may exceed the safety limit of the circuit resulting in overloading.

A very high current may flow in a circuit when a very low resistance path is provided to the flow of current. This situation may happen when the live and neutral wires touch or you connect the two terminals of the cell without using a resistor.

NUMERICAL

1. An electric iron of resistance 500Ω is connected across 220 V power supply. Calculate the heat produced in 1 hour?

R= 500Ω

V= 220 V

t= 1 h= 3600 s

H= V^2t/R

H= 316,800 J or 316.8 kJ

CHECK YOUR PROGRESS 36.7

1. Compute the heat generated while transferring 72000 coulomb of charge in one hour through a potential difference of 20 V.
2. 600 J of heat are produced each second in a 6 Ω resistance. Find the potential difference across the resistor.

RECAPITULATION POINTS

- Current electricity refers to flow of charge in an orderly manner in a conductor.
- For the current to flow, potential difference (V) has to be applied across the conductor. This can be achieved by using a cell/ battery
- Current and voltage in a conductor are related by Ohm's Law, Vα I
- All conductors offer opposition to the flow of current, this property is called as resistance (R)

- Conductors which obey Ohm's law are called as ohmic conductors. V=IR is always obeyed.
- Resistance is a conductor specific property while resistivity is material specific property.
- Resistance depends on shape, size and material of a conductor
- Resistivity of a material depends only on temperature.
- Resistors can be connected in series, which ensures that current in all resistors is same while potential difference across each is different.
- Resistors can be connected in parallel which ensures that current in each resistor is different while voltage across each resistor remains the same.
- Parallel combination is preferred over series combination of resistors.
- When current passes in a resistor, heat is produced which can be determined by Joules's law of heating

Formulas Used

- Q=ne Q= total charge, n=number of charges, e= charge on 1 electron/proton
- V= W/Q V= potential difference, W=work, Q= charge
- I=Q/t I= current, Q= charge flowing t=time
- R= ρl/A R= resistance, ρ= resistivity, l= length of conductor, A= area of cross section of conductor
- V= IR
- R (in series) = R1 + R2 + R3
- 1/R (in parallel connection) = 1/R1 + 1/R2 +1/R3
- H= I^2Rt
- H=V^2t/R
- H=VIt

SI unit

- Charge (Q)= coulomb (C)
- Potential difference (V)= volt (V)
- Current (I)= ampere (A)
- Resistance (R)= ohm (Ω)
- Resistivity (ρ)= ohm meter (Ωm)
- Heat (H)=joule (J)

TERMINAL EXERCISE

I. Choose the correct answer in the following questions:

1. If n resistors each of resistance R are connected in series and then in parallel, the ration of series combination to that of parallel combination will be-

a) R/n^2
b) n^2
c) n^2R
d) R/n

2. Calculate the current in a wire if 900 C of charge passes through it in 5 minutes.

a) 180 A
b) 4500 A
c) 3 A
d) 0.05 A

3. If 200 J of heat are produced each second in a 2 Ω resistance, find the potential difference across the resistor.

a) 10 V
b) 20 V
c) 30 V
d) 40 V

4. The fuse wire must have the following properties:

a) Low resistance and high melting point

b) High resistance and high melting point
c) Low resistance and low melting point
d) High resistance and low melting point

5. Parallel connections of resistors is preferred in domestic circuits as:
a) This ensures all resistors get the same voltage and different current
b) This ensures all resistors get the same current and different voltage as per their requirement
c) This decreases the current in the circuit and saves energy
d) This ensures that all devices can be operated by the same switch

II. SHORT ANSWER TYPE QUESTIONS

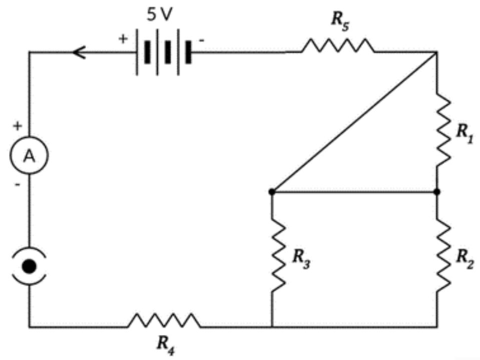
1 Define the SI unit of resistance and of resistivity
2 A piece of wire is cut into 6 equal parts, how will resistance of the original wire compare with that of the combination of if the 6 pieces are connected in parallel?
3 Draw a schematic diagram of a circuit comprising of a battery of 3 cells, 2 resistors of 10 Ω and 15 Ω connected in parallel, an ammeter, a voltmeter and an open key.
4Why is Nichrome generally used to make heating elements?
5Two resistors of 2Ω and 4Ω are connected such that minimum current flows through the circuit. If a potential difference of 12 V is provided in the circuit, calculate the value of current in the circuit.
6 What is the role of free electrons in a) conductors b) in determining the property of resistance.

III. LONG ANSWER QUESTIONS

1Derive the expression for equivalent resistance in a circuit when 2 resistors of different values are connected in series.
21Derive the expression for equivalent resistance in a circuit when 3 resistors of different values are connected in parallel.
3.State and derive Joule's law of heating.
4. What is the function of a fuse wire? What should be properties of the fuse wire? What will be the physical differences between 5A and 10A fuse wire?

IV. NUMERICAL QUESTIONS

1.Consider the following circuit-

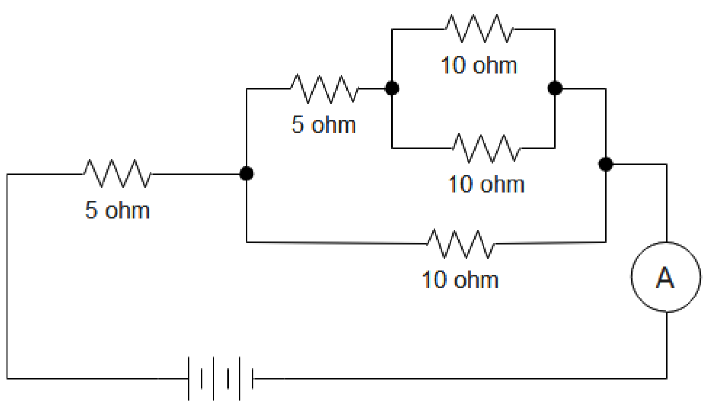


a) Which resistors are connected in series and which ones are connected in parallel?

b) If each of the resistors have a resistance of 5 Ω, determine the net resistance in the circuit

2.There is a wire of resistance 2R cut into two equal parts. At one time, these parts are connected in series in a circuit and at another time, they are both connected in parallel across the same potential difference. The current is allowed to flow across both circuits for “t seconds”. In which circuit- series combination or parallel combination of these resistances- is the heat produced more and by how much?

