SCIENCE AND TECHNOLOGY
A FOUNDATION COURSE

BLOCKS I - III

DR. B.R. AMBEDKAR OPEN UNIVERSITY

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PREFACE

What is Science? In the earlier years, science was regarded as natural philosophy. Science is characterised by the experimental method and by the use for the purpose of and distinguishing truth from error. The progress of science since the 18th century has been phenomenal. While pure scientific inquiry provides basic fundamental knowledge, it is often applied to technical practice. Such applications go under the label 'technology'. Science and Technology have come to exercise, with the passage of time, an increasing influence which has had the effect of refining the quality of human existence. It is, therefore, necessary for one living in modern world to cultivate a scientific attitude of mind and appreciate the innumerable benefits that science and technology could confer on mankind. It is for this reason a Foundation Course on Science and Technology is included in the Undergraduate Programmes of this University. The aim of the Foundation Course on "Science and Technology" is to acquaint the student with the concepts of science and major scientific developments in order that he may become aware of the extent of scientific development.

The first Block of this course provides a profile of the growth of science and technology during prehistoric times, the discoveries made in science and technology by major ancient civilizations and finally the developments during the scientific revolution which took place between the 16th and 19th centuries. The other five blocks acquaint the student with basic developments in different branches of science, the many useful discoveries made for the benefit of man, and also questions relating to medicine, food, the environment and the 'Future of Man' are discussed. A brief account of India's scientific progress made in major basic and applied fields of science are mentioned at appropriate places.

The six blocks of this course are divided into 26 units. Each Unit starts with a statement of its **aims** and **objectives**. At the end of each Unit the examination model questions and a glossary of unfamiliar words or terms are given.

It is hoped that the student who takes this course will gain an understanding of the scientific and technological enterprise of man, the benefits that science and technology conferred on man and also the great progress made therein by our own country.

CONTENTS

BLOCK-I HISTORY OF SCIENCE AND TECHNOLOGY

This block is a presentation in brief of the history of science. The main idea of this block is to illustrate how scientific knowledge originates, grows and develops on the basis of human inquisitiveness and human needs. Man observes Nature and learns many things from the phenomena occurring in Nature. The curiosity of the man to know the origins of these phenomena and the constant interrogation of Nature by man are the two main pillars on which science develops. Science grows differently in different social conditions and social needs. In the early periods of human history people were interested to develop the basic science and tools needed for their food and shelter. But soon when these basic needs were satisfied, people began thinking of comforts. For example the village communities of the past were fully satisfied with the ammenities provided by the Nature. They were only trying to harness these natural resources for their food and shelter. They never bothered about modern ammenities such as faster transport facilities and quicker communication technologies. But after industrial revolution, radical changes took place in the outlook of people. The people of the highly industrialised society looked forward for quicker means of transport and communications and for better quality of food and shelter. These aspirations of people led to great developments such as supersonic aircrafts and satellite communications. Science gradually and radically changed societies. Science and technology not only served the basic needs of the people but also contributed greatly to improve the quality of life. Consequently the man has become a slave of technology instead of technology serving the man. Some of the fundamental discoveries of science and technology even led to the unwarranted development of lethal weapons. For example, the nuclear weapons and the missiles have now become great threats for human life itself. Therefore this block will give you an account of the chronological developments that took place in the growth and development of science and technology besides their origins in the stone ages and the ancient and medieval times. The origins, growth and maturity of modern science, the method of science in the pre and post renaissance periods are the thought provoking steps in the historical development of science and technology. You learn in this block the development in science from the stone ages to the modern period through ancient and medievel times.

The Block is divided into 5 units as follows.

1. Science, a human endeavour
2. Science & Technology in ancient times
3, 4 Science & Technology in medieval times I & II
5. Modern scientific revolution.

We expect that after you completed this block you must be able to

1. understand that science and technology are a result of human endeavour to overcome some difficulties associated with the human existence.
2. appreciate that science and technology had their origins even in the stone age periods.
3. understand the interdependence of science and society on each other and how the developments in science and technology influenced the dynamics of a society.
4. get an insight into the process of growth of science, its changing pace in different societies and in different periods.
5. assess for yourself objectively the achievements of science and technology of different ancient and medieval traditions and the place of India in these developments.
6. understand finally for yourself the good and the bad, the desirable and the undesirable aspects of science and technology vis-a-vis the cultural and social demands of a society or a nation.

UNIT 1 SCIENCE : A HUMAN ENDEAVOUR

Contents

1.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about

1. how human endeavour resulted in the early emergence of science.
2. the meaning of history of science
3. the reasons for calling science an "institution"
4. the traditions followed in science
5. the mutual relations between science and society

Objectives

After you completed the unit, you must be able to answer the following questions.

1. what is History of Science?
2. why science can be considered as an "institution"
3. what are the traditions of science?
4. what are the social obligations of science?

1.2 INTRODUCTION

Even from pre-historic times, human beings were trying to control Nature to achieve human welfare. For this they were observing nature carefully and trying to understand Nature. In these activities human beings found the means to get the things and the goods needed for them from Nature. Thus the understanding of nature led to useful applications. But at the same time it opened up further questions, problems and avenues of enquiry. This human endeavour in fact enriched man's knowledge and also led to improved methods and techniques for satisfying his needs.

Thus the everlasting enquiry of Nature and using the understanding derived from this enquiry to control and use nature for the welfare of human beings can be called 'Science'. This process of enquiry of nature known as "scientific process" is ofcourse not a smooth one. It has many ups and downs. Thus the story of scientific process is a very interesting one. This may be very broadly called "history" of science. But it definitely does not mean dates, names and places as you generally encounter in the study of social history. The roots of science lie in the life of primitive human beings. The story of science thus starts from the point of dawn of human history. The transition from a primitive society to the modern agricultural and industrial society is a consequence of the birth of "science".

1.3 HUMAN ENDEAVOUR AND EMERGENCE OF SCIENCE

Science as said earlier has its roots in the life of primitive human beings. The history of human civilization shows that the progress of science is not steady. For example mathematics and medicine had advanced tremendously in India even about 2000 years ago. But no comparable developments are there in the later 2000 years. Similarly during the period when India had progressed greatly in the fields of calculations and observations, Europe was only in the primitive stage. But during the period of British rule in India, there was Industrial revolution in Europe. Thus even though the picture of the developmental activities is complex, we cannot but say that science and human activities are closely and intimately related to each other. They together give rise to what we can call human civilization. While science has brought large benefits to human beings, it also is used as a means of destruction. Therefore many questions now arise which relate to science and human life and happiness. For example

(1) Is science a boon or a threat to human race?

(2) Can science solve all human problems?

(3) How far science is responsible for the social conflicts existing between different races, different people and even different nations?

(4) Is it because of science that man is deprived of humanitarian approach to life problems?

How do we answer these questions which are of vital importance to human life. What ever may be the type of answer "Yes or No", we should all accept that we consciously or unconsciously accept science as a part of our lives. We all hope that it, the science, will bring us a better life. What ever may be our wishes, we are all now facing many problems & impediments which are either distorting the purpose of science or only benefitting a small minority of our people with the fruits of science. Science should be the means by which the whole of our civilization and all the sections of the people should benefit. In the past, science grew steadily and imperceptibly and hence its effects were not seen spectacularly. But now science is progressing very rapidly and perceptibly. Therefore the fabric of civilization is also changing very rapidly and perceptibly. Therefore to understand the present growth trends in science and their implications on human life and civilization, it is essential to search the past in order to understand the present and control the future. In order to draw the full benefits from science, we have to also understand how science was related to social and economical factors in the past. In other words we have to know the history of science to plan for the future of science. But what is meant by "History of Science". This you will learn in the next section.

Check your Progress

1. How science emerged in the past?

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2. How was emergence of science in ancient India?

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3. Does science really help all sections of society equally?

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1.4 HISTORY OF SCIENCE

What is History of Science?

It is easy to put this question but it is very difficult to answer it. For example does "history of science" mean a chronological description of events of scientific discovery or is it a story of an ongoing interaction of human activity and society. You would definitely agree that it is not a chronological description of scientific events. It is surely a narration of an ongoing interactive activity between science and society. It is a story that tells us how, social and economical issues of a society necessitated the inventions and innovations. You all know the saying that "necessity is the mother of invention". Innovations generally lead to social stability and the stability unfortunately leads to stagnation. This stagnation does not allow radical changes in the society. But society must be always conducive to rapid changes. The general observation in the past was that the changes were rapid in a particular period of time and slow in a different period of time in the same society. The social, cultural and economic conditions of a given society in the said periods of time were probably responsible. Thus the history of science can be taken as the story of human life, a story of human sufferings, struggles and strengths. It is a story of the interaction between science and the other dominating forces of the human society. These forces may be political, cultural, psychological or social problems. In the past science was not an organised and specialised human activitiy. Science was only a part of general culture. Science and Scientists had to face great oppositions and hardships not only from the people but also from the church. Frustrated and exploited groups or sections of the society created tough times for the progress of science. But at every phase science undoubtedly put the society qualitatively at a higher level. But at every higher level social relations and problems have also assumed complex nature. It became again necessary for science to solve these problems and issues. Thus history of science can be considered as a description of an ongoing process of the interaction of science and society.

1.5 INSTITUTION OF SCIENCE

An organised and collective activity of some trained persons can be considered as science. In this activity many people participate very actively. We find them working with instruments, apparatus and other devices and these appear strange to common men and lay men. These trained persons conduct experiments, make observations and perform complex calculations. It is difficult for a common man to understand these things and sometimes even to appreciate these things. These persons involved in these activities are generally referred to as scientific workers or sometimes as "Scientists". Scientists thus are considered as a "selective group of persons" engaged in experimental or theoretical work. The activity of these selective group of persons is called "scientific activity".

A large, well organised and diverse scientific activity imparts an **institutional character** to science.

Thus science as an institution attempts to solve specific problems in different areas. But these solutions should be within the broad frame working of existing social conditions.

Influence of science on our daily life is very spectacular and is also growing day by day. But at the same time the common man is unable to understand science easily. Even the scientists also find it difficult to understand progress in all branches of science with same ease. This is because these days scientific activities are getting restricted to very narrow areas of science. The specialisations are so narrow that even in any particular discipline of science, scientists specialised in one area find it difficult to understand the discoveries and findings in other area of the same discipline. For example a chemist specialising in organic chemistry finds it difficult to understand the developments in physical chemistry. Similarly a zoologist working on vertebrates is unable to understand clearly the latest developments in the area of invertebrates. We can go on enlisting examples in this way. But the fact is that specialization is probably dominating in unimaginable proportions. Specialization means a deep study of a limited range of phenomena or happenings or occurrences of science. Too narrow a specialization may often lead to loss of broad scientific understanding. It may make even the scientist lose her or his ability to relate the scientific findings of specialization with those of the other. This may in turn hamper the growth of scientific knowledge. The over specialization may even force scientists use special and highly technical language to make their reports. This prevents the common man really understand the latest discoveries of vital importance in our daily life. Hence common man will not be able to get the benefits of scientific discoveries. Very often this may lead to stagnation and even decay of scientific activity.

Now comes the real question. Is science, a social institution or not? If the answer is "yes", then the objectives of science must be social objectives. The motivation for scientific activity will be then decided by these social objectives. The important areas of social life namely agriculture, natural resources, industrial developments, trade, health etc. will determine the areas of activity of science and also establish the goals for science. But defence requirements of a country also decide the areas of science activity. This may perhaps not lead to human welfare and also may pervert scientific activity. But all over the world the scientists have realised now the dangers involved in developing the deadly war weapons such as missiles, nuclear arms etc. Therefore an anti nuclear weapons drive is launched all over the world. In a similar way, if science is used as a tool for profit making in commercial sector, production of goods will be for making profits rather to meet the needs of the society.

Thus it is the common people who should decide the meaning and values of science. The scope of science and its working as an institution must be understood by all of us, the common people. Everyone including the scientist must realise and feel that science is for meeting our needs and welfare. It is only then that science as an institution grows and develops.

Check your Progress

1. What is History of Science?

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2. Why science can be called an institution?

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3. Is specialization in science good or bad for human life?

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4. Name some benefits and disadvantages of narrow specializations.

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1.6 TRADITION OF SCIENCE

Scientific endeavour differs from other aspects of social achievement. Scientific knowledge gained at any point of time is an addition or modification or both of the previous scientific knowledge. Scientists generally plan their methods of study taking into account the previous knowledge of science in the area of study. Scientists always try to give new interpretations to the existing knowledge and will not even hesitate to change or modify the existing truths of science. Thus in science the current state of knowledge is of great importance because in it is fused the past knowledge also. Science is cumulative. All the scientific knowledge available till a point is added up and presented as the current knowledge. Unlike in other areas such as art, music, literature, not many people feel the need to read past scientific papers or books in original. But one should know how these old scientific facts are used and interpretted in the present context. Art and religion are based on personal faith and sentiment, where as science is objective and impersonal. It is not based on faith and sentiment. Results of science can always be checked and verified. They can be repeated by anybody and everywhere. Science is "universal", in character. The success of science lies in its application. Generally scientific knowledge that can not be tested in real life and that cannot be used for welfare of mankind becomes unpopular. Thus tradition of science is entirely different from the traditions of society, culture and art.

Thus in science, current state of knowledge is of great importance. One important reason for this is that the past knowledge is always fused into the present knowledge.

Check your Progress

1. What is tradition of Science?

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2. Is tradition time dependent or society dependent? Give reasons.

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3. Success of science depends on which aspects of it?