3.Study the circuit given below-



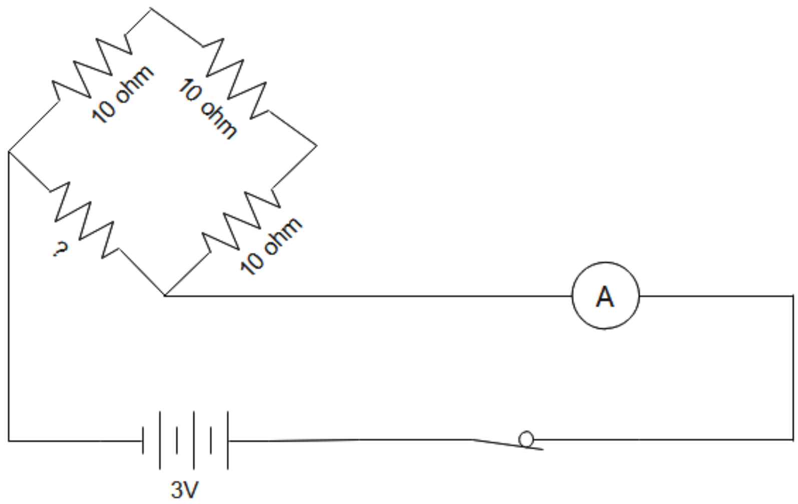
If the potential difference in the circuit is 10 V, determine

a) Net resistance in the circuit

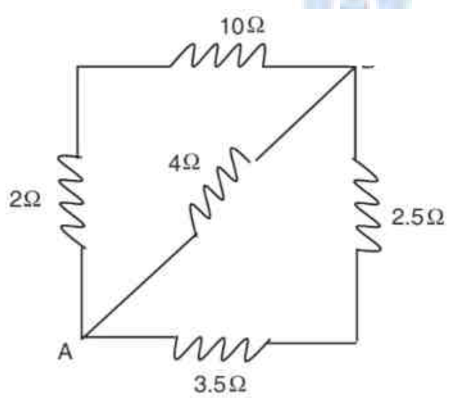
b) Net current in the circuit

c) Potential difference across the resistor R1

4.In the circuit diagram given below, find the unknown resistance if the potential difference provided by the battery is 3V and the current reading in the ammeter is 0.6A.



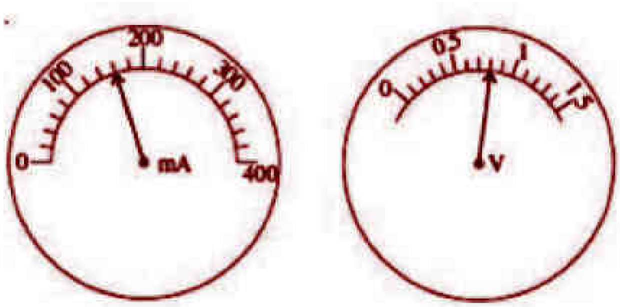
5. In the given circuit determine the equivalent resistance across AB



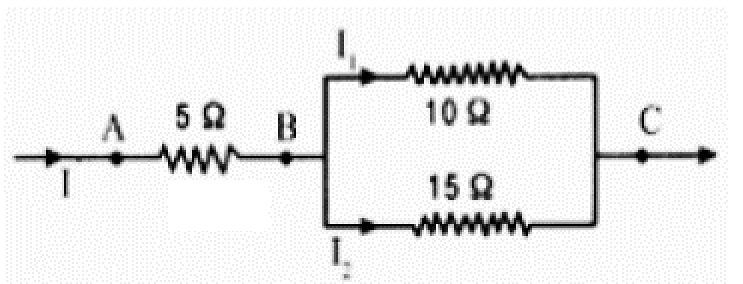
6.Calculate the resistance of 3 km long copper wire of radius 3 mm.
(Resistivity of copper = 1.72 x 1 0^{-8} Ω m)

7. A laptop battery charger passes a current of 1.50A for 30 minutes with an output voltage of 30 V. Calculate how many electrons are transferred to the computer battery in this time interval?
(Charge of an electron is 1.6×10 −19 C)

8.In the following diagram, determine the least count of ammeter and voltmeter and calculate the resistance



9. Study the following circuit



If 2 A of current flows in the 5Ω resistor, determine

a) Potential difference across AB and BC

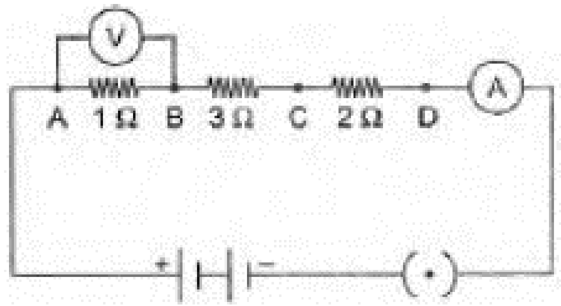
b) Total resistance offered by the circuit

10. Three resistors of 1 Ω, 3 Ω and 2 Ω are connected across a battery of 6V, a shown.

a) What will be the reading of the ammeter and voltmeter?

b) What will be the reading of voltmeter if it is connected between C and D

c) How will the reading of ammeter change if it is connected to the left of A?



ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 36.1

a) false

b) True

c) False

d) False

e) False

f) False

g) True

CHECK YOUR PROGRESS 36.2

1. 1.25×10^3

2. 10 C

3. 20 V

4. 2 C

CHECK YOUR PROGRESS 36.3

1. liquids with acid/salts

2. 1.33 A

3. 250A

4. 80 micro A

CHECK YOUR PROGRESS 36.4

1. 4.4A

2. 3.7×10^{-8}-ohm m

3. 144 ohm

4. 160 ohm

5. A

CHECK YOUR PROGRESS 36.5

1. a) 18.8 kohm,	b) 5/3-ohm	c) 9.22 ohm
2. a) 6A, 3A, 1A	b) 10 A	c) 3 ohm
3. a) 29 ohm	b) 0.25 A	c) 5 V &1 V

CHECK YOUR PROGRESS 36.6

1. 18 ohm, 0.66 A

2. 14 ohm

CHECK YOUR PROGRESS 36.7

1. 400 J

2. 60V

37

MAGNETIC EFFECTS OF ELECTRIC CURRENT

INTRODUCTION

Magnets are all pervading. They are found in our headphones, TV's, computers, are a part of motors which run not only are domestic machines such as mixer grinder, washing machine but also our car, in engines, wipers, automatic window control. The list of devices that use magnets is endless. Thus it is important to understand how magnetic field is produced and used. Although electricity and magnetism were considered as separate branches of physics for a very long time, research conducted by scientists in the early nineteenth century established the magnetic effect of current. This indicated that the branches of electricity and magnetism are like two sides of the same coin. Not only does a current carrying conductor produce a magnetic field, magnetic field can be used to generate current. The relation between electricity and magnetism changed the face of technology and its applications ushered the era of modern living.

Thus electric current not only produces heating effects but also magnetic effect. To understand this effect first, we need to revise the basics of magnetism.

37.1 LEARNING OBJECTIVES

After reading this lesson, you will be able to:

- Differentiate between magnet and electromagnet
- Understand the concept of magnetic field
- Draw the magnetic field of a bar and horse shoe magnet.

- Explain the properties of magnetic field lines
- Understand right-hand thumb rule and left-hand thumb rule
- Gain knowledge about parts and working of electric motor and electric generator.
- Elucidate the process of generating current
- Apply the knowledge regarding electricity and fuse in day-to-day life.

37.2 MAGNETISM

When we think of magnets, the first image that comes to our mind is that of bar magnets. Such magnets are man-made. The magnets in fact were first discovered by ancient Greeks, when they learned about magnetite, an ore of iron which could attract small pieces of iron. Such natural magnets are weak and have irregular shape. The first recorded use of magnets is by the Chinese. They used it to find direction or as a compass. The most impressive feature of magnets is that they exert a force, called as magnetic force which can be attractive or repulsive and is a non-contact force. This force can be experienced by certain materials like iron, nickel and cobalt which are termed as magnetic materials. How can magnets exert a force from a distance? This is because magnets influence the region around them, produce a magnetic field and can exert magnetic force.

Fig 37.1 Natural magnet (Magnetite Fe_3O_4)

Fig 37.2 Different shapes of man-made magnets

Magnets of different shapes have same properties but their applications may be different. Man-made magnets are usually made of alloys like Alnico (Aluminum, Nickel, Cobalt and Iron plus some amounts of Copper, Titanium and Niobium.) Magnets may be used to separate magnetic materials (as in junk yard) to lift objects (as in a crane) to move things (as in an electric bell) and also in converting energy from one form to another (electrical to mechanical in a motor)

37.2.1 Properties of Magnet

1. Magnets have two poles; these are the regions where the magnetic force will be the strongest. Monopoles in magnets do not exist.

2. Like poles of a magnet repel each other while unlike poles of a magnet attract. Magnets also have the ability to attract other magnetic materials like those made of iron, nickel and cobalt.

3. if we take a magnet and suspend it with the help of a thread, it will always point in the North-South direction. The pole that faces the geographic north is termed as north pole and the pole faces the geographic south direction is the south pole.

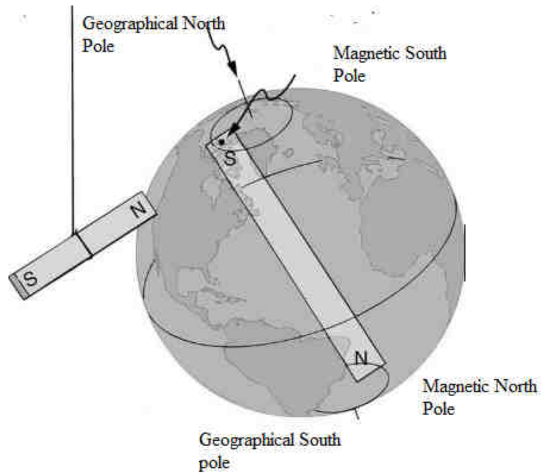


Fig 37.3: Freely suspended magnet

This is because the earth itself behaves as a giant bar magnet with its magnetic south pole towards the geographic north direction and as unlike poles attract, we get this orientation of the magnet.

It is this property of the magnet which enables it to be used as a magnetic compass.

Fig 37.4: Magnetic compass

37.2.2 Magnetic Field

Activity 37.1

Take a bar magnet and place it under a sheet of paper

Take some iron filings (very small pieces of iron) and sprinkle on the paper.

Gently tap the paper,

The iron filing, by themselves will be arranged in a certain pattern.

Evert time the experiment is repeated; the pattern of the iron filings remains the same.

This pattern does not extend to a very large distance but remains in the vicinity of the magnet

This space around the magnet up to which the magnetic force exerted by it can be experienced is termed as magnetic field.

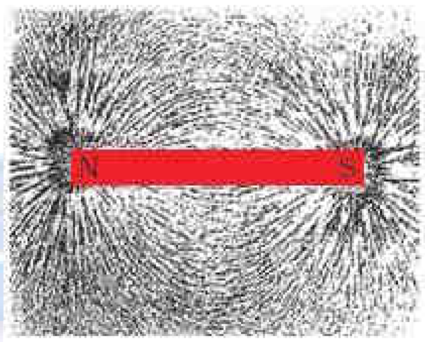


Fig 37.5 Iron filings arranged around a bar magnet.

While the arrangement of the iron filings tells us about the properties of magnetic field, there is another way of studying and understanding magnetic field.

37.2.3 Mapping the magnetic field lines using a compass and determining its properties

Activity 37.2

For this activity we need a bar magnet, a magnetic compass, a pencil and a paper.

Place the magnet on the paper and place the magnetic compass close to the north pole of the magnet.

The north pole of compass will point in a certain direction, away from the magnet.

Mark the point in which north pole is pointing and now place the compass at that point.

Repeat the process till the compass finally points to the south pole of the magnet. When we connect all the points in which the compass was pointing, we get magnetic field lines. Here we have outlined the magnetic field in the form of magnetic field lines.

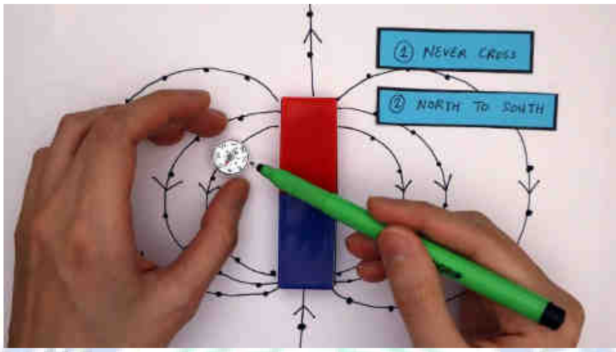


Fig 37.6: Magnetic field lines

The magnetic field is a vector quantity and has both magnitude and direction. When a compass is placed at a point in the surrounding area of the magnet, the direction in which the compass points is the direction of magnetic field at that point.

Where ever the magnetic field lines are very close, the magnetic field is stronger. The field lines emerge from the north pole of the magnet and towards the south pole. They do not end there, but move from south to north pole inside the magnet. That is why it is said that magnetic field lines are closed curves. If we have traced the magnetic field lines, the direction of magnetic field can also be found by drawing a tangent at that point.

When the field lines are parallel and in the same direction and uniformly spaced, they represent uniform magnetic field.

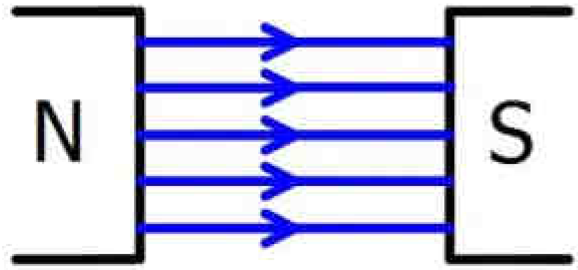


Fig 37.7: Uniform magnetic field

A very important property of magnetic field lines is that they do not intersect.

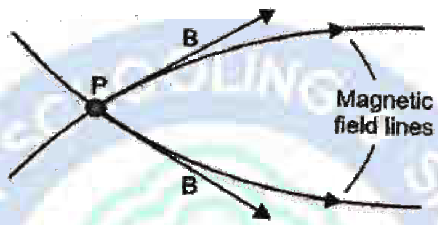


Fig 37.8: Magnetic field line do not intersect

Suppose two magnetic field lines did intersect each other. If a compass was to be placed at P, the point of intersection, then it would have to point in two different directions for the field lines. Or, if we draw a tangent, there would be two tangents for the two magnetic field lines. Both observations would mean that direction of magnetic field at point P would be in two directions, which is not possible. Hence two field lines due to a magnetic never intersect.

Magnetic field lines due to a bar magnet and a horse shoe magnet can be drawn as under-

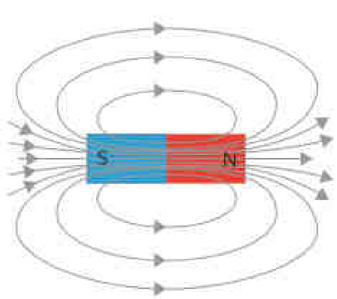


Fig 37.9: Magnetic field line of a bar magnet

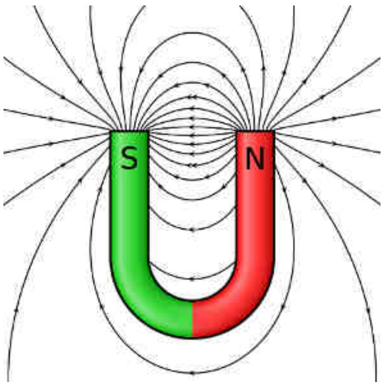


Fig 37.10: Magnetic field line in horse shoe magnetic

CHECK YOUR PROGRESS 37.1

1. What are the properties of magnetic field lines?
2. Draw the pattern of magnetic field lines if two bar magnets were placed with their north poles facing each other.
3. How can a magnet be used to find the direction, explain?
4. Why is it not possible for two magnetic field lines to intersect?