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1.7 SOCIAL FUNCTIONS OF SCIENCE

In this unit, so far you have learnt about early emergence of science, the meaning of history of science, institution of science and the tradition of science. All these aspects describe the character of science. But these aspects do not clearly explain the mutual dependance and interaction of science and society. For example these aspects will not specifically elaborate the social factors that cooperate or discourage the growth of science in any society. In a similar way we will not be able to answer the question how does science influence the way a society develops? Therefore it is very essential to know the requirements of a society for its welfare and the role of science in achieving these.

Science has two main aspects. These are **theory** and **application.** Therefore science plays a key role in production (application) as well as in the advancements of ideas and concepts (theory). Production is concerned with application part and ideas & concepts are concerned with the theory part of science. Let us now examine these aspects in greater detail.

Man always has been attempting to control and transform Nature for his own welfare and development. In this endeavour science has always played a crucial and important role. Man always gave importance to production and in this activity he developed many tools and methods of production. But if we examine carefully the historical aspects of production methods and methodologies, we find that they have been becoming complex and complex with the progress of time. But at the same time the efficiency and the perfection of the methods and tools developed also increased very satisfactorily. The development of science led to increased production of goods, but the range and level of production in quality and quantity have limits in any society. Over production is as dangerous as under production. Therefore science stagnated wherever there was over production. At the same time under production leads to starvation, poverty, as well as under development. Moreover the unequal sharing of the produce also led to the creation of dominant and subservient classes. There was also transformation of the nature of society depending on the nature of the products produced. Human habitations were distributed over large rural areas when agricultural production was prominant. Industrial towns grew up when factory-based production took a lead over agricultural production. This situation even led to the breaking up of societies, the social classes even came into conflict with each other. New social organizations emerged and dominated over the old ones. But as years passed on agricultural science and industry developed together and this to some extent bridged the gap between agriculture and industry as well as the rural and urban classes.

But science is not always for the enlarged production of goods. It is just one aspect of science. The other aspects of science are theory and concepts. The theory and practice however are linked intimately to each other. Also major advances in science occurred when a modification was necessary for theory. Without fresh ideas and new approaches science becomes formal and mechanical in its outlook. Scientific theories are also influenced to a great extent by the intellectual atmosphere in the society in which the scientist works. Sometimes new theories developed based on new discoveries may conflict with the old theories. This in turn may lead to conflicts with the social thought. For example we find such conflicts in the field of astronomy. Galileo using his telescope proposed that earth revolves round the sun. But these new scientific ideas were against the prevailing concepts that the sun revolved around the earth and that God had created these planets. Galileo had to undergo trial on account of his new theory. Some times the advancements in science may also conflict with the social practices and beliefs. For example science could invent methods for birth control and population growth. But many societies opposed such applications of science. But a close study of history shows that except few exceptions, new ideas in science could always overcome the social oppositions and came to be accepted as time passed on.

Thus science advanced by leaps and bounds and also influenced the intellectual thinking in general and tried to bring in social reforms too.

Check your Progress

1. Can science be independent of society? Give reasons.

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2. What are the obligations of science to society?

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3. What are the responsibilities of the society for the progress of science?

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1.8 SUMMARY

In this unit you learnt that the development of science is an integral part of human endeavour. For example you learnt that

1) History of science tells us that science or scientific activity had its origin even in the primitive society.
2) History of science is not a chronological description of events of scientific discovery.
3) History of science is a story of human life and is a description of an ongoing process of the interaction between science and society.
4) History of science is a story of human sufferings, welfare and strengths.
5) Science is influenced by different forces in the society namely the economical, political, psychological and cultural forces.
6) Science is considered as an institution in view of its well organised and large & diverse activities.
7) Science is a cumulative tradition of knowledge.
8) The past knowledge forms the basis for the new knowledge.
9) Science has several functions to perform. It plays significant roles in the production as well as in its preservation.
10) Science is influenced by the prevailing social thought. At the same time changes in scientific ideas influence the general attitudes and beliefs in the society.
11) In science theory and practice are intimately related to each other.
12) Science in the present-day society is looked upon as a social institution having its own methods, methodologies and tradition.
13) The changed material conditions lead to changes in social conditions giving rise to a higher phase in society.
14) But the higher phase creates complex problems and these problems need further changes in science. Thus the growth of science is necessitated.
15) The prevailing social thoughts in any period of time influence the ideas and theories of science.
16) Last but not least that science and society are two inseparable entities of human life. Science depends on society for its growth and society too depends on science for its development.

1.9 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. Give an account of human endeavour and early emergence of science.
2. What is history of Science? Explain with illustrations.
3. Explain how we can call science an institution?
4. What is meant by "tradition of science" and explain the same.
5. Discuss the social functions of science.

Answer the following in about 15 lines each.

1. Explain the early emergence of science.
2. What is History of science.
3. Give some reasons to call science, an "institution".
4. What is meant by "tradition of science".
5. Name a few social functions of science.

1.10 GLOSSARY

1) Phynology : Science of normal functions of living organisms.
2) Primitive : Ancient, under developed
3) Stagnation : Slow moving state or state of inertia
4) Social functions : The obligations of the society

UNIT 2 SCIENCE AND TECHNOLOGY IN ANCIENT TIMES

Contents

2.1 AIMS AND OBJECTIVES

Aims

In this unit, it is attempted to trace the status of Science and Technology in Palaeolithic, Neolithic and Chalcolithic ages and also to sketch out the activities of man in these ages.

Objectives

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

1. describe Palaeolithic age, evolution of man, different stages of Palaeolithic age, the achievements made by man in this age;
2. appreciate the progress made by man in the fields of agriculture, animal husbandry, weaving, potmaking etc;
3. describe the transformation of rural civilisation to urban civilisation and the achievements of man in culture, science and technology in the Chalcolithic age.

2.2 INTRODUCTION

Ice age or Pleistocene covers more than four fifths of the whole of human history. Man as we understand him today as the direct ancestor of modern man called *Homo sapien*, came into the existence during the last phase of middle period of Palaeolithic age. In this unit we trace the pre-history of science and technology in archaeological terms. In the prehistoric times the science and technology are inseparable from each other.

2.3 PALAEOLITHIC OR OLD STONE AGE

This age began some where between 5,00,000 and 2,50,000 years ago and ends as late as 80,000 years ago. This vast period has been sub-divided into lower, middle and upper Palaeolithic Ages. The most significant fact about Palaeolithic Age is that man was essentially a food gatherer rather than a 'food-producer'. This 'gathering' was made possible and facilitated by implements which he produced out of wood, bones and stones. This is why the 'palaeolothic stage' of human evolution is also called 'food-gathering stage'. This way of sustaining himself underwent a radical improvement by one of the greatest inventions in human history, namely, the production and use of fire.

Homo sapien, appeared on the scale of biological evolution only 28000 to 30000 years ago. Hence, he is by and large a phenomenon of the upper or last phase of the Palaeolithic Age. During the greater part of the early Palaeolithic Age the scene was peopled by not 'Man' but 'Hominids' who were 'Men-like' creatures. The hominid resembles man and is perhaps near-ancestor of modern man. He is both man-like and ape-like. It is his 'ape-likeness' which leaves a biological gap between him and 'Man'.

Archaeologists have identified stone tools made even before the beginning of the Palaeolithic Age by some man-like creatures. It is very difficult to distinguish them from the stones subjected to natural fracture (i.e. stones splintered, split and shaped by heat or frost or jostling in river gravel). But they appear to be intelligently chopped. The archaeologists call such stone-tools 'eoliths'. The 'human' workmanship of these eoliths is accepted by many archaeologists but rejected by some.

However, conclusive evidence is available for our belief that during the early or lower Palaeolithic Age, 'Men' were manufacturing implements made of stone. Probably the first tools served various purposes such as killing animals, cutting their bodies and scraping hides and skins for the purpose of 'dressing'.

Men of the early or lower Palaeolithic Age have another achievement to their credit. This is making and using of 'fire'. It served them well in liberating themselves from the bondage imposed on them by nature. Man could endure cold nights and could thus penetrate into temperate and even arctic regions. The flames gave him light at night and allowed him to learn about the interior of the sheltering caves. Fire scared away other wild beasts. Food was made edible and easily digestible by cooking. Man is no longer restricted in his movement to a limited range of climates. His activities were not entirely limited by the sun's light.

As a food-gatherer, the earliest 'Man' had, to engage in hunting, catching fish and lizards, collecting fruits and eggs, and digging for roots and other edible material for his livelihood. In this process he made important observations concerning animals. He also learnt the properties of different species by collecting eggs, fruits and roots. In doing so, he eventually deciphered the calender of the heavens, phases of the moon and the positions of stars. Early man was thus simultaneously laying the foundations of chemistry, geology, zoology, botany and astronomy and, therefore, the foundations of science as a whole.

As the early phase of the Palaeolithic Age was reaching its end and the middle phase began to dawn, 'men' improved their tools and developed two types of stone technology. Insome regions the tool-makers adopted the procedure of separating convenient flakes from the parent-lump (technically called 'core') and then trimming up the flakes to work as actual tools. In other regions the procedure was to trim the core itself. The former is called "flake industry" and the latter 'core industry'. In some areas these industries got blended. Apart from the improvement in terms of care and delicacy of workmanship as well as the emergence of different types of stone-industrial traditions, one also finds the aesthetic dimension acquired by the tools with the passage of time.

Though the *Homo Sapiens* appeared in the middle of the Palaeolithic Age, the scene is still dominated by man-like creatures or 'Hominids'. The most well-known hominid in the middle Palaeolithic Age is called **"Neanderthal Man"**. The contribution of the Neanderthalers and their middle Palaeolithic contemporaries to the evolution of civilization is immense. They possessed more multiformed and differentiated stone implements than their predecessors. They possessed specialised weapons like spear-heads and distinct tools for scraping and chopping. Their mode of hunting became far more paying. They began to hunt mammoths and rhinoceros. In doing so they were more organised than their predecessors, since hunting on a large scale would be possible only through collective activity.

Modern man appeared on the scene and got established in the later or upper Palaeolithic Age. The proper story of man then unfolds itself at this stage. Modern man inheriting a stable technical tradition began to build an impressive edifice. He devised a variety of distinct tools for different purposes. He began to use bones and ivory for making tools, especially those that are used for making smaller tools, i.e., secondary tools. He even invented simple mechanical devices like bow and spear-thrower. These increased his capacity to throw weapons to long distances accurately. Further, man began to provide himself with artificial protection from climatic changes by building tents out of animal skins or even substantial houses. This is how man developed the technical tradition handed down to him.

The devising of bow and spear-thrower requires enormous knowledge concerning motion of objects - the subject matter of machanics which is the most important branch of physics. The paintings of animals and man in the caves reveal remarkable knowledge of anatomy and physiology. Thus, man laid the foundations of new sciences adding to the storehouse of knowledge of other sciences laid by his ancestors.

The ancestors of man, i.e., hominids, had contributed to science in two ways : (1) by laying the foundations of chemistry, zoology, geology, botany and astronomy, (2) by introducing the method of trail and error - the experimental method - which is the soul of science. This method was further strengthened by man in his endeavour to develop better tools. But he added other elements without which science would be inadequate. These other elements have their sources in primitive man's art and religion.

The Palaeolithic man could only kill animals, but could not feed them and increase their number. The inability to search for new resources, and to control the existing resources makes the end of the Palaeolithic Age and the beginning of the Neolithic or the New Stone Age.

Check Your Progress

1. Palaeolithic man was essentially, a ______________________________
2. Ancient men before Palaeolithic Age, used some stone tools called ____________
3. List out important contributions of Men in Palaeolithic Age.

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2.4 NEOLITHIC OR NEW STONE AGE

The hallmark of the Neolithic Age is the innovation of two related activities viz., (a) agriculture and (b) animal husbandry. These two are related activities and they together enabled man to effect for the first time a productive economy. In the Neolithic Age he was able to wrest from nature what he wanted by acting upon it and established control over his food-supply. He did this by planting, cultivating and improving by selection, edible grasses, roots and trees. The idea of sacrificing some seeds in order to get many times more than that, is a significant idea in human history. Wheat and barley were at the root of this agricultural economy. Man chose them or was forced to choose them because the wild grasses which were nutritious and could be easily stored. Their yield was high and their cultivation did not demand much labour.

Man learned the taming and use of some animals and provided them with fodder and protection. He got from animals meat, milk, leather, wool and manure.

Human civilization characterised by agriculture and animal husbandry and domestication could flourish only on river banks, which provided alluvial soil and water. Also, agriculture led to the formation of village communities. Thus the Neolithic Age heralds the beginning of village civilization. The villages of Neolithic Age gradually replaced the communities of hunters as units of human society. Because of ample food supply, the population increased tremendously. For the first time in history there was 'surplus' production. This led to the relative self-sufficiency of the village communities. The surplus was used for the purpose of 'trade' with other communities who were lower in the scale of agriculture and production but could provide things which agricultural communities needed. Thus agriculture and animal husbandry which together constitute 'Farming Technology' ushered in an era of great progress. Man made the transition from the food-gathering to the food-producing stage.

Other most important technologies of the Neolithic Age are wood-working, making of pots and manufacturing of textiles. As the Ice Age was coming to an end, tundras and steppes began to be replaced by forests rich in timber. Man was tempted to use this rich resource. He created 'polished stone celt' or 'axe' or 'adge'. This implement is a big slice or pebble of fine grained stone. Its end is ground down in order to give it a sharp cutting edge. It is then fixed into the end of a stick to form an axe. This replaced the 'hand-axe' or 'flint' of the Old Stone Age. This is beginning of carpentry.

The manufacture of the earthern pot was a great invention. For the first time man had a vessel which could unlike a basket withstand heat and hold liquids. This vessel was very much necessary for the preparation and storage of cereal food. In manufacturing pot, man understood not only the property of the plasticity of mud, but also the very complex process of giving a stable form to an unstable substance. Man for the first time realised that he could create something out of a formless mass.