37.3 MAGNETIC FIELD CAUSED BY CURRENT

It was the genius of Hans Christian Oersted, a Danish physicist who proved that magnetic field is not produced by magnets only, but a current carrying wire too produces a magnetic field.

Activity 37.3

Place a compass near a straight current carrying wire.

You shall see that as the current passes through the wire, compass needle is deflected. When the current is switched off, the compass comes to rest, pointing in the north-south direction.

Now, the compass can only be deflected by a magnetic field.

The only explanation that we can thus give is that magnetic field is generated by a current carrying wire.

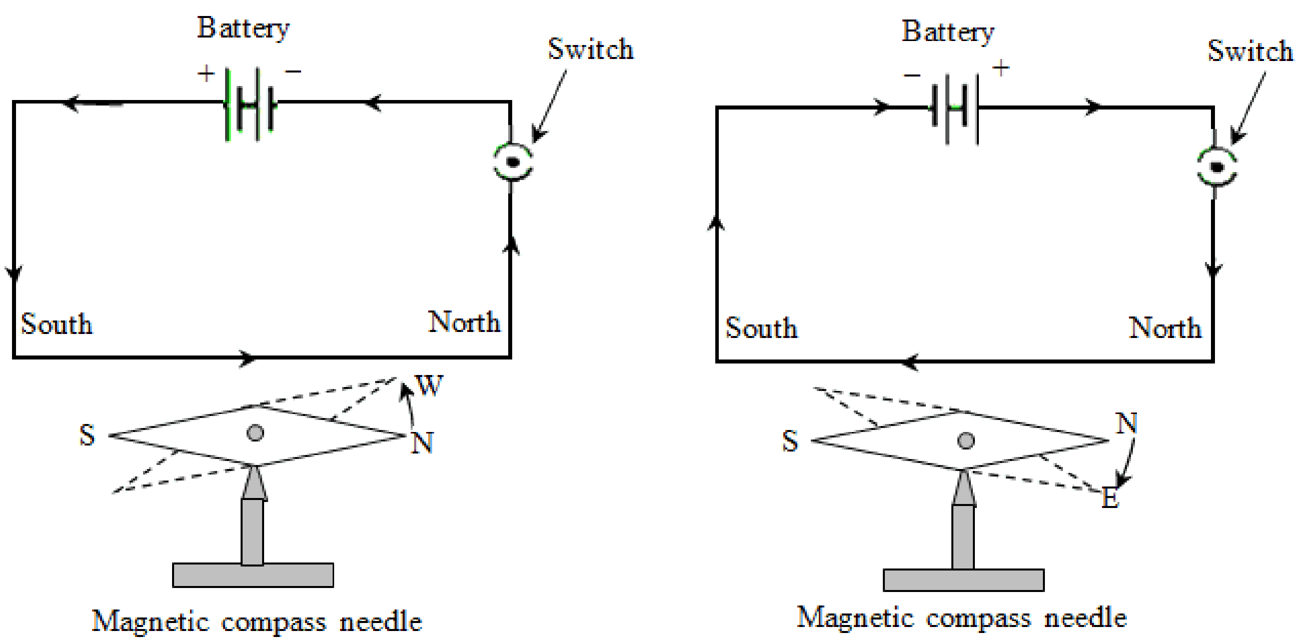


Fig 37.11: Magnetic field generated by a current carrying wire

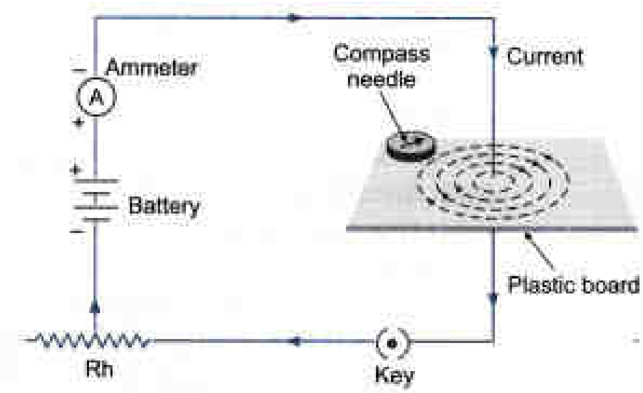
37.3.1 Magnetic Field Around a Straight Current Carrying Conductor

Every conductor that carries current generates a magnetic field, which can be imagined in the form of magnetic field lines.

The pattern of the filed lines looks different for different shapes of conductor although the filed lines have the same properties.

Let's consider a straight current carrying wire. Magnetic field can be studied by either sprinkling iron filings or with the help of magnetic compass as described earlier.

Set up the circuit as shown below



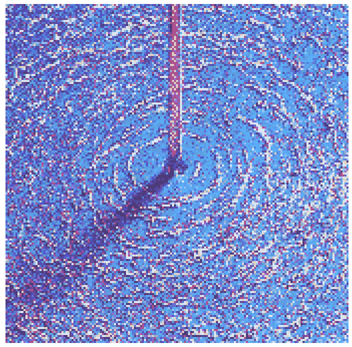


Fig 37.12: Magnetic field around a straight current carrying conductor

- As the current flows in the circuit, iron filings get arranged in concentric circles, with centre on the wire and the radii of the circles increases as we move away from the wire.
- Even if we use a magnetic compass and mark the direction in which the north pole of the compass is pointing, same pattern is obtained
- The direction of the magnetic field lines reverses if the direction of current is reversed.

These observations establish that

- Magnetic field produced by a current carrying wire is directly propotional to the current
- When the current is reversed, direction of field also reverses

The direction of field around the wire can be determined with the help of Maxwell's Right hand thumb rule

37.3.2 Maxwell's Right hand thumb rule

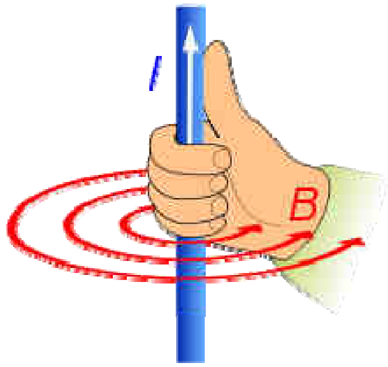


Fig 37.13: Maxwell's Right hand thumb rule

Hold the current carrying straight wire in your right hand.
Open the thumb in the direction of current
The direction(clockwise or anticlockwise) in which the fingers curl give the direction of magnetic field around the wire.
(I stands for current and B for magnetic field)

37.3.3 Magnetic Field Around a Current Carrying Conductor Circular Loop

Make a circuit comprising of battery, a circular loop and key as shown. Iron filings or compass can be used to draw the pattern of magnetic field lines.

While the field lines are concentric circles in the vicnity of the loop, they are nearly unofrom in the space between the loop.