The Neolithic villages became the centres of textile industry, manufacturing garments of linen and wool. This required a tremendous amount of technical knowledge concerning fibrous substances like flax, cotton and wool. Apart from that, it required mastery of spinning and weaving. This implies the possession of implements necessary for them, like the loom. 'Weaving' is clearly a further adaptation of basket-making. The forms or patterns produced in weaving and the number of threads involved in producing them are essentially of a geometrical nature. This led to a deeper understanding of the relations between form and number.

We find that the Neolithic Age broke new grounds in the technological evolution. The Neolithic man added to his Palaeolithic heritage the chemistry of pot-making, the physics of spinning, the mechanics of loom, the botany of flax and cotton (agricultural botany), the biochemistry of baking and brewing, the biology of animal reproduction, geometry and arithmatic. More than anything else the relation between seed and yield brought about by labour further extended man's conception of 'cause and effect' which was to become later the basis of a rational and conscious science.

Check Your Progress

1. The main achievements of Neolithic Age Man are, ____________ and __________
2. Man in Neolithic Age made transition from ____________________ to __________

2.5 CHALCOLITHIC OR METAL AGE

The Neolithic or New Stone Age lasted till about 4,000 B.C. During this period remarkable progress was made by man in the field of science, technology and culture in general. The Neolithic Age has the village as its social unit, and it is, therefore, a rural civilization. It was succeeded by the Chalcolithic or Metal Age which heralded the ushering in of an urban civilization or civilization proper. It added to the self-sufficient villages of the farmers of the New Stone Age. The towns and cities developed by industries and trade, internal and foreign. Therefore, the revolution brought in by man in the Chalcolithic Age is called the 'Urban Revolution'. The first phase of the Metal Age which is called 'Copper Age' lasted for a thousand years between 4,000 B.C. and 1,000 B.C. During this period urban centres or cities actually appeared. The second phase is called 'Bronze Age' This lasted for 1,000 years between 3,000 B.C. and 2,000 B.C. Cities and towns appeared in this Age only. The third phase which is called 'Iron Age' is separated from Bronze Age by a time gap which is characterised as 'dark' period. During these dark periods some Bronze Age civilizations either disappeared or suffered from severe stagnation. It was during the Iron Age which started in the early period of the last millenium B.C. that urban civilization came to be consolidated and firmly established.

Copper-Bronze Age

The Copper-Bronze Age, especially the Copper Age, is an extremely fruitful period in the history of mankind. In this period man has succeeded to a remarkable degree in his struggle for a better life. It is in this period, and especially, in the first phase, the Copper Age, we find that man has learnt to harness the force of oxen and of winds. He invented the plough, the wheeled cart and sailing boat. He discovered chemical processes involved in smelting copper ores. He worked out an accurate solar calendar. He has thereby equipped himself for urban life and prepared the way for a civilization which shall require writing, processes of reckoning and standards of measurement.

Metallurgy was the prime agent of change in the Copper-Bronze Age, as the name itself indicates. The use of copper brought about veritable metallurgical revolution. Bronze is only its alloy. Working on metals became possible because of important discoveries, namely that copper when heated and then melted could be cast in any required shape. Copper could be produced by heating certain stones or earths with charcoal. Man realised the superiority of metal over stone because of its being fusible and castable. These characteristics of metal freed the artificer from the restrictions imposed upon by the shape and size of bones and stones. Metals have the plasticity of the potters mud and hardness of the stone and bone. Their malleability and ductility are added virtues. The discoveries of metals might have come as a very pleasant shock to man.

After inventing the method of mixing, melting, casting and shaping copper, in quick succession, man discovered other metals like tin and lead. He learned their use for further development. These innovations are extremely important because exclusive dependence on pure copper would have a crippling effect on a metallurgical progress. Copper is a very rare metal since the deposits of copper are very sparcely distributed on earth. Secondly the temperature at which copper melts is very high. Man felt the need of a metal which has all the merits of copper but did not need such high temperature. More important it should be more economical than copper which is a rare metal. These needs were responsible for the invention of bronze, which turned out to be, to the great joy of man, harder than copper. Thus metals and metal products replaced slowly but steadily stones and stone tools.

The second important step man took in the Copper-Bronze Age is harnessing of natural power. This is also a step of great importance. Man began to use beasts like oxen and ass, the former for ploughing and carrying loads and the latter only for carrying loads. To these were added, later horses, and other animals. Thus there was a radical transformation in connection with transport and communication. These were further revolutionised by the use of another power, namely, wind. Man learnt the art of sailing. This enormously increased the range and efficiency of shipping.

Another most important invention of this age was the 'Wheel'. The wheel was the crowning achievement of prehistoric carpentry; it is the precondition for modern machinery, and applied to transport, it converted the sledge into a cart of wagon-the direct ancestor of the locomotive and the automobile. The wheel served two purposes. Its vertical use brought in qualitative change in transport and communication. Its horizontal use qualitatively transformed the pot industry. By adopting the wheel the potters increased the efficiency of their work and their productivity. The use of wheel gave their products the symmetrical character which it has not had before. With the invention of wheel, man's progress became accelerated and diversified.

The most significant contribution of the Copper-Bronze Age to the growth of science is the development of the idea of 'quantity'. The temple activities which became more extended and complicated than mere worship. This forced the priests to 'record' rather than merely 'remember' the qantities of goods received from various agencies and individuals. Apart from temple activities, the administrative business became more complex and wide-ranging which necessitated the use of 'measure' and its standardisation. The question of 'measurement' of 'weight' was solved by the invention of the balance.

But weight was only a part of the problem of measurement. A more sophisticated system was necessary to deal with the entire problem of measurement. Thus, a beginning was made in the development of 'Number System'. Gradually the symbols were extended to cover objects and actions. Lastly they stood for 'words'. In this way, the foundations for writing were laid.

Another important science whose foundations were further strengthened was astronomy. Astronomical knowledge was needed not merely for calender-purposes, as in the case of the Palaeolithic and the Neolithic Ages. Not only the 'phases' of the moon but also the 'erratic' movements of the stars and planets were recorded. Since these observations were connected with religion, speculations concerning the cosmos followed on religious and theological lines. Thus, theorectical astronomy and cosmology originated.

The development of medicine is another achievement of the Copper-Bronze Age. The symptoms of the diseases were carefully observed and studied and cures were provided. The study of the anatomical and physiological system made during this age is really remarkable. For medical purposes the 'doctors' had to make a study of different herbs and thus the foundations of botany were further strengthened.

The most remarkable achievement was in the field of chemistry. This should be obvious because of the fact that this age is distinguished by the use of metals. The processes of smelting ores, purifying metals and colouring them all need a sophisticated chemical knowledge. The metallurgy of these times discloses the knowledge of at least nine elements, gold, silver, copper, tin, lead, mercury, iron, sulphur and carbon. It also reveals the use of compounds of zinc, antimony and arsenic and alkalies like potash and ammonia (in the form of fermented urine) and alcohol. The manufacturing of alloys involves knowledge of chemical analysis of a very high order. The use of chemical analysis is one of the most crucial developments in the history of chemistry. Here again, the Egyptian achievement stands out as the most important one in respect of the development of scientific theory and practice of chemical analysis. The success in chemistry gave man in this age such a sense of righteous pride and confidence that he began to think that anything could be made possible-which expressed a healthy optimism needed for progress.

Iron Age

The next phase of the Chalcolithic Age, which succeeded Copper-Bronze Age is called the Iron Age. It carried the achievements of the Copper-Bronze Age to their logical conclusion. The most distinctive achievement of the Iron Age is the discovery of iron. By adding this new dimension to the metallurgical technology, the use of metals became more extensive. That is to say, the use of metals, became more popular. Copper is a rare metal and hence cannot be used by a great number of people and for a great number of activities.

Another remarkable development of the Iron Age is the invention of writing. The urban revolution gave rise to a distinct intellectual class which being free of manual work began to concentrate on intellectual activities. Its major achievement was the invention of writing. It did this by making written symbols stand for 'sounds' rather than mere words by developing an alphabet. Rather than being confined to officials, writing became a popular activity among priests, intellectuals and other elitist sections of the populace. By this the handing down of knowledge and tradition was remarkably facilitated and the path was thus cleared for knowledge to progress by leaps and bounds. The result of this revolution was immediate and most palpable. This is evident in the fundamental transformation of the very attitude of man towards nature.

The intellectual revolution that was ushered in during the middle period of the Iron Age replaced, at least partially, this type of world-view with a new one. The new world-view sought to conceive of nature not in terms of gods and goddesses but in terms of principles. For the first time in history man began to ask the question; "what is the most fundamental principle underlying the Nature or Reality?" Note the difference between this question and the question 'who is the most powerful god?' The transition from 'gods' to 'principles', enabled man to go in search of explanations that were free from teleological and animistic thinking. It is this new thinking which gave rise to 'philosophy' and 'science'. Thus we have the beginning of science in the sense of 'theoretical science'; autonomous and independent of its technological application. Instead of being a shadow of technical know-how science became the light which illuminated the path to the understanding of nature in terms of impersonal entries and mechanical laws. Along with 'science' we see the rise of 'philosophy' as a search for the most general principles underlying reality. Both science and philosophy have had the effect of freeing man of animistic thinking. The new science and new philosophy are thus responsible to bring a new epoch of bold speculation in terms of fundamental constituents and basic principles underlying nature.

With the ushering in of the Iron Age and the invention of writing, man passed from prehistory to history. By this time different human communities or societies had distinctive features. As the Iron Age advanced the distinctive features of various communities had crystallised sufficiently to render any narration of the future story in terms of common elements inadequate. That is why the next phase of scientific and technological achievements dealt with in terms of distinct civilizational units.

Check Your Progress

1. The type of civilization in the Metal Age was ______________________

2. The time gap between Copper-Bronze Age and Iron Age is called ______________

3. List out the important achievements of man in Copper-Bronze Age.

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4. Most important achievements in the Iron Age were ______________________

2.6 SUMMARY

1. The Palaeolithic Age which geologists call 'Pleistocene' or Ice Age covers more than four fifths of the human history. It begins some where between 5,00,000 and 2,50,000 years and ended as late as 80,000 years ago. This large period has been sub-divided into lower middle and upper Palaeolithic Ages. Man was essentially a food gatherer in this age rather than food producer. He produced instruments out of wood, bones and stones to gather food. It is only in this period in the human history man produced and used fire. In the early palaeolithic age man was engaged in hunting, catching fish and lizards. He was collecting fruits, roots and eggs by digging the earth. In this process he learnt about the seasons, the properties of plants and calender of heavens to fix up suitable period for hunting.

2. In the middle phase of the Age, man developed stone technology. He introduced two types of stone industries to prepare tools. One is called "Flake Industry" the other "Core Industry".

3. The upper Palaeolithic Age was dominated by modern man. He devised a variety of distinct tools for distinct purposes. He invented simple mechanical devices such as bow and spear thrower. He laid foundations of chemistry, zoology, geology, botany, and astronomy. They introduced the method of trial and error.

4. The great achievements of Neolithic Age are agriculture and animal husbandry. These two activities enabled man to effect productive economy. He could exploit nature for the food. He did this by planting, cultivating and improving them by selecting edible grasses, roots and trees. The idea of sacrificing some seeds to get many more is an epoch-making idea in human history. Wheat and barley were mainly produced. Man also learned the taming and rearing of animals. He could get meat, milk, leather, wool and manure from animals. These activities of agriculture and animal husbandry were started on river banks. Agriculture led to the formation of village communities. Thus Neolithic Age illustrates the beginning of village civilization. Because of ample food supply, population also increased greatly. There was 'surplus' production of food. This "surplus" initiated 'trade' with other communities. The other important technologies are wood working, pottery, and manufacture of textiles. Neolithic man thus added to Palaeolithic heritage the chemistry of pot making, physics of spinning, the mechanics of loom, the botany of flax, the biochemistry of baking, the biology of animal reproduction and the geometry of basket making.

5. The Chalcolithic Age or Metal Age succeeds the Neolithic Age or New Stone Age. The first part of Metal age is called "Copper Age". This lasted for 1000 years approximately (4000- 3000 B.C.) The second phase of Metal Age is called 'Bronze Age' (3000-1000 B.C.). The third phase is called 'Iron Age'. This started in the early period of last millenium B.C. It is in these three Ages, the urban civilization was established, developed and consolidated. The metals copper, iron and alloy 'bronze' had been discovered and extensively used in this Age. Hence the Age was referred to as 'Metal Age'. Metallurgy, the process of winning of metals from its ore, was introduced in this period. All this was possible since it was discovered that metals have some superior properties over wood, stones, and bones. To transport the raw materials or the finished goods, animals like ox, ass and horse were used. To facilitate quick transport by increasing the speed of cart, "wheel" was discovered.

6. Added to the discovery of metals and alloys there were many developments in the area of 'science'. Measurement and its standardization were introduced in this Age only. Astronomy as a science to study the movements of planets took its roots. They had the knowledge of at least nine chemical elements gold, silver, copper, tin, lead, mercury, iron, sulphur and carbon.

2.7 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. List out the important achievements of Palaeolithic men that led to the development of Science and Technology?
2. Discuss the important innovations of neolithic men that led to the development of village communities?
3. Write the contributions of ancient men to the fields of Science and Technology during the Copper-Bronze Age?

Answer the following in about 15 lines each.

1. Early Palaeolithic man was a food gatherer rather than a food producer. Explain.
2. Mention the important inventions in the upper palaeolithic age?
3. The hallmark of neolithic age is the invention of agriculture and animal husbandry. Explain
4. When did the man invent the wheel? How did it help him?
5. Write briefly about the most important inventions in Iron age?

2.8 GLOSSARY

Adze	:	A cutting tool with an arched blade which set at right angles to the handle.
Alluvial	:	Matter transported in suspension and deposited by rivers or floods.
Animistic	:	The belief that the soul exists apart from the body.
Casting	:	To form a liquid or plastic substance into a fixed shape by letting it cool in the mould.
Compounds	:	A substance whose molecules consist of unlike atoms and whose constituents cannot be separated.
Cupel	:	A small vessel used by goldsmiths in assaying precious metals.

UNIT 3 SCIENCE AND TECHNOLOGY IN MEDIEVAL TIMES - I

Contents

3.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about the contributions made to science and technology by different civilizations of medieval times. These include Egyptian, Mesopotamian, Greek, Roman, and Chinese.

Objectives

After you completed the unit, you must be in a position to

1. know what great progresses were made in the fields of science and technology in the different traditions.
2. judge for yourself which tradition has contributed greatly to the development of science and technology
3. assess also the reasons and causes for development of one branch of science in preference to other branches of science in any particular tradition.

3.2 INTRODUCTION

In this unit you will know the reasons for studying the history of science. Science today is a social institution. It has its own method of science. But we have to look into the origins of science to understand the need for it. From the life patterns, trades and customs of our ancestors we learn what science was like in ancient times. Therefore scientific practices followed in the ancient and medieval times have to be gathered from the social and cultural life of those times.

From the wealth of information gathered and stored by the historians we try to build the story of the origins of science & its growth in early human societies. But you should remember that this is not fiction. Every aspect of science that is narrated is based on concrete evidences.

In this unit you will study about some aspects of primitive human society that led to the birth of science later on.

The medieval scientific traditions covered in this unit are

1) The Egyptian and Mesopotamian Scientific traditions.
2) The Greek and the Roman Scientific traditions.
3) The Chinese tradition.

3.3 EGYPTIAN TRADITION

The history of human civilization is unthinkable without the Egyptian contributions to it. But the Egyptians lost their dynamism as mankind entered the Iron Age. The civilization became stagnant and ultimately disintegrated. The Egyptian societies continued to survive even after 1000 B.C. But without, having any cultural vigour and vitality in them, they ceased to occupy a respectable place in the civilizational map. It is an irony, that the Egyptians who set the pace in pre-iron Age civilization became insignificant when the Iron Age began. But Egyptians made important contributions and you will learn about them in the following subsections. Egyptians excelled in architectural achievements as evidenced by the pyramids. They had indisputable and remarkable knowledge of chemical substances and processes. The invention of papyri itself was an epoch making achievement. It is even said that the word "Chemistry" is derived from the word "Chem", which stands for "black mud" in Egyptian language. Thus Egypt is to be considered as mother of Chemistry. It also had to its credit achievements in carpentry and wood work. They had an irrigation system which would be regarded as a triumph of their engineering and technology.

Astronomy

The Egyptians have developed a very accurate calender dividing the year into 365.2422 days. This would be possible if there had been constant and careful observations of the sun and stars. The Egyptian priests prepared as early as 2700 BC a solar calendar which continued to be used for centuries to come. Evidently they established by means of empirical methods, the relations between "Zodiac" year containing 365 1/4 days and approximate year containing 365 or 366 days. The calculations seemed to have been based on the observations of the time of occurrence of floods in the river Nile and on the intervals between the dawn rising of Sirus and the passage of the sun through the ecliptic etc. An astronomer called **Cidenas** had calculated the movements of the sun and the moon.

Mathematics

The Greek scientist **Herodotus** declared that geometry came to the Greeks from Egypt. Obviously, the Egyptians confined themselves to the practical side of mathematics and did not take interest in its theoretical side. They knew the properties of plane triangles and figures. They were able to solve mathematical problems with two unknowns which served their practical needs. They considered the Pythagorean theorem only in its practical application. Long before 1100 BC an Egyptian mathematician by name Ahmas wrote a book describing the nature and properties of fractions. This work was in recent times brought by Henry Rindh to England and is now available in the British Museum.

Medicine

The Egyptian medical and pharmacological knowledge was also extraordinary. They made use of all kinds of substances (animal, vegetable and mineral) for medical purposes. They used even the scrappings from horns and tortoise shells for preparing medicines besides portions of skin, bones and falcons calcified and ground. They invented special containers to preserve medicines. They used sensitive balances and weights for weighing ingredients of medicines.

Check your Progress

1. Egypt is considered to be the mother of ______________.
2. Pyramids were constructed by ______________.
3. Accurate calendar was developed by ______________ with the help of ______________.
4. Ahmas wrote the book on ______________.
5. Egyptians were making use of substances ______________ for medical purposes.
6. Egyptians were using ______________ and ______________ for weighing ingredients of medicine.

3.4 MESOPOTAMIAN TRADITION

Mesopotamian or Babylonian contributions to human civilization are no less important than others. Mesopotamian societies continued to survive even after 1000 BC. But these Mesopotamians who set the pace in the pre-historic Age civilization became insignificant where the Iron Age began.

The Mesopotamian or Babylonian civilization had equally remarkable achievements to its credit. They made accurate astronomical observations and measurements of cosmic phenomena in order to formulate scientific laws and to forecast occurrences like eclipses. They had made observations of the courses of the sun, the earth and the other planets in relation to the fixed constellations. They, infact, had a conception of the Zodiac. They attempted to work out theories concerning solstices and equinoxes and calculated the duration of days and nights in various seasons. Herodotus has ascribed to the Babylonians, the inventions of astronomical instruments which were later made use of by the Greeks. Apart from these achievements they knew the Pythagorean theorem and could solve mathematical equations with two unknowns. They also know surgery and had fairly detailed knowledge of anatomy.

3.5 GREEK TRADITION

Greeks were no where near civilizations like the Egyptian and Babylonian which excelled in scientific and technological achievements. The Greeks had not at that time even progressed as much as secondary civilizations like those of Crete and Anatolia. The Greeks did not figure in the Bronze Age civilization in any conspicuous manner. They were only peasant communities. But they came into contact with Egypt and Babylonia. They borrowed the latter's scientific technological tradition and tried to develop a new frame-work of thought. Their social and political situation was liberal enough to allow free thought. Their society unlike that of Europe or Babylonia was not characterised by the dominance of a strong priestly class acting as a custodian of an orthodox mode of thought. The fortunate Greeks were eminently successful in using, their favourable condition to bring about a new revolution in thought which gave rise to natural philosophy in the west.

Different Schools of thought on Universe

The Greek scientific tradition is the mother of all traditions in modern science. Science made its first appearance in 700 B.C. in Greece. Also natural philosophy developed in the west with the development of Greek thought. In other words in the West, it is in the land of the Greeks that science acquired a new character. It became an autonomous body of knowledge and attempted to explain nature in non-animistic terms. They attempted to explain nature in terms of ultimate principles. This accounts for the great contributions of Greek Science. The Greek scientific tradition is divided into three phases. (1) **Ionian** (600BC), (2) **Athenian** (480-380 BC) and (3) **Helenistic** (330-200 BC). The last phase ended with the collapse of Greek states under the onslaught of the Romans who conquered them.

Ionian School

The greatest thinkers of the Ionian phase of Greek science were **Thales**. **Anaximander** and **Anaximens**. The school founded by **Thales** is called the Ionian school. **Thales** (640-550 BC) asked the question "What is the basic substance of which the universe is made?" His answer was "water". He is the founder of natural philosophy because to his questions he gave a naturalist's answer. His naturalist attitude was retained by his successor, **Anaximander** (610-547 BC) who gave a different answer to the question of **Thales**. According to him it was 'matter', of which the universe was made. Another successor of **Thales, Anaximens** regarded 'air' as the primary substance and **Heraclitus** 'fire'. Thus, the **Ionian School** of philosophy could be said to have inaugurated natural philosophy.

Pythagorean School

As against Ionian School another school arose. Its name is Pythagorean School founded by **Pythagoras** (582-500 BC). **Pythagoras** and his disciples were not so much concerned with the primary substance as with the contribution of things in Nature. Their number and their measure. In other words, their attitude towards Nature was mathematical. Though later they took recourse to mysticism, the Pythagoreans made great contributions. They are important in that they stressed the need for interpreting Nature in mathematical terms.

Eleatic School

Eleatic School founded by **Parmanides** (470 BC) opposed the Ionian School and its thinkers. The Ionian thinkers were in search of a principle that would account for change. Water, matter or air was supposed to be responsible for the actual change seen in nature. In other words, their search was for a dynamic principle. The **Eleatic thinkers** on the other hand were in search of a principle which would be non-dynamic. They considered the natural changes to be illusions. Reality, they thought is changeless. According to them nature which changes is not real.

School of Natural Philosophers

Later, yet another school came into being, a school of young natural philosophers who tried to synthesise the teachings of both Ionian and Eleatic philosophers. They were in quest of a principle that does not change but is responsible for change. **Anaxagoras** (500-428 BC) cameout with a new materialist view. According to this view matter is the primary substance. It is changeless and yet it brings about change because it is made of atoms. Thus he was the first in the west to put forward an atomic theory which was improved upon by his followers. **Empedocles** (492-432 BC) and **Democritus** (460-370 BC). For **Anaxagoras** the atoms are infinite in kind while for **Empedocles** atoms are only one of four kinds namely, earth, water, fire and air. For **Democritus**, the atoms do not differ in quality but only in configuration, position and arrangement. The motions of atoms are due to forces inherent in atoms themselves and not due to any mysterious external force or forces.

Great Philosophers

The next great philosopher was **Socrates**. He did not worry about such questions as what is the fundamental principle underlying in Nature? His concern was social and ethical. His disciple, **Plato** is one of the greatest philosophers of all times. His view was spiritualistic and he was opposed to Natural Science and Philosophy. For him nature was corrupt and very unreal. So his views instead of promoting science hindered its progress. His disciple **Aristotle** was much interested in Natural Science. He became one of the greatest scientists and philosophers that the world had produced. According to him, nature is made up of two principles, matter and form. Form is responsible for change and matter is inert. Matter is composed of five elements, earth, water, fire, air and others. The material things on earth are made up of the first four elements and heavenly bodies of the fifth one only. **Aristotle** put forward the doctrine of the causes of physical change in his work, Physics.

Aristotle ended the thinking concerning the character of ultimate principle underlying nature. **Aristotle's** natural philosophy dominated the western scientific tradition till 17th century. Hence it may be said that the tradition of natural philosophy in Greece had started with **Thales** and ended with **Aristotle**. It is to this tradition of natural philosophy that the Greek science owes its character.

Greek Tradition - Contributions

Ancient Greeks made much progress in different fields of science, particularly in astronomy, physics and medicine. Let us discuss their achievements in different branches of science.

Astronomy

In the field of astronomy, the Greeks made tremendous progress. They learnt many astronomical facts from the people of Anatolia, Syria, Egypt and Babylonia. But they did not stop at that. They sought to explain them in terms of theories. The Ionian philosophers tried to formulate laws of nature governing astronomical bodies. **Thales** the great Ionian philosopher, was himself a great astronomer and he predicted some eclipses. **Phythagorus** attempted to describe the astronomical phenomena in terms of number and harmony. All had a geocentric view.

All astronomers of these times faced one difficulty. They could not account for the irregularities in the motion of the planets. They all held that heavenly bodies move around earth with only uniform circular motion, the only one kind of motion worthy of heavenly bodies. But planets do not move in that way. So **Plato** asked **Eudoxes** to work out a model to explain such movements and to carry out the task brilliantly. He suggested that every planet was fixed to a transparent shell, capable of rotating on an axis uniformly. The totality of the rotations produced the appearance of irregularities, though in themselves planets do not move irregularly. **Eudoxes** needed a total of 26 spheres to work out his theory. Later **Aristotle** increased the number to 55 to overcome some more difficulties and still the model of **Eudoxes** could not explain many facts. But such failings were considered to be minor. This model with such modifications were followed till it was given up, thanks to the investigations of **Copernicus, Galileo** and **Newton.**

The last of the ancient Greek astronomers were **Hipparchus** and **Aristarchus**. **Hipparchus** tried to improve the model of **Eudoxes** but only made it all the more complicated. He invented various astronomical instruments which came to be used for centuries. He also prepared a catalogue of stars for the first time. **Aristarchus** (310-230 BC) boldly put forward a **helio centric** theory. But his theory was not taken seriously even though he was an eminent astronomer. The idea of the earth moving around the sun was unthinkable in those days.

Mathematics

The Greek thinkers made very valuable contributions to mathematics. They learnt many mathematical truths from the Egyptians. But they did not stop with the collecting of mathematical truths and solving mathematical problems, but undertook the construction of the most elegant and abstract mathematical structures. The most significant contribution of Greek mathematicians is the idea of mathematical proof.

Pythagoras and his followers really mastered the "number theory" and created the science of geometry. They eminently succeeded in acquiring, the deepest insights into the geometrical properties of plane figures and solids. They were indeed founders of the theory of proportions and the theory of musical intervals. It is interesting that while enquiring into numbers, they seemed to have been surprised to discover irrational numbers like the square root of 2. It is the discovery of the irrational numbers that led the Greek mathematicians away from "number" to geometry in which their greatest contribution to science could be seen. In this context, the most crucial role was played by **Hippocrates** (450 BC) on whose work **Euclid** built his classic **"The Elements"**. **Eudoxes** advanced his work on the **"The method of successive approximation"** for measuring lines and areas. The method of **Eudoxes** was later improved by **Archimedes** which in turn and in course of time became the basis of infinitesimal calculus. **Archimedes** improved the determination of π (Pi) value to five places. **Appolonius** (220 BC) made studies of ellipse, parabola and hyperbola. The results of his study were so satisfactory that two thousand years later they were used by **Kepler** and **Newton** in their study of planetary motion. But the greatest achievement of Greek mathematics has to be credited to **Euclid** (300 BC). His work represents the climax of that extraordinary vigorous mathematical thought which the Greek tradition exemplified. He integrated all the geometrical knowledge of his time in one form of single, logical, wholesome and elegant structure. It is a concrete expression of the vision of a pure deductive proof. For centuries to come it remained a unique and unparalleled work of genius.