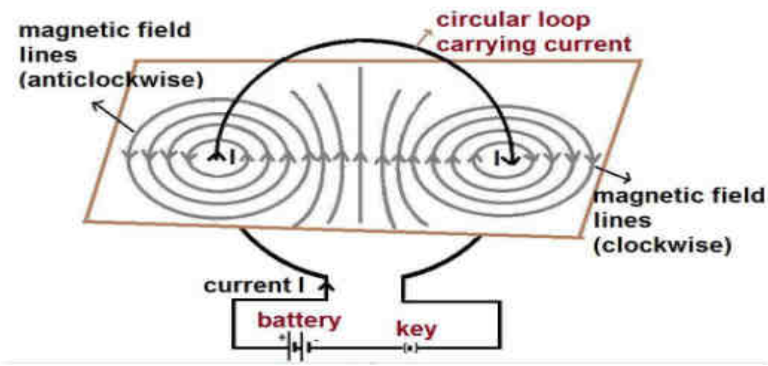


Fig 37.14: Magnetic Field Around a Current Carrying Conductor Circular Loop

Fig 37.15 Magnetic field lines for a circular coil

We can thus infer that:

- Magnetic field is nearly unifrom in the space between the loop
- More the number of turns, stronger is the magnetic field
- Magnetic field that is produced at the centre of the coil is inversely propotional to the radius of the coil
- More is the current in the coil, stronger is the magnetic field

Direction of the magnetic field can be determined by Right hand Thumb rule. For this curl the fingers of the right hand in the direction of current. Open the thumb. The direction in which the thumb points is the direction of magnetic field

37.3.4 Magnetic field around a current carrying solenoid

We are familiar with the shape of a spring. It comprises of very close turns and its length is much greater than its diameter.
If we have such a cylindrical wire, which resembles a tightly wound spring, it is termed as a solenoid.
Magnetic field around a solenoid can be studied with the help of the following setup.

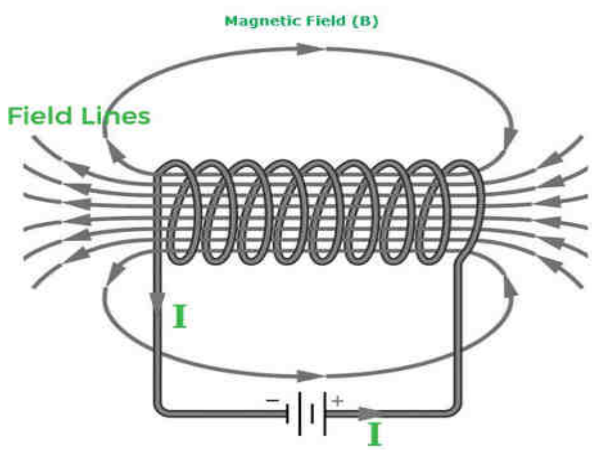


Fig 37.16: Solenoid

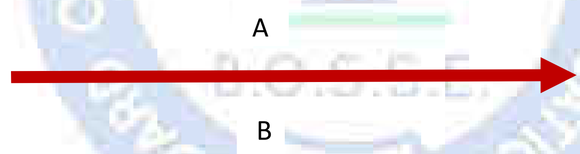
Each turn in the solenoid produces magnetic field. As can be seen as above, the pattern of magnetic field lines is similar to that of a bar magnet.

- The magnetic field inside the solenoid is unifrom and strong.
- Magnetic field is directly proporyional to the current in the solenoid
- Greater the number of turns per unit length, more strong is the magnetic field

Imagine you are holding the solenoid in your rigth hand with fingers curled along the direction of current. The direction of thumb then gives the direction of magnetic field. The thumb points towards the end where the north pole of the solenoid appears.

CHECK YOUR PROGRESS 37.2

1. Answer as True/ False
    a) Magnetic field lines can be observed with the help of iron filings
    b) The magnetic field pattern due to a current carrying solenoid is in the form of concentric circles
    c) Magnetic field in the space between a current carrying loop is non-uniform
    d) Magnetic field due to a circular coil is inversely proportional to the current in the coil'
2. Draw the pattern of magnetic field lines for a circular loop when current through it flows in the anti-clockwise direction
3. Suppose an iron core is inserted in the space between the solenoid, how do you think this will impact the magnetic field when current is passed through it?
4. Can a current carrying solenoid be used as a temporary magnet? Justify your answer.
5. Indicate the direction of magnetic field at the points A and B near a current carrying straight wire?



37.4 FORCE ON A CURRENT CARRYING CONDUCTOR IN A MAGNETIC FIELD

In the Oersted's experiment it was observed that a force is exerted on a freely suspended magnet when placed near a current carrying wire. Andre' Marie Ampere proposed that if we place a current carrying wire that is suspended freely in a magnetic field, it would also experience a force. (Newton's third law)

This can be demonstrated with the help of following setup

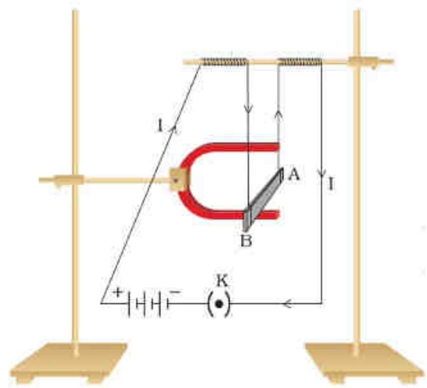


Fig 37.17: Force on a Current Carrying Conductor in a Magnetic Field

The experiment proved that

- When the current is passed the wire moves sideways, perpendicular to direction of current and direction of magnetic field
- If we reverse the direction of current or the position of poles, direction of force too is reversed
- There is no force exerted if the wire is placed such that it is parallel to the magnetic field
- Numerical value of the force experienced by the wire depends on
  - ❖ The magnitude of current, greater the current, more is the force
  - ❖ Stronger the magnetic field, more is the force
  - ❖ More is the length of the wire in the magnetic field, greater is the force experienced by it

    F= BIL

F= force

B= magnetic field strength

I = current

L=length of wire in magnetic field

37.4.1 Direction of force on a current carrying conductor in a magnetic field

John Ambrose Fleming provided a simple rule to find the direction of force experienced by conductor that has been placed in a magnetic field. This rule is known as Fleming's left hand rule.

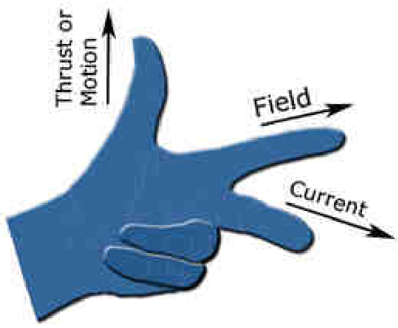


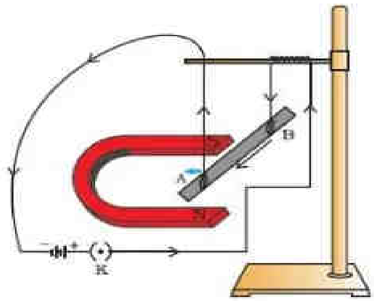
Fig 37.18: Fleming's left-hand rule

Stretch the thumb, first finger and middle finger of your left hand such that they are mutually perpendicular.

The middle finger represents the direction of current, the first finger the direction of magnetic field, the thumb will point in the direction of force.