Physics

The Greeks made a very significant advance in Physics. We have already spoken of the atomic theory developed by Greek thinkers early in the history of science. The Pythagoreans' "mathematical" theories were given physical interpretation by atomists like **Democritus**. Thus a foundation of mathematical physics was laid. The Pythagoreans' mathematical work on the phenomenon of musical sound helped to develop acoustics. **Anaxagoras** even anticipated by many centuries the law of conservation of mass, one of the foundations of modern physics.

The views of **Aristotle** in Physics has constituted the foundations of Physics till the 17th century. He was against atomic theory. He did not believe in the possibility of void. According to Aristotle earthly bodies have either upward movement or downward movement as their natural movement. Heavenly bodies have circular movement as their natural movement. The velocity of falling bodies depends on their weight. "Rest" is the natural state of matter. The most important point to be noted here is that within **Aristotle**'s Physics, physical phenomena were not explained in terms of only mechanical laws, ideas like "natural", "tendency", "purpose" and such other teleological concepts were cited. However his Physics was a complete system. That is why even when a particular theory of his was proved to be wrong it was still retained because it was a part of a whole system. In order to throw away any one of his theories it was necessary to over throw his whole physics. But this could not be done till the 17th century. So Physics till the 17th century remained absolutely **Aristotelian.**

One of the greatest physicists of the Greek tradition was **Archimedes** (287-212 BC). It is through him Greeks made great contributions to mechanics, the most important branch of physics. In his **'Elements of Mechanics'** he gave a detailed account of various types of simple machines. He defined the concept of centre of gravity. He laid the foundations of

Statics. He founded hydrostatics and studied the nature of floating bodies. He used his studies for testing the purity of metals and for devising methods for ship building. He invented **steelyard, endless screw** and **water-snail**. He is called the father of experimental physics. **Ctesibices** (270 BC) founded the science of pneumatics, the study of air movements. He invented cylinder, plungers, force pump, water organ, water clocks, several catapults, war engines etc.

Biology

The Greeks have a long tradition of biological study. In Greek society serious study of particulars of animal, vegetable and mineral nature began in the fourth century BC. But it originated in the keen observation especially by poets and artists of nature which had been going on for centuries. Inheriting a wealth of biological knowledge, **Aristotle** added to its store-house using all his enormous gifts for keen observation and analytical investigation. He recorded biological facts concerning plants and animals. His record is amazingly rich in range and quality. He made most valuable contributions to the classification and anatomy of animals. For a long time his biological theories came to be followed for biological research.

Medicine

The Greek medical science remained for a long time. Treatment was done on the basis of dream interpretation. The magical treatment was later replaced by clinical treatment. The tradition of magical cure was challenged by the school of **Cnides** (700 BC) and **Cos School** (600 BC), but it was not given up. In fact, it continued along with physicians' traditions for a long time resulting in the continuance of the conflict between them. The Pythagoreans who were otherwise magical and mystical in their attitude surprisingly took interest in the physicians' school. They conducted dissections of animals to gain anatomical knowledge. They made discoveries concerning the optic nerve and **"Eustachian tube"**. Like the Indian physician scientists, they believed that disease was due to disharmony between elements constituting the body and that health consists in their harmonious functioning. **Empedocles** believed that pnuema (air) was the element that gives and preserves life. His view was adopted and developed by **Diogenes** (500 BC) known for his accurate observations. **Diogene** "discovered" that respiration takes place through the pores of skin. The magician school received a set back with the advent of **Hippocrates** who wrote several medical treatises (about 450-350 BC). In those works which questioned the spiritual cures of diseases, he ridiculed the ideas concerning the magical causes of diseases. Thus Greek medicine once freed from the magical cult made progress by leaps and bounds **Herophilus** (300 BC) was a great anatomist and physiologist. He was a pioneer in the study of nerves and was the first to realise the clinical use of the pulse to distinguish between sensory and motor nerves. **Erasistratus** (280 BC) discovered the significance of the convulsions of human brain. All these significant achievements of Greek medical science were later explained further by **Galen** who raised them to next levels of significance. The Greeks excelled in both medicine and surgery. The whole of the Roman Kingdom was dependent on Greek medicine. In surgery as early as 400 B.C., The Greeks were using numerous and sophisticated types of surgical instruments which **Hippocrates** mentioned in his works. These instruments included probes of various kinds, knives of different lengths and degrees of sharpness and shape, trepanning saws, dentists clamps and so on.

Check your progress.

1. Explain the different views of the thinkers of Ionian School on universe.

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2. Indicate True or False regarding the correctness of the following statements.
   a) Pythagoreans attitude towards nature was mathematical. T/F
   b) Thinkers of Ionian School were in search of a non-dynamic principle. T/F
   c) Eleatic thinkers thought that the nature's changes are real. T/F
   d) The philosophers of Ionian school thought the Universe is made up of water. T/F
3. Socrates view on Universe was ________________.
4. Plato's view on Universe was ________________.
5. According to Aristotle Universe was made of ________________.
6. Helio centric theory was put forward by ________________.
7. Match the following :

(a)	Pythagoras	( )	(1)	The elements
(b)	Euclid	( )	(2)	Infinitesimal calculus
(c)	Archimedes	( )	(3)	Number theory
(d)	Appolonius	( )	(4)	Astronomer
(e)	Eudoxes	( )	(5)	Eclipse, Parabola, Hyperbola

3.6 ROMAN TRADITION

This tradition is a continuation of the Greek tradition of science. The total stagnation suffered by the Greek science was due to socio-political instability arising from wars between the Greek City-States. By the second century A.D., Greece fell into the hands of Romans. The Romans were eager to accept the religious and mystical ideas of the Greek rather than their Natural philosophy and science.

Nevertheless, there were some heartening developments, one relates to **Lucretius** a great thinker, who in the best tradition of Greek science put forward his atomic theory. It was quite advanced and sophisticated for his times. Further the Roman concept of law and order in society favoured the concept of a universal law of nature. Scholars like **Cato, Vasso** and **Cellsus** wrote encyclopaedias on agriculture and medicine. **Pliny's** encyclopaedia on natural history and those on geography, mathematics, physics, anthropology, physiology, zoology, botany and so on by **Gellius, Serenus, Papas** and others were significant contributions to the advancement of knowledge. **Ptolemy** was a great astronomer and mathematician. His **geocentric** and **geostatic** theories influenced most astronomers till the 17th century. His book **"Almagest"** also puts forward principles of spherical geometry, dimensions of the earth, co-ordinates of places and climate. He undertook many voyages. Roman mathematics benefited from the work of **Diophantus** on arithmetic, particularly in polygonal numbers and indeterminate analysis. The Roman number system, is unique in its own and used in Europe for a long time. It is however quite unsuited to modern science which uses Arab numerals derived from **India**. Some important contributions in respect of simple machines were made in the period of **Heron**. He discussed levers, windlasses, wedges, screws and pulleys. He had also investigated the nature of hydraulic power and the use of pneumatics for pumps, organs, water-clocks and water machines.

Plant science and medicine also progressed to some extent under the **Romans**. In the first and second century A.D., they started a college of medicine and a school of medicine (Rufus) which excelled in anatomy. **Galen** is the most renowned medical scientist of the times. He wrote a large number of books on medicine, anatomy, pathology, therapy, diagnosis and as well as commentary on the works of **Hippocrates**. Galen's works remained authoritative till the 17th century. **Dedanius** wrote **Di Metria Medica**. Innovations in pharmacology, surgical tools also occurred at that time.

Check your progress.

1. The Roman thinker Lucretius proposed ________________.
2. Match the following :

(a)	Pliny	( )	(1)	Arithmetic
(b)	Diophantus	( )	(2)	Geocentric theory
(c)	Ptolemy	( )	(3)	Encyclopaedia on Natural history

3.7 THE CHINESE TRADITION

The Chinese civilization is one of the most ancient civilizations of the world. Indeed of all the ancient civilizations, the Indian and the Chinese civilizations have the longest history. The uniqueness of these two civilizations consists in both their antiquity and their continuity.

Like the Indian civilization, the Chinese civilization can boast of having one of the oldest and longest scientific traditions of the world. The Chinese scientific tradition made very important contributions to western science in both ancient and medieval times. It significantly contributed to the great intellectual revolution of Europe that brought about the rise of Modern Science.

The Chinese scientific tradition made amazing progress in all kinds of scientific inquiry. Both in the realm of physical ideas, and that of practical application, the Chinese scientific tradition occupies a historical position. Many of the significant achievements of the Chinese scientific tradition were made known to Europe by the Arabs and Jesuit missionaries who visited China in the early part of the 17th century. Thus Chinese science was able to play its role in the development of modern science.

Confucianism

Even during the period when China was ruled by the Shang dynasty (1520-1030 BC) it made remarkable progress in terms of its Bronze Age achievements. With the replacement of the Shang dynasty by the Chou dynasty (1030-220 BC), China entered the Iron Age. As in other societies 'writing' came into existence in China around 1000 BC. By 600 BC the Iron Age civilization swept China. Writing gave rise to a great intellectual movement, namely, the **Confucianism** which became in the second century BC the Official State Doctrine. But neither **Confucius,** its founder, nor his followers concerned themselves with science. In fact, Confucianism paid little attention to physical or naturalist thinking. But Confucius stressed the value of universal education. The wide spread literacy enabled the people to participate in the ongoing intellectual activities at least to some extent. This spread of literacy and education helped the growth of ideas in China. **Confucius** did not allow religion and meta-physics to influence his philosophy and rationalistic approach to questions concerning nature and man. His thinking was free of animism and superstition. He represented a new mode of thinking, radically different from old one. But his thinking did not help in the rise of "Science". His concern was basically with ethical problems and social issues. His total preoccupation with individual and social morals prevented him from inquiring into world of nature.

Taoism

The religious movement which succeeded Confucianism is one of the most important events in Chinese history. Taoism founded by Lao Tzu (570 BC) marks the beginning of 'Science'. The word "Tao" itself means "way" or "order". It stands for "natural" order. Taoism attempted to conceive nature in terms of cosmic order instead of those of divine creation by god or gods. It recognised unity and spontaneity in nature. Taoists also emphasised the need to "find the causes" of things and events. In fact, "find the causes" was their catchword. This desire to find causes enabled them to engage themselves in the observation of nature. Observation of and reflection of nature according to them, constitute a spiritual necessity. In other words, inquiry into nature and acquisition of knowledge are sources of peace of mind. Thus the Taoists came to attach a spiritual value to scientific knowledge. The Taoists in their investigations invariably paid attention to "change" in nature. According to them, knowledge should explain change and transformation in nature. That is why so early in the history of science, they came to acquire a theory of biological evolution. Even the non-biological world was treated as an evolving phenomenon. Also, Taoism developed a Tantric tradition. Just as the Indian Tantric tradition helped the growth of physical theory or natural philosophy, the Taoist tantrism also helped the growth of natural philosophy in China.

Other Schools of Thought

After Taoism many different schools of thought came into existence, each of which contributed to the growth of science and scientific thinking. The **Mohist** school founded by **Mo Ti** (479-381 BC) and the school of logicians reflected upon the nature and types of scientific method, the relation between cause and effect, the applicability of mathematical quantification of nature and many other logical issues. They also had their own ideas of infinity and atoms, and the thought "atomism" as such, was introduced only by later Mohists and Logicians.

Naturalism

But the biggest impetus to science in China was given by the naturalist thinkers. The father of this school "Naturalism" was **Tsou Yen** (350-270 BC), the real founder of all Chinese scientific thought. Two theories constitute the basic tenets of the naturalist school. They are (1) **the five element theory** and (2) **Yin-Yang theory**.

According to the five elements theory everything in this world is made of five elements, namely water, fire, wood, metal and earth. In other civilizations like the Indian wherever a five element theory is spoken of, we have air and void in place of wood and metal. These elements do not stand for fundamental substances, but for fundamental processes. The Naturalists tried to trace all natural changes to five interacting processes represented by the five interacting elements. The analogy with chemistry is, many followers of the **"five element theory"** were chemists.

The **Yin-Yang** theory attributes the origin and evolution of nature to a union of Yin and Yang which are the female and male principles respectively. It was thus a biological bias which is worth noting. The theory is not animistic because Yin and Yang are principles and not gods. The two principles always co-exist, though sometimes Yin dominates and sometimes the Yang dominates.

Contributions by Chinese tradition

Ancient Chinese were interested in the practical application of science. They made significant progress in various branches of science especially in mathematics, biology and medicine.

Astronomy

Chinese astronomy is built upon the idea of **rotation**. Astronomy made great progress during the period of **Han** dynasty. The calendar was improved and outstanding developments took place in the study of earth. They invented various astronomical instruments. The German astronomer, **Joseph Von Fraunhofer** invented in 1842 a special clock to drive a telescope so that it could follow the stars continuously in spite of the rotation of the earth. The Chinese had done this eight centuries earlier. Though Chinese borrowed many ideas like "lunar mansions" from others, they continued to make independent progress. The height of astronomical excellence was achieved during the **Sung** period (10th-11th century AD). The achievements include (1) the work of **Shen Kua**, (2) the work on **armillary sphere** by **Su Sung** in 1080, (3) stone carving of the "chart of heavens" and (4) **Suchow** "plain sphere" provide striking evidences of the Chinese astronomical achievements. Many **chinese** astronomers were invited to collaborate on a great astronomical observatory with library of 400,000 volumes started by **Arabs** at Maraghah in the 13th century.

Mathematics

The chinese did not apply themselves much to science, although they did develop mathematics. The chinese made a number of interesting studies in numerology with its number mysticisms rather than solid number theory. They had a rudimentary knowledge of binary arithmetic which they represented in terms of hexagramic lines and diagrams. The seventeenth century mathematician and philosopher Leibnitz, gained some knowledge of

Chinese work in this direction. He developed his own system of binary numbers which is important to science.

The Chinese did not develop an abstract geometry. Though, in fact they were particular about "form & position" of houses, "cities", buildings, roads and bridges. They were content with practical knowledge of geometry. Developments in algebra reached climax in the Sung period. The chinese intellectual activities seemed to have acquired a mathematical orientation as early as 3rd century BC. **Legalism** and philosophical school, responsible for the development of civil law in china insisted upon quantification of everything. Its emphasis on numerical terms was responsible for remarkable standardizations introduced by first **Chinn** emperor, the unification of scripts, the normalization of weights and measures, even the gauge of chariot-wheels.

Physics

The Chinese made very impressive progress in Physics, especially in magnetism. The **Mohists** evinced great interest in mechanics. They were interested in military art and activities. They developed theoretical knowledge of motion which helped them in inventing war instruments. Thus their work in defence instruments contributed to the development of physics. Further they were also concerned with the theoretical part of physics too. The Logician school developed relativistic conceptions of space, time and change. They pointed out the paradoxical character of many of the prevailing ideas including atomism. The most significant period of Chinese physics is the **Sung Period** in which astronomy and mathematics developed a great extent. **Shen Kua** for the first time described in detail the magnetic compass. In fact the whole world owes the invention of magnetic compass to the chinese. The invention of the magnetic compass testified to their immense knowledge of magnetism.

Chemistry

Chinese progress in chemistry was remarkable. Their enormous knowledge of chemical substances enabled them to invent paper, printing and gun powder very early in the history of civilization. The invention of porcelain and the advances in ceramic arts bring out the amazing range of their chemical knowledge. They have also mastered sericulture and sophisticated methods of iron casting. Like other civilizations, the Chinese never gave up alchemy.

Biology

The biological and medical sciences were of prime importance to the Chinese scientific tradition. As early as 500-400 BC biology was given a special status and had received special attention. The Taoist thinkers not only concerned themselves with topics relating to "life", but also attempted to lay their whole world-view on a biological basis. They adopted an evolutionary attitude towards the biological issues. Their interest in biology was kept alive by their followers. As early as 100 AD, that is during the rein of Han dynasty, methods of classifying plants and animals were attempted. **Wang Chung**, the greatest scientist of ancient China, went to the extent of developing a theory of genetic inheritance to explain individual peculiarities. The tradition of biological knowledge continued unhindered and in the tenth and eleventh centuries a great deal of work on Botany and Zoology was done. The output was so extraordinary that nine great treatises on pharmaceutical natural history and a host of specialised monographs in botany appeared. In the same period **Shen Kua** wrote his great work which dealt with Astronomy, Physics and Chemistry. It also contained very significant notes on fossils and innumerable valuable biological observations. In the **Mig** period (1500-1600 AD) many imperial princes as well as commoners took a lot of interest in botany. A botanical garden was maintained by the rulers. There appeared a great work in 1406 "Natural History of Famine Times" with very instructive plant illustrations. Topping all those is **Li Shih Chen**'s classic **Pen Tshao Kang Mu** (The great pharmacopoeia). The work contains detailed descriptions of about 1000 plants and 1000 animals. It classifies them into 62 divisions according to their ecological character. Biological science in China continued to make progress and improve in the hands of **Wang-Fu-Chih**, an eminent thinker of the seventeenth century.

Medicine

The chinese developed a fertile tradition of medicine. This tradition began almost in the beginning of chinese civilization. Like others, it made great strides in the pharmaceutical tradition of medicine. Apart from this it gave the world a new system of medicine namely acupuncture. This is China's unique contribution. It is a system of curative art that involves the puncturing of the skin with needles. Its scientific basis and effectiveness have won world wide fame. Even to-day it is considered as an effective system. Chinese medicine was famous in the 11-12 centuries. Many efficient physicians appear in **Sung** times. These old systems and acupuncture were later improved. New discoveries like variolation became popular. In 1111 AD works of high standard on medicinal plants and their uses appeared in large numbers. In 1247 **Sung Tzhu** founded forensic medicine. By 13th century chinese medicine became world famous. Many Arab medical books of the 14th century acknowledged their debt to chinese physicians. They took keen interest in the works of **Galen. Li Shih Chen's** work "Pen Tshao Kang Mu" provided great information on distillation. Mercury, iodine and kaolin were used in therapeutics.

Check your progress.

1. Confucius emphasised on the value of ______________________.
2. School of Naturalism consists of ______________ theory and ______________ theory.
3. Match the following :

(1) Shen Kua	( )	(a)	Theory of genetic inheritance
(2) Wang Chung	( )	(b)	Invention of magnetic compass
(3) Li Shih Chen	( )	(c)	Founder of Forensic Medicine
(4) Sung Tzhu	( )	(d)	Pen Tshao Kang Mu

4. Define the system of acupuncture.

3.8 SUMMARY

Egyptian and Mesopotamian Traditions

1. The history of human civilization is unthinkable without Egyptian and Mesopotamian contributions.
2. They set pace in the pre-Iron Age civilization. But they lost dynamism as mankind entered the Iron Age.
3. They survived even after 1000 BC, but they lost vigour and vitality.
4. Egyptians excelled in architecture as is evident from the construction of pyramids.
5. They had good knowledge of chemistry as evidenced by "Papyries".
6. Egyptians confined to the practical use of mathematics and developed an accurate solar calendar as early as 2700 BC.
7. Cidenas, the astronomer, calculated the movements of sun and moon.
8. Ahmas, wrote a book on "fractions".
9. Egyptians possessed great knowledge of medicines and they used animals, vegetables & minerals for medical purpose. Even horns, tortoise shell, skins, bones and falcons were used to prepare medicines. Special containers were made to preserve medicines.

10. Mesopotamian or Babylonian civilization also had remarkable achievements. They could forecast eclipses. They had the conception of zodiac. They had knowledge of human anatomy.

Greek and Roman Traditions

11. Greeks were no where near civilizations such as Egyptian civilization, but Greeks achieved greatness in science. They explained nature in terms of ultimate principles.

12. Greek scientific tradition can be divided into three phases (1) Ionian (600 BC), (2) Athenian (480-320 BC) and (3) Hellenistic (330-200 BC).

13. Greatest thinkers of Ionian period were **Thales, Anaximander** and **Anaximens**. These three considered water, matter and air respectively as the primary substances.

14. The other important schools of thought are Pythagorean school (580-500 BC), Eleatic School (470 BC) and Natural philosophers. The last school included **Anaxagoras, Empedocles** and **Democritus**. These believed that universe is made of 'atoms'

15. Next great philosopher was Socrates. A disciple of Socrates, namely Plato believed that nature was corrupt and unreal. But his disciple Aristotle was much interested in science. His natural philosophy dominated the western scientific world till 17th century. Thus tradition of science started with Thales and ended with Aristotle.

16. Greeks made tremendous progress in Astronomy. Thales predicted eclipses. Pythagoreans described astronomical phenomena by numbers. They believed in geocentric view. Plato, Eudoxes and Aristotle explained the motion of planets through the use of spheres. Hipparchus invented good instruments and Aristorchus proposed helio-centric theory.

17. They mastered number theory, introduced geometry and theory of proportions. Archimedes introduced calculus and improved the determination of the value of Pi (π). Euclid is the greatest mathematician.

18. Foundations were laid for atomic physics. Foundations for mechanics, statics & hydrostatics were laid by them.

Chinese Tradition

19. Chinese civilization is one of the most ancient civilizations of the world. Shang dynasty (1030-220 BC) was responsible for early developments. Taoism (570 BC) marks the beginning of science. It conceived nature in terms of cosmic order instead of creation by Gods. Taoists emphasised the need to find the causes of things and events. Taoists developed Tantric tradition.

20. Chinese put forth two theories (1) five element theory and (2) Yin-Yang theory to explain nature.

21. Astronomy made great progress during the period of Han dynasty. Calendar was improved, astronomical instruments were discovered.

22. Contributions to physics and chemistry were noteworthy. Contributions to magnetism were impressive. They invented paper, printing, and gun powder.

23. In 500 B.C., biology was given special status. Wang Chhung developed theory of genetic inheritance. Many books, treatises and monographs appeared in botany and pharmacy. Shen Kua's book contained significant notes on 'fossils'.

24. Chinese developed a very fertile tradition of medicine. It gave "Acupuncture" to the world. Li-Shih–Chen's work provided lot of information on small pox, inocculation and use of mercury, iodine and kaolin for treatments.

3.9 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. Discuss the important contributions of Egyptians and Mesopotamians to astronomy and mathematics and other sciences.
2. Discuss the different schools of thought on universe that existed in Greek and Roman traditions.
3. Discuss the contributions of Greeks to different branches of science.
4. Elaborate the important contributions of ancient Romans to Science.
5. Discuss the important achievements made by the ancient Chinese in the field of sciences.

Answer the following in about 15 lines each.

1. Discuss the important contributions of Egyptians to astronomy & mathematics.
2. What are the main contributions of Mesopotamians to Science.
3. Who was the founder of Pythagorean School?
4. Explain briefly the views of Socrates, Plato, Aristotle on Nature.
5. Discuss briefly the contributions of Aristotle and Archimedes to the field of physics.
6. Mention the contributions of ancient Romans to the fields of astronomy, mathematics.
7. Write briefly about Confucianism.
8. Explain the main features of Taoism.
9. Describe the school of Naturalism and its two theories.
10. Describe briefly the chinese contributions to the fields of biology & medicine.

3.10 GLOSSARY

Acoustics	:	A branch of physics that deals with the study of sound.
Alchemy	:	A science which tried to convert base metals to gold.
Anatomy	:	Branch of science dealing with the structure of man, animals or plants.
Anthropology	:	The study of interrelations of biological, cultural, geographical and historical aspects of mankind.
Algebra	:	A branch of mathematics dealing with the properties of relationships between quantities by means of general symbols.
Cosmic	:	related to whole universe.
Calcination	:	Strong heating of chemical substance to convert them into oxides.
Calculus	:	A branch of mathematics dealing with differentiation, integration and related topics.
Centre of gravity	:	A fixed point in a material body through which the resultant force of gravitational attractions act.
Capricious	:	Being likely to change suddenly.
Distillation	:	The process of producing vapour from a liquid by heating the liquid.

Dyeing	:	The process of application of dye to fabrics.
Ecology	:	The pattern of relationships between living and non-living things.
Hypothesis	:	Tentative or provisional statement that links observations and facts obtained from them.
Helio centric	:	Sun as centre.
Hypnosis	:	The production of sleep like state.
Hydrostatics	:	The study of liquids at rest and the forces exerted on them or by them.
Geometry	:	The qualitative study of shape and size.
Geocentric	:	Earth as centre.

UNIT-4 SCIENCE AND TECHNOLOGY IN MEDIEVAL TIMES - II

Contents

4.1 AIMS AND OBJECTIVES

Aims

In this unit you learn 1) about the contributions made by the ancient Indians in the fields of science and technology and also 2) about what science, technology and culture mean and the interrelation between them.

Objectives

After you completed the unit you must be knowing the following

1. What are the contributions made by the ancient Indians in the fields of astronomy, mathematics, physics, chemistry and medicine.
2. What are the different branches of ancient Indian medicine?
3. The meaning and significance of the terms, "science, technology and culture".
4. The interrelationship between science, technology and culture.

4.2 INTRODUCTION

Science and technology advanced greatly in ancient India. The progress made in the fields of astronomy and medicine is praise worthy. Ancient Indian medicine namely Ayurveda is still in use in many parts of the country. Science, technology and culture so intimately related to each other that they can not be separated from one, another. They can not exist without one another.

You learn about the significance of science, technology, culture and their mutual relationship.

4.3 INDIAN TRADITION

India's contribution to science is immense and varied. It is both ancient and modern. Ancient Indian scientists with their imagination, rigorous thought and keen observation contributed to almost all branches of science. What is given here, is only a brief sketch of the long and glorious tradition of Indian science. The scientific thinking of Indians can be traced back to the vedas. The different branches of science such as phonetics, grammar, prosody, etymology, astronomy and medicine are considered as ancillary subjects of the vedas (vedangas). Indian scientific tradition progressed till 18th century AD.

Vedic tradition

The contents of vedas is predominantly religious and animistic. So science in early vedic times was not what it is today. The early thinkers spoke of world being governed by 'order'. The 'order' according to them depended on gods and did not exist in its own right. Indian philosophy has its origin in vedas and hence is spiritual. But it has stressed the need of practical realization of truth. Even the early vedic thinkers felt the need for moving away from purely animistic thinking. This is inferred from the song of 'creation' in the early vedas. In that song, the poet-philosopher traces the origin of the universe not to the work of any God, but to a primordial substance. In those times, which were dominated by gods and goddesses; this was really a bold statement.

The upanishads, the concluding portions of vedas are by and large opposed to natural philosophy or physical speculation. Their tone is spiritualistic. Upanishads do mention the names of natural philosophers of the contemporary times. The greatest amongst them were **Brihaspati, Shukra** and **Uddalaka**. The conception of Universe which was materialistic and atomistic was formulated by **Uddalaka**.