CHECK YOUR PROGRESS 37.3

1. What will be the direction of force on an electron if it is moving
   a) from east to west in a uniform magnetic field directed away from you.
   b) From west to east in the earth's magnetic field
2. Determine the direction of force on the following moving from south to north in a uniform magnetic field which is directed from east to west
   a) Neutron
   b) An alpha particle
3. What will be the direction of force on the wire in the following setup-



37.4.2 Electric motor (DC)

An electric motor is a device designed to convert electric energy into mechanical energy. It works on the principal that when a current carrying conductor placed in a magnetic field, it experiences a force. This force causes a rotation and does mechanical work

Construction

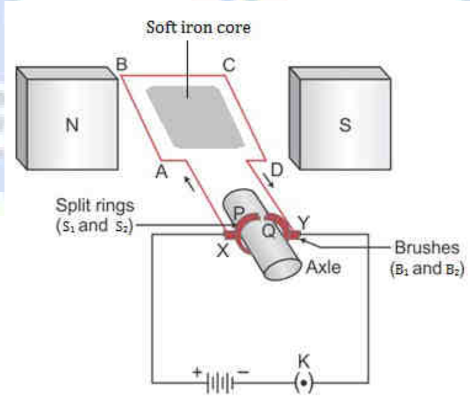


Fig 37.19: Electric motor

Electric motor comprises of

- **Armature coil**- In the above figure, ABCD represents the armature. This consists of a large number of turns of insulated copper wire

- **Field magnet-** A coil is positioned amid the two poles of a strong magnet. The magnet is usually a U-shaped magnet so that the coil is placed in a uniform magnetic field.
- **Split rings-** S1 and S2 are the split rings. The inner side of the rings are attached to the axle
- **Brushes-** Two brushes made of copper, Bi and B2 touch the revolving split rings and provide current to the coil from the battery
- **Battery-** This is used to supply current to the coil

Working-

- As the current is passed in the coil, the arm AB experiences a force downward and CD experiences an upward force (By Fleming's left-hand rule)
- As the two forces are equal in magnitude but opposite in direction, they rotate the coil in the anticlockwise direction
- After half the rotation, AB comes in contact with brush B2 and CD with brush B1
- This reverses the current in the coil
- Now AB experiences a force upward and CD downward
- This forms a couple and the coil continues to rotate anticlockwise

Power of the motor can be increased by

- If the number of turns in the armature coil is increased
- Using a soft iron core on which the coil is wound
- Increasing the area of the coil

- Increasing the strength of the magnet

CHECK YOUR PROGRESS 37.4

1. Match the column

A	B
1. Force on a current carrying wire placed in uniform magnetic field is given by this rule	1. Carbon brushes
2. A magnet can be replaced by this in a motor	2. Fleming's left-hand rule
3. The current in the armature in the motor enters through these	3. Electromagnet

2. Give 3 applications of electric motor in your daily life
3. What is the function of split rings and brushes in a DC motor?

37.5 ELECTROMAGNETIC INDUCTION

It was the genius of Michael Faraday who proved that moving magnet can generate electricity. When properties of magnetism are used to generate (induce) electricity, the phenomena is termed as electromagnetic induction or EMI

37.5.1 Faraday's experiment

Faraday's experiment comprised of a wire of large number of turns connected to a galvanometer. He observed-

- When a strong magnet was moved in the vicinity of the coil (inside it, near it, pulled outside the coil) there was a deflection in the galvanometer, or current was induced.
- There was no deflection in the galvanometer if magnet was stationary in the vicinity of the coil
- If North pole was moved towards the coil, the defection was in a certain direction (say, right), if north pole was moved away from the coil, the deflection was towards left
- If South pole was moved towards the coil, the defection was towards left, if south pole was moved away from the coil, the deflection was towards right
- If arrangement was such that the coil was moved and the magnet was kept stationary, similar results were observed

Thus it was inferred that-

- Galvanometer showed deflection only when either the magnet moved or the coil or both (but at different speeds)
- More the relative velocity, more was the deflection

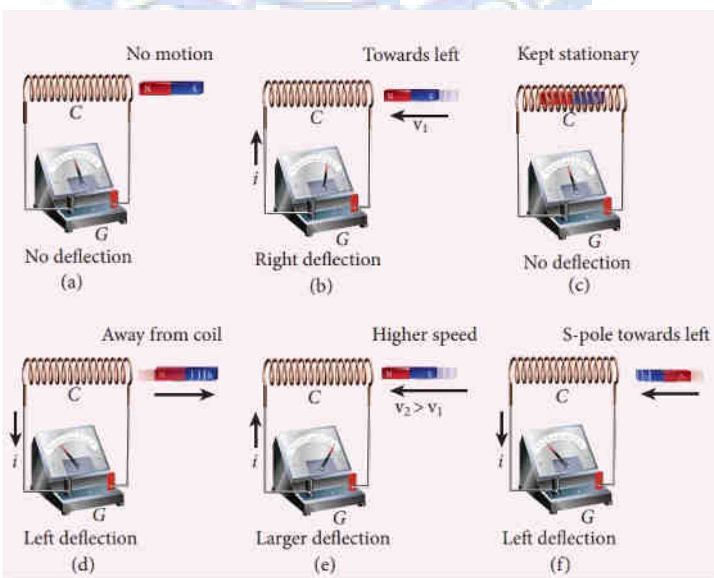


Fig 37.20: Faraday's experiment

Explanation

When there is a relative movement between the magnet and the coil, there is a change in the number of magnetic field lines that pass through the coil. The magnetic field lines that pass through the coil are termed as magnetic flux.

This change in magnetic flux (whether increase or decrease) makes current in the coil. This current is called as induced current.

In this process mechanical energy is changed into electric energy

37.5.2 Two coils linked experiment

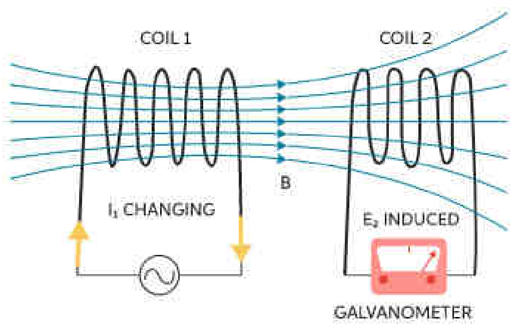


Fig 37.21: Two coils linked experiment

The hypothesis was confirmed by using the above setup.

As the current in coil 1 was changed, this inducedd current in coil 2.

Whenthe current in coil 1 was steady, no current was induced in coil 2.

37.5.3 Faraday’s Right-hand Rule

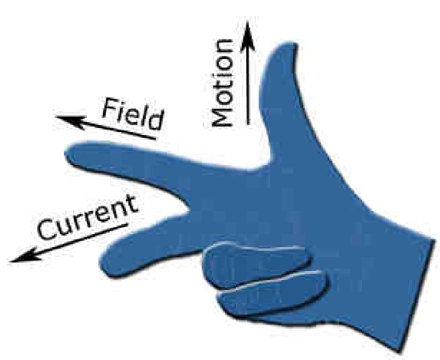


Fig 37.22: Faraday’s Right-hand Rule

The rule helps us to determine the direction of induced current when there is relative motion between magnet and a wire

Stretch the thumb, the finger next to the thumb and middle finger of your right hand such that they are mutually perpendicular to each other.

If thumb gives the direction of motion, first finger gives the direction of magnetic field and second finger gives the direction of induced current.

The induced current;

- Is found to be directly proportional to the rate of change of magnetic field lines passing through the coil
- Increases with increase in number of turns in the coil
- Increases with increase in strength of magnetic field

37.5.4 Electric Generator

This is a device that converts mechanical energy to electrical energy.it is also called as a dynamo. It can be an AC (generates alternating current) or DC (generate direct current)

37.5.5 AC Generator

Principle: This works on the principle of electromagnetic induction. A coil is placed in a strong and uniform magnetic field and it is rotated very fast. Due to rotation, the number of magnetic field lines that pass through the coil also changes rapidly and this induces current in the coil

Construction:

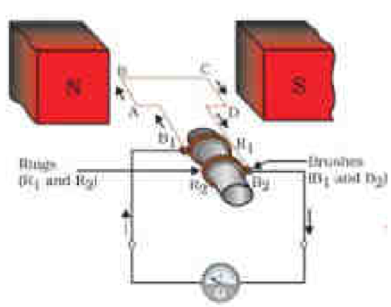


Fig 37.23: AC Generator

It comprises of:

1. **Armature-**Like in a motor, in a generator too, armature is a rectangular coil which has a large number of turns of insulated copper wire. The wires are wrapped on a soft iron core.
2. **Field magnets-** The armature is positioned between the poles of a strong magnet/electromagnet which provides a uniform magnetic field.
3. **Slip rings and carbon brushes-** The armature coil are linked to the slip rings, R1 and R2 which are always in contact with graphite(carbon) brushes B1 and B2. The brushes remain stationary while the slip rings rotate. The brushes are in contact with the external circuit in which the current is supplied by the generator.

WORKING

The armature coil is rotated. This can be done by energy of flowing water (hydroelectricity, by burning coil, boiling water and using steam thus produced to rotate the coil, that is thermal electricity or by any other means)

As the arm AB moves up and CD arm moves down, , current is induced in the coil whose direction is along ABCD and is determined by the application of Fleming's Right Hand rule

After half a rotation now arm AB moves down and CD moves up. This induces current from DCBA. Thus the current through the armature changes direction after every half rotation, or twice in each rotation and we get an AC output.

CHECK YOUR PROGRESS 37.5

1. Give the difference between electric motor and generator.
2. What do you think will be the essential difference in the construction of AC and DC generator?
3. What is the difference in the current provided by cell and generator?

4. How do we decide that in a given situation we need to use the Fleming's Right Hand or Left-Hand rule, explain?

37.6 DOMESTIC ELECTRIC CIRCUITS

We use many appliances in our homes. These appliances primarily work on AC current. In India domestic electric supply is at 220V and 50 Hz frequency. The cables used in our homes primarily comprise of three insulated wires-

1. **Live wire:** This is maintained at 220 V. the current enters the device through the live wire. This wire has a red/ brown color insulation
2. **Neutral wire:** This is maintained at 0 V. As the current enters the device through the live wire, it passes through the device and returns through the neutral wire. Many appliances which do not use too much power have two terminals only (tube light, fans et.) and thus are connected across live and neutral wires. This wire has a black/blue insulation
3. **Earth wire-** Those devices that have three terminals like washing machine, mixer grinder, etc. which usually have a metallic body have a third wire called as earth wire. The earth wire which has a green or yellow insulation is connected to the body which is made of metal of the appliance and its other end is earthed. So it is maintained at zero potential. This ensures that in case there some current manages to leak into the body of device, and we accidently touch it, we will not get a shock as the current has flown down to the earth.

Fig 37.24: Domestic Electric wire

37.6.1 Domestic electric wiring

All electric appliances in our homes are connected across live and neutral wires and in a parallel arrangement. This ensures that all appliances get the same potential difference of 220V and draw current as per their requirement or power rating.

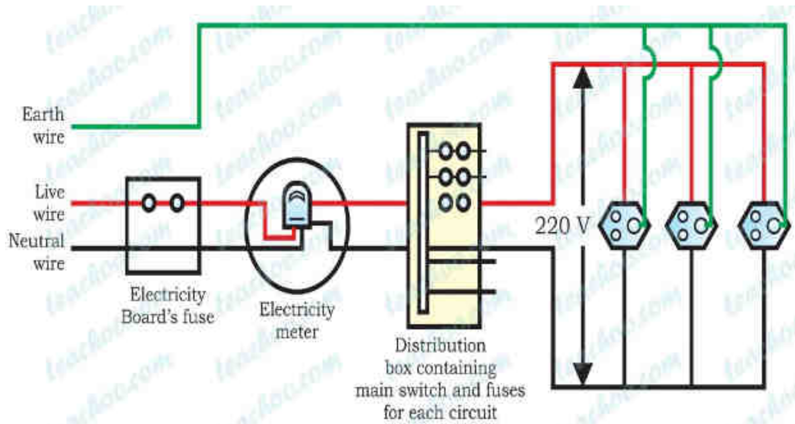


Fig 37.25: Domestic electric wiring

Appliances in our homes which have a high resistance require less current and those with less resistance require more current. Thus the current carrying capacity of wires used may be 5 A or 15 A

37.6.2 House hold safety devices

Do prevent accidents due to electric faults such as over loading, short circuit etc. we use safety devices such as fuse wire and earthing. However, the safety device which is much convenient to use is a MCB, miniature circuit breaker.

An MCB comprises of a solenoid connected in series with the live wire. A soft iron core is placed partially in the coil. When the current in the circuit exceeds the safety limit, the iron core gets pulled in the solenoid. The core then hits the switch and opens the switch thus stopping the flow of current to the device.

The switch can then be manually switched on after the problem is rectified.

RECAPITULATION POINTS

- Magnets exert magnetic forces. These forces are generated by magnets and also current carrying wires.
- Magnets create a magnetic field, which has both magnitude and direction through which the force is exerted.
- Magnetic field can be visualized with the help of magnetic field lines, these can be plotted either with the help of iron filings or a magnetic compass
- A straight current carrying wires produces a concentric magnetic field, with the center of the circles lying on the wire
- The magnetic field of sucha wire increses with the increase in current and decreses with increase in distancefrom the wire
- The direction of the magnetic field can be obtained with Maxwell's Right hand thumb rule
- For a circular loop/ coil the magnetic field is uniform in the soace within the coil
- A current carrying solenoid generates a strong magnetic field within it.
- If a freely suspended current carrying wire is placed in a magnetic field, it experiences a force. The direction of force can be determined by Fleming's Left hand rule
- Just as current generates magnetic field, a magnet can be used to generate current in a coil. This is termed as electromagnetic induction
- The current is induced in the coil only when there is a change in magnetic field lines linked with the coil.

- This is achieved when there is a relative motion between the magnet and the coil
- The direction of induced current is given by Fleming's Right hand Rule
- Both motor and generator convert one form of energy to another. Motor converts elecrtical energy to mechanical while generator converts mechanical energy to electrical
- In India the domestic electricity supply isat AC 220 v and frequency 50 Hz
- The live wire maintained at 220 V brings the current to the device and the current leaves through the neutral wire which is maintained at 0 V
- To prevent hazards caused by electricity, we use fuse wire, earth wire and MCB.