Tantric Tradition

This tradition promoted some branches of science and contributed to the development of natural philosophy. These philosophers identified soul with body and concerned man in purely natural terms. The human body was considered as micro expression of the whole universe. Since body is physical, whole universe was considered physical. Just as human body is a result of sexual union, the universe was also considered as the result of the union between the masculine and feminine principles. Though tantrism is accompanied by occultism and superstition, its contribution to physical speculation can not be neglected.

Views on Universe

There were divergent views on the nature of universe. Among them two schools of thought are worth studying.

Out of the tantric tradition grew the philosophy of the **Sankhya school**. This considered the universe first in terms of one principle. Prakriti and later in terms of two principles Prakriti and Purusha. It adopted an evolutionary view towards the universe. The Sankhya school contributed to the consolidation of natural philosophical thinking in India.

This school furthered the cause of naturalist speculation. This is founded by **Kanaada**. The vaisheshika philosophy conceived the universe in terms of seven physical and semi-physical principles. It developed a sophisticated atomic theory. The **Charvaka** (materialist) thinkers, the **Buddhist** and the **Jain** philosophers also contributed to the developments of physical speculation concerning the universe.

Indian Tradition - Contributions

The chief contributions were to the astronomy and medicine.

Astronomy

Astronomy (including mathematics) and medicine were the chief concern of Indian scientists. These figured as vedangas. Astronomy in India as in other civilizations was inseparable from astrology. In fact astronomy (Jyotisha) was divided into **Siddhanta** (astronomy proper). **Samhita** (collective astrology predicting occurrences affecting communities) and **Hora** (individual astrology predicting the future occurrences affecting an individual). The intimate relation between astronomy and astrology is found everywhere. It is to be noted that one of the distinguished astronomers of modern times, **Kepler** was also an astrologer. He developed the astronomical system to assist him in his astrological pursuits.

Astronomy in India originated in the **Vedas** as a **Vedanga.** Indeed **Yajurveda** (1000 BC) speaks of stellar constellations and planetary movements. Basing his thoughts on the vedic observations, **Lagadha** wrote **Vedanga Jyotisha** (700-600 BC) in which he discussed calendar calculations, sun rise etc. But the astronomy of vedas and vedanga jyotisha was primarily meant for ritualistic purposes i.e. for the purpose of finding good and auspicious times for rituals and rites. But Indian astronomy however passed this stage and established itself as an independent discipline. It aimed at gaining knowledge of astronomical phenomena. Its glorious development was due to the unceasing efforts of Indian astronomers. The most important of whom were **AryaBhata** (5th century AD), **Varahamihira** (6th century AD) and **Bhaskaracharya** (12th century AD). The history of Indian astronomy is characterised by the development of five different schools of astronomy. These are (1) **Brahma** or **Pitamaha Siddhanta**, (2) **Paulisha Siddhanta**, (3) **Romaka Siddhanta**, (4) **Visista Siddhanta and** (5) **Saura Siddhanta**. **Brahma Siddhanta** was the earliest but it fell into disuse when the other schools chose to dominate the scene. **Romaka Siddhanta** is thought to have been derived from the **Roman tradition** and **Paulisha Siddhanta** from the work of the classical astronomer Paul of Alexander, **Saura Siddhanta** has its brilliant exposition in the work. Surya Siddhanta written in the 4th century BC. But all the latter four popular systems faced crisis since the astronomical facts increasingly came into conflict with their traditions. Aryabhata then revived the old **Brahma** or **Pitamaha Siddhanta**, which began to dominate the scene. His Aryabhatiya became the guide for future work. In one of the works of Varahamihira there is a detailed critical discussion of all the schools of astronomy. He was not in favour of Brahma Siddhanta and preferred Saura or Surya Siddhanta to it. Later Brahmagupta (7th century AD) perfected Brahma Siddhanta and wrote **Brahmaputra Siddhanta.** On the basis of this work, **Bhaskaracharya II** wrote his astronomical treatise as a part of his great work, **Siddhanta Siromani**. It is held by Indian astronomy that the moon's position relative to the fixed stars changes through a cycle of 27 days and 7 3/4 hours. On the basis the sky was divided into 27 portions. They were named after the group of stars near which moon makes its cyclical movement. Later astronomers added the 28th star to correct the error due to sidereal month. The Indian astronomers knew of seven planets and added two more later. They believed that at the beginning of each year all the planets start together and return to the same position at the end of it.

The irregular motion of the planets were explained on the basis of **epicycles**. In their opinion the apparently different angular motions were due to their being situated at different distances from the earth. They adopted the **geocentric** theory, though Aryabhata and Bhaskaracharya spoke of the heliocentric theory as well. They knew the precision of the equinoxes and accurate values of astronomical constants. Indeed they could forecast eclipses with remarkable accuracy. One example is sufficient to indicate the accuracy of their calculation. The difference between values for the circumference of earth given by Brahmagupta and Bhaskaracharya and those of modern astronomy is only 13 miles. But we know very little about the astronomical instruments used by the Indians then. However Bhaskaracharya II describes the various astronomical instruments used in his times. But he describes that "intelligence" is a better tool than all those instruments.

Mathematics

The Indian astronomers considered mathematics to be an essential tool for acquiring astronomical knowledge. It is no wonder they developed the science of mathematics to very high degree. The sophistication and the depth of the mathematical knowledge of the ancient Indians are almost unparalleled in the history of mathematics. Surprisingly, Bhaskaracharya discusses in his Siddhanta Siromani the method of some trigonometric calculations. It is also surprising to know that Bhaskaracharya has a fairly good knowledge of calculus for the birth of which Europe had to wait for another five hundred years. India had developed a system of mathematics superior in everything except geometry to that of the Greeks.

Physics

In Physics, the contributions of the Indians was some what limited. No doubt the atomic theory was developed, but it did not progress very much. The atomic theories of ancient India are brilliant imaginative explanations of the physical structure of the world. They agree in part with the theories of modern physics. They are nevertheless much to the credit of the intellect and imagination of early Indian thinkers. Apart from atomic theory, the idea of gravitational attraction was known atleast to Bhaskaracharya. He speaks of it while explaining the fall of the bodies as well as the movement of planets. One branch of physics that developed to a remarkable degree of sophistication is acoustics, the science of sound. It became an important field of investigation owing to the significance of sound in the context of vedic chanting. The development of music and musical theory was yet another factor responsible for progress in acoustics. The division of the musical scale is based on calculations of a very high order of accuracy.

Chemistry

The study of chemistry was mostly confined to metal and drugs. The former was for technology and the later for medicine. **Kautilya** in his Arthasastra speaks of the ministers in charge of metallurgy who were supposed to be well-versed in the science of metals. Chemical researches in connection with medicine gave Indians a knowledge of chemicals used as poisons and antidotes.

The medical chemists were able to produce many alkalis, acids and metallic salts. Processes of steaming, sublimation, calcination and distillation were known. Gradually chemistry turned into alchemy, **Rasatantra**. It is in its alchemical stage that the followers of the tantric tradition contributed to the growth of chemistry in an irrepressible measure. Many tantrics wrote important works on the chemical processes, especially those concerning mercury. The tantric works became store houses of chemical knowledge.

The cast iron of ancient India was chemically excellent. There was great industrial development in Gupta times. Even imperial Rome looked to India in respect of dyeing, tanning, soap making, glass and cement. An entire work dealing with mercury written by **Nagarjuna** was available in the second century BC. By the sixth century AD, India was ahead of Europe in industrial chemistry. The tempering of steel in ancient India was of perfection, which was not achieved in the west till recent times. Thus rust free Iron pillar of Ashoka and the secret of manufacturing "Damascus" blades bear great testimony to ancient India's great achievement in metallurgy.

Medicine

Medical Science claimed the greatest attention of the ancient Indian Scientists. Ayurveda, the Indian medical system has not lost its vitality even now. Many eminent authorities on medicine acknowledge the greatness of Ayurveda. The history of Indian medicine is one of great developments in the Vedic and Buddhist periods. Ayurveda was considered as an ancillary of vedas (vedangas). It originated as a part of **Rigveda**. It is said to have been founded by a sage called **Atreya**. The chief god of medicine in India was **Dhanvantri**, the physician to other gods. He "received" the Ayurveda directly from Brahma. The Atharvana veda discusses various topics like illness and nutrition. The Bhela Samhita (800 BC) is yet another great work of Ayurveda. Agnivesha Samhita written by **Agnivesha** (700 BC) is yet another classic that served as the basis of later researches of **Charaka**. Kashyapa Samhita (600 BC) deals with paediatrics.

Chivara Vastry (500 BC) deals with ophthalmology. All these works point to the many sided developments of medicine and medical research in those times. But the major contributions to Indian medicine could be attributed to the period during 100 AD to 300 AD and these were due to **Charaka**, **Vegbhata** and **Sushruta**. **Charaka** wrote his Charaka Samhita, a classic of Indian medicine in which he discussed medicine, anatomy and physiology as well as symptoms, causes & cure of various diseases. To this work, later progress in Indian medicine could be attributed. **Dhanvantari** was an authority on surgery although there was not much work. But his thoughts on Ayurveda in general and Shalyatantra (surgical science) in particular are recorded by his disciple, **Sushruta** in his famous Sushruta Samhita (200-300 AD). The work speaks of 300 surgical treatments, 45 surgical operations, 121 types of surgical instruments and 680 medicines. This monumental work set the course for future surgical activity and research. The two works of Charaka and Sushruta constitute the twin pillars on which the edifice of Indian medical science was erected. Urinalysis was a favourite method of diagnosis. Measurement of the pulse was popular. Therapy was based on hygiene, diet and drugs. Laprotomies, cataract operations and above all rhinoplasty and autoplasty were far advanced. Hypnosis was used for anaesthetization. Variolation was practiced against smallpox. Many of the Indian medical herbs have found their way to western medicine, particularly **Rauwolfia Serpantina** for treating hypertension. Indian medical science has various branches. Some of the branches are Sarira Sastra (Physiology), Kaya Chikitsa (internal medicine), Bala Chikitsa (Paediatrics), Griha Chikitsa (Psychiatry), Salya tantra (Surgery), Vishatantra (Toxicology), Rasayantantra (Geriatrics), Vajikarana tantra (study of male sterility, impotency and promotion of virility). During vedic and later periods as in the time of the emperor Ashoka, surgery progressed to a great extent.

Ayurveda believes that the body is composed of five Dhatus (elements), Vayu (wind), Agni (Fire), Ap (water), Bhumi (earth) and Akasa (void). Of these, the first three dhatus are most active. Life depends on the harmony of the activity of these datus. Because three doshas are concerned with metabolism, tri doshas arise out of disharmony of these datus. The causes of the diseases are (1) Immoral and perverse activities, (2) environmental changes, (3) contact with bad things like bad food.

The last is considered to be very important. That is why ayurveda attaches great importance to hygiene and dietetics.

Indian medical scientists really excelled others in their knowledge of medical drugs. Medicines were prepared from animal, vegetable and mineral products. For example, the oil of chaulmugra tree is still used in treatment of leprosy.

In surgery their achievements are astonishing. Caesarean operations and plastic surgery were mastered. The extent of variety of surgical operations undertaken is unbelievable. Bone setting was done with unimaginably high degree of skill. In the ancient India almost every major operation except ligature of the arteries was performed. The great scientific tradition of India continued to flourish for centuries. It was enriched by contributions from Sumeria, Egypt, Persia. Indian rulers actively encouraged science. The Indian scientific tradition survived with vigour till 18th, 19th centuries. Many European scientists and historians of science of the 18th century have left vivid accounts of the richness of India's scientific tradition. But the great tradition faded away under British Imperialism. Imperialism liquidated it as it did other components of Indian heritage.

Check your progress.

1. Indian scientific thinking is linked to ____________________.
2. Vedangas or the ancillary subjects of vedas are ____________________.
3. Upanishads are ____________________.
4. The principle behind tantric tradition is ____________________.
5. Famous ancient Indian scientists were ____________________
____
6. The different schools of astronomy were ____________________
____
7. Dhanvantari was considered to be the ____________________.
8. Chief medical system in ancient India was ____________________.

9. Match the following.

(a)	Kashyapa Samhita	( )	(1)	Surgery
(b)	Chivara Vastry	( )	(2)	Paediatrics
(c)	Sushruta Samhita	( )	(3)	Ophthalmology
(d)	Charaka Samhita	( )	(4)	Medicine, Anatomy, Physiology

10. The branches of Indian medical science are ______________________________

____

11. Human body is composed of five elements ______________________________

____

12. Vaisheshika school is ______________________________.

____

4.4 SCIENCE, TECHNOLOGY AND CULTURE - THE INTER RELATION

Science and technology play an important role in the shaping of contemporary times. These have a great significance in the history of mankind. They brought radical changes in the realm of material conditions of our day to day life. No aspect of our life - material, intellectual, social, political, artistic or any other - has remained unaffected by science and technology. These have decisively influenced our past, have undoubtedly moulded our present and are going to determine our future. Science and technology are part and parcel of "culture", since human activity is central to the idea of culture.

Culture

In any society man is engaged in activity that ensures preservation and enrichment of his life. It protects life from the dangers and uncertainties that surround man's life. They also enhance the quality and standard of life. Man therefore adapts his environment (physical & biological) to his needs and requirements.

The totality of meanings which members of community read into their life and surroundings is called "culture". The culture of a society gives a sense of direction and purpose to human activity. Culture also derives its sustenance from human activity. The culture and human activity are so organised that one cannot be understood without the other. One cannot exist without the other. One is pre-condition of the other. A culturally dead society cannot have an activity. An inactive society is culturally dead. Culture lubricates the working of a society and minimises the frictions in the society. It gives a sense of cohesion to society. Thus the culture and human activity are inseparable and interdependent.