TERMINAL EXERCISE

1. Choose the correct option

a) Magnetic field lines-

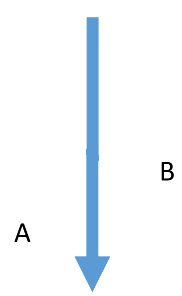
i) Move from south to north pole outside the magnet

ii) Can intersect at then poles

iii) Are closer to each other away as we move from the magnet

iv) Are closed curves

b) In the following figure, a magnetic needle is placed at the point A and B, choose the correct option



i) Magnetic needle will deflect in the same direction at A and B

ii) Magnetic needle will deflect opposite direction at A and B

iii) Magnetic needle will deflect at A and not at B

iv) Magnetic needle will not deflect at any of the points

c) The pattern of magnetic field lines due to a straight current carrying conductor are-

i) Concentric circles

ii) Parallel lines

iii) Parabolic in shape

iv) Elliptical in shape

d) Solenoid find many applications in appliances because-

i) It produces a strong electric field outside itself

ii) It produces a strong electric field within itself

iii) It produces a strong magnetic field outside itself

iv) It produces a strong magnetic field within itself

e) If you are given a coil and a bar magnet, it is not possible to induce current in the coil by-

i) Moving both together in opposite direction

ii) Keeping one stationary and moving the other

iii) Moving both mutually perpendicular to each other

iv) Keeping one stationary and moving the other around it

f) The device that comprises of an armature is-

i) A motor not a generator

ii) A generator not a motor

iii) Both motor and generator

iv) Neither motor nor generator

g) The slip rings or commutator is used in a DC motor to-
   i. Draw the current in the external circuit
   ii. Adjust the magnitude of current in the armature
   iii. Change the direction of current in the armature
   iv. Ensure that the current in the armature flows in the same direction
h) An MCB is based on –
   i. Heating effect of current
   ii. Magnetic effect of current
   iii. Chemical effect of current
   iv. All of these
i) In domestic electric circuits Fuse wire-
   i. is connected in series with live wire
   ii. is connected in series with the neutral wire
   iii. is connected in series with the earth wire
   iv. can be connected in series with any of the wires
j) the devices which have a three pin plug have the following wires connected to its three terminals-
   i. live, neutral and fuse wire
   ii. live and two neutral wires
   iii. two live wires and a neutral wire
   iv. live, neutral and earth wire

2. Fill in the blanks
   a) The potential difference between live and neutral wire is ………………
   b) The number of times AC current changes direction in 1 second is…………….
   c) The color of the wire in which the switch has to be connected is ……….

d) When there is a sudden increase in the current in domestic electric circuit, this may be due to ……………. or …………………

e) If the color of the insulation of a wire is black, this will be a …………… wire.

f) The wire that does not carry any current unless a fault is developed in the circuit is ……………...wire

g) The shape of the magnetic field lines in the space between a current carrying loop is ……………

h) If we move a magnet away from a coil of wire, this produces a current in the coil. This is an example of ………………. phenomena.

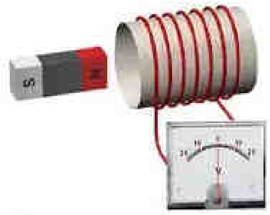
i) A wire carrying current from south to north is placed in a uniform magnet field which moves from west to east. The wire will experience a force in ……………… direction

j) If a loop of wire and a magnet are moved in the same direction with the same speed, will this generate current in the wire? ………. (Yes/No)

3. Answer the following questions:

   i. Why does a compass needle always align in north-south direction in absence of a magnet?
   ii. Can we produce magnetic field without a magnet, explain?
   iii. What is meant by induced current?
   iv. What are the two ways of inducing current in a coil?
   v. Why is it essential to earth certain devices in our homes?
   vi. If the fuse blows, we should not replace it with a copper wire, why?
   vii. What is the significance of the wire with black/ blue insulation in domestic electric circuits?
   viii. Why can AC not be used for electroplating?

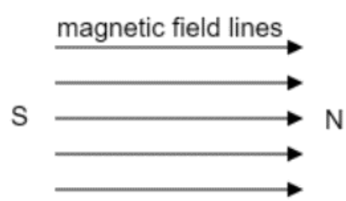
ix. Study the figure-



if the deflection in the galvanometer is towards right when North pole of the magnetic is taken near it, what will be the direction of deflection when-

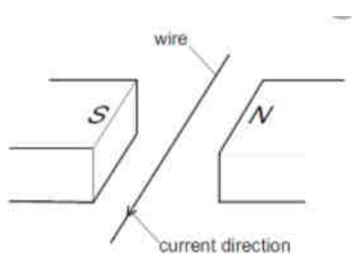
a. We move the North pole away from the coil
b. South pole of the magnet is taken away from the coil
c. We place a magnet above the coil
d. Magnet is placed within the coil
e. North pole is taken towards the coil in which a soft iron core is placed.

x. The figure below depicts a uniform magnetic field. Determine the direction in which



a. an alpha particle will move if it moves into the plane of the paper
b. a proton moves if it is projected towards you
c. an electron moves if it is projected in the vertically upward direction

xi. Study the following diagram-



What will be the effect if-?

a. Wire is moved downwards

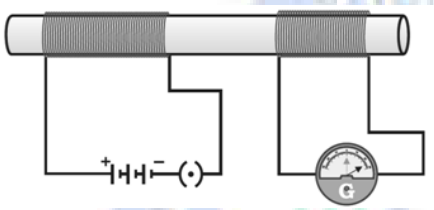
b. Wire is moved downwards with a greater speed

c. A stronger magnet is used

d. We reverse the direction of current in the wire

e. Wire is moved at a high speed in a direction that is along the magnetic field

xii. Study the following circuit-



a. When will there be a deflection in the galvanometer?

b. If we increase the number of turns in the coil, how will this impact the reading of the galvanometer?

c. If the number of turns in the coil connected to the galvanometer is increased, how will this impact the reading of the galvanometer?

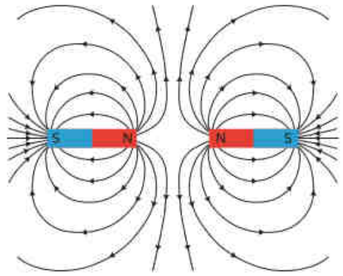
d. If the distance between the two coils is changed, how will this impact the reading of the galvanometer?

e. If the battery is replaced by an AC source, how will this impact the reading of the galvanometer?

ANSWERS TO 'CHECK YOUR PROGRESS'

CHECK YOUR PROGRESS 37.1

1. Field lines are closed curves, start from North pole and move towards south pole outside the magnet, are more crowded in the regions where field is stronger

2. 

3. If a magnet is suspended freely, it will always come to rest in the North- south direction

4. Two field lines cannot intersect as that would mean that at the point of intersection magnetic field is directed in two different directions and this is not possible.

CHECK YOUR PROGRESS 37.2

1. a) True

b) false

c) False

d) False

2. Refer article 37.3.3

3. Increased

4. It can be suspended freely

5. A- outside the plane of paper

   B- inside the plane of paper

CHECK YOUR PROGRESS 37.3

1. a) Upwards

   b) Away from us, into the plane of paper

2. a) Does not experience force

   b) In the upward direction

3. Towards left

CHECK YOUR PROGRESS 37.4

1. 1-2, 2-3, 3-1

2. Mixer grinder, washing machine, fan

3. Refer article 37.4.2

CHECK YOUR PROGRESS 37.5

1. While motor converts electrical energy to mechanical energy, generator does just the reverse conversion

2. AC will have slip rings while DC generator shall have split rings

3. A cell provides DC while generator provides AC

4. In case in the given set up the current is being produced; this means we have to apply the Fleming's Right-hand rule