What does culture stand for ? What does it consist of ? These are the important questions.

Culture consists of the most general views concerning world, life, society, man and values, concerning happiness, goodness, beauty etc. These views and values are expressed through philosophy, religion, myths, literature, art, socio-political ideas, ethics etc. All these constitute the culture of a given society. The culture of a society at any time possesses two dimensions, **spiritual** and **material**. Science is one of the most significant components of spiritual dimension and technology of material dimension. Culture is characterised by both universality and speciality. Culture is universal, in the sense, that every society has produced a culture of its own. No society can survive without actively preserving and enriching the life of its members. No society can exist without culture. Therefore science and technology are universal. Therefore it is wrong to say that only some societies have culture and that only some societies have monopoly over science and technology. But every society has its own culture, unique to itself. Thus all societies are culture specific and all cultures are society specific. A society seeks and finds identity in its culture. Similarly culture finds its uniqueness in the society. This does not mean that there are no common characteristics in different cultures. It does not also mean that there are no cross-cultural exchanges. The cross-cultural exchanges took place between many societies, ofcourse, without any society losing its cultural identity. This is known as **free cultural exchange**. An outright cultural imperialism means that the subjected party gets culturally liquidated.

Check your progress.

1. Culture means ______________________________.
2. Culture possesses two aspects ______________ and ______________.
3. The two inseparable things are ______________ and ______________.
4. The two important components of culture are ______________ and ______________.
5. Every society has its own ______________________________.
6. Free cultural exchange means ______________________________.
7. In outright imperialism culture gets ______________________________.
8. All societies are culture ______________________________.

Science

Science is the everlasting interrogation of Nature by Man. It does not have a specifiable beginning and it will not end. From observations of phenomena, hypothesis arise. Hypotheses give way to theories and theories can assume the nature of laws. These in turn await amendment. Scientific explanations are verifiable, but carry no guarantee of ultimate certainity. Science is characterised by not being dogmatic. It involves a process of continuous revision of its conclusions instead of offering ready-made and irreplaceable solutions. Einstein said that science gives life breadth, religion gives depth. The individual events in science are explained by general terms. But how are we provided with these general terms? It is the laws of nature that provide us with those terms. Therefore in its search for general terms, science goes in search of laws of nature. The most salient feature of scientific explanation is that it is done in terms of what are supposed to be regularities in nature. If nature becomes disorderly and chaotic that would be the end of science. In its explanatory function, science tends to be as much mechanical as possible and as little teleological as possible. By "teleological" we mean involving purposes, intentions, goals, and so on. Scientific theories try as much as possible to explain phenomena without having recourse to goals and purposes supposedly inherent in nature. They attempt to explain phenomena purely in mechanical terms. Science tries to answer the question "why" in terms of "due to what" and not "what for". Scientific statements have hierarchical structure. These are expressed in the form of a diagram.

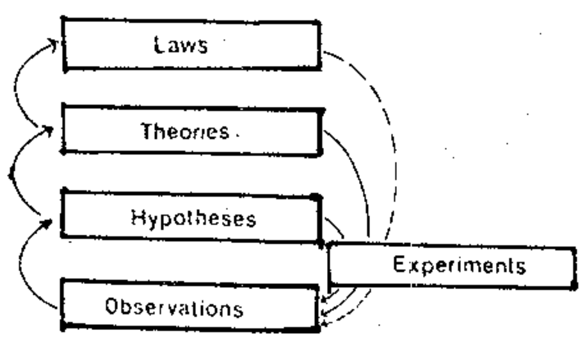

Fig. 4.1 Interrelations between observation, hypothesis, theory and experiment

Science would not have progressed had it confined itself to purely expressions of qualitative nature only or natural phenomenon. Measurements constitute an important tool in all scientific studies. Thus numbers, symbols and mathematics come to represent the life of science. Science not only explains but also predicts. The success of science depends on the success of predictions. It also tests the validity of predictions. But the distinction of scientific prediction lies in its being a constant activity. Also conscious and deliberate attempts are made to state them in as precise terms as possible. Prediction and precision always go together in science.

It is commonly held that science proceeds from observation to theorising. Scientists observe facts and from identifiable regularities of facts they make a generalisation or theory. This is generally true and is called scientific method or Method of Science. But there are certain qualifications to be made to this simple formulation. First, sometimes, a scientist may start with only a guess about nature and proceed towards the formulation of a theory which he tests through experiments and observations. Secondly, observations need not be regarded as more pure than generalizations derived from a series of observations. Sometimes observations may be biased. Thus the process of "Method of Science" is a complex one. The observation-theory sequence can be accepted only with some reservations. However it is undeniable that theory and observation are interdependent.

The most important point is that science did not arise at, all of a sudden one day. Science has undergone a historical process of change. At various stages in evolution, it has acquired various features. This mode of evolutionary change will continue.

Check your progress.

1. Science is not there without ______________________ & ______________________.
2. The different components of "Method of Science" ______________________.
3. Give the diagrammatic representation of "Method of Science"

Technology

The role of technology is central to man's activity and history of man. Archaeology divides human history in various Ages based on the different kinds of technology man developed. The human history is thus divided into **Old Stone Age, New Stone Age** and **Metal Age.** Technology does not mean mere "technique" or "use of technique". "Logos" means reasoning from which the word "logic" is derived. So technology by its name involves reasoning or abstract thinking or in other words, theorising. The story of man's progress is the story of technology. It contributed to man's struggle for survival and growth. But man is not unique in this respect. Other living species were also engaged in this act. In fact many other species are gifted with strategies and mechanisms to aid them in their struggle. These species which have succeeded in survival are biologically more gifted than man. The physical modifications, these species acquired made them extremely efficient in coping with their environment.

Therefore the technology helps the man to compensate for the absence of these biological gifts in man. But nature gave man efficient hands and fertile mind to produce this technology. Thus technology enables man to make himself fit to survive, to protect his life and to facilitate reproduction of his species and also enhance the quality of his life.

Thus technology is man's extra corporeal organ. Technology contributed directly to economic growth namely (1) production of large outputs, (2) discovery of new things, (3) introduction of new commodities and services and (4) qualitative alterations in the old technologies. In human history clothing, tools and weapons took the place of fur, claws and tusks provided by nature to animals. Unlike non-human animal's mechanisms man's mechanisms are not parts of his body. Man can discard his technology if not needed. But animals cannot discard their god given gifts. For example in Ice Ages which lasted for 1000s of years, an elephant species existed. This developed a coat of hair. These were called "Mammoths". These changes were there to protect themselves from severe cold that existed in these Ages. But man made artificial coat made of animal skin to protect himself from cold. Thus both the animal and man succeeded in protecting from severe cold in Ice Ages. But with the onset of hot climate, the same hair coat of mammoth proved to be an obstacle to its survival. On the other hand man could simply throw away his skin coat.

Technology is a cultural phenomenon and technological products are cultural artifacts. Technology includes a cultural expression or style. Technology has a cultural ingredient central to it. Birds and beasts in India are not much different in their equipments from those of, say, Africa or China. The variations if any are only limited to those related to geographical differences. But variations in technology are too multifarious which cannot be explained only by geographical differences. Thus culture and these geographical differences may bring in differences in technology. Each society produces its own type of technology. The technology will have a cultural stamp peculiar to itself. Even in the history of a single society, different types of technology are produced because the type of technology is greatly influenced by the kind of culture which a society has at that time. Thus culture imparts to technology a distinctiveness.

Relation between science and technology has been very close throughout their history. But gradually they have become autonomous and distinct. But there is still a lot of give and take between them. Science provides knowledge concerning the new materials and technology uses this knowledge. Science improves the efficiency and speed of technological innovations. Science is also benefited by technology. For example modern science is impossible without highly sophisticated technology in the form of scientific instruments.

Thus science, culture and technology are intimately related to each other and dependent on each other.

Check your progress.

1. Differentiate the technology of animals from that of human beings.
2. Technology is transmitted to the next generation through ______________.
3. How are science and technology related?

By biological inheritance animals get these protecting equipments from one generation to the other. That is why these are called inherited equipments. The species of the succeeding generation learn the use of these equipments by natural 'instinct' only. But technology is not biologically inherited, but socially transmitted. Therefore technology is called acquired character, but not inherited character. Thus the making of tools and using of them are the results of learning processes but not inherited processes. Thus transfer of technology from generation to generation is a social tradition. This is possible because man learnt "language" a unique mode of communication. Technology is thus preserved and transmitted with the help of "language". Thus without social inheritance technology is impossible and without language social inheritance is impossible. Thus without language technology can not be transmitted. Technology is dynamic in quality. This is the main difference between natural biological gifts of animals and technological assets of men. The methods adopted by non-human species now are not very much different from those adopted some thousands of years ago by animals. But the technologies, strategies and mechanisms adopted by man now are far superior to those adopted by men some thousands of years ago. Thus technology constantly changes and progresses. This change may be slow or fast. But technology does change. Thus technology is dynamic.

Inter-relations between culture, science and technology

It is a mistake to think that science constitutes theory and technology only the practical application of science. Technology draws heavily from science in terms of theories concerning materials and energy resources and use them. But technology has its own theoretical dimensions, independent of what science gives to it. It is therefore not easy to draw a clear separating line between technology and science.

Technology is culture specific. There are as many cultures as there are societies and there are as many technologies as there are cultures. Technology is a subsystem of culture. It is a component of culture like religion, art, science etc.

4.5 SUMMARY

Indian Tradition

1. India's contribution is immense and varied. It is both ancient and modern. The scientific tradition has its origin in vedas. Astronomy, medicine and mathematics were greatly studied by Indian scientists. Astronomy (Jothisha) was inseparable from Astrology.

2. Astronomy was divided into (1) Siddhantha (Astronomy proper), (2) Samhita (Astrology affecting communities) and (3) Hora (Astronomy affecting individual).

3. There were five different schools in Indian Astronomy. They are (1) Brahma or Pitamaha Siddhanta, (2) Paulisha Siddhanta, (3) Romaka Siddhanta, (4) Visista Siddhanta, (5) Saura Siddhanta.

4. Aryabhata revived the first and prescribed it as Aryabhatiya. Varahamihira preferred Saura Siddhanta. But Brahmagupta (7th century AD) perfected Brahma Siddhanta and wrote Brahmaputra Siddhanta. Bhaskaracharya II wrote his astronomical Siddhanta Siromani.

5. They were holding the geo centric theory. But Aryabhata and Bhaskaracharya spoke of heliocentric theory. Indian Astronomers could forecast accurately occurrences of eclipses. They could calculate the circumference of earth correctly.

6. Contributions to medical science are also very important. Ayurveda was considered as vedanga. Dhanvantari was considered as chief god of medicine. He is the physician to gods.

7. Indian medicine was discussed by many works even from 800 BC. Bhela Samhita (800 BC), Agnivesha Samhita (700 BC), Kashyapa Samhita (600 BC) and Chivara Vastry (500 BC) were some of the works which described Indian medicine.

8. Ayurveda considered that body is composed of five dhatus, Vayu, Agni, Ap, Bhumi & Akasa. Life depends on the harmonious activity of first three. Tridoshas arise due to disharmony of three dhatus. These are vata, pitta, kapha.

9. Urine analysis, pulse examination, caesarian operations, cataract operations, plastic surgery were known to Indians. They were using vegetables, animal materials to prepare drugs. Some important medicines are Rauwolfia Serpantina for B.P. and Chaulmugra oil for leprosy. There were many medical publications. These are Agnivesha Samhita, Kashyapa Samhita, Chivara Vastry, Charaka Samhita and Sushruta Samhita. The important medical scientists are Agnivesha, Charaka, Vegbhata, Sushruta.

10. Contributions to physics & chemistry are limited. They developed atomic theory. They knew about gravitational attraction. Acoustics was well developed. Study of chemistry was confined to metals & drugs. Chemical processes such as sublimation, distillation, calcination were known to them. Chemistry gradually changed to alchemy. Dyeing, tanning, soap making, glass, cement and steel manufacture were known to them.

Culture, Science and Technology

11. The totality of human activity can be broadly identified as culture. Culture consists of most general values concerning world, life, society and man. It also consists of values concerning happiness, goodness and beauty of man and society. Culture is characterised by universality and specificity. Exchange of cultures takes place between societies. These are of two types, Free Cultural exchange and cultural imperialism.

12. Science is everlasting interrogation of Nature by man. Science has no specifiable beginning and it will not end. Science explains events or processes in general terms. Science explains phenomena in purely mechanical terms. It is little teleological. Science proceeds from observation to theorising. Method of science involves observations, hypothesis, theories and laws. Experiments function as the required tools.

13. To protect itselves from enemies, animals are gifted with tusks, horns etc. Such things are not possible in men. Yet man is also successful in protecting himself from the environment. Man therefore used his intelligence and hands and created tools. This activity of man is called 'Technology'. This technology is man's extra corporeal organ. Technology is dynamic in nature. Man can invent new technology and discard the old ones.

4.6 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. Give a detailed account of the contributions of ancient Indians to Astronomy and Medicine.
2. What are the major contributions of ancient Indians in the fields of Mathematics, Physics, Chemistry.
3. What is "Culture". Explain its origin and different aspects of it.
4. Explain what is Science and Method of Science.
5. What is Technology? Why is it called as an extra corporeal organ?
6. How are culture, science and technology inter related?

Answer the following in about 15 lines each.

1. Discuss the different schools of thought of ancient Indians on Universe.
2. Who were the famous mathematicians and physicists in ancient India? Mention their contributions.
3. What was the chief medical system of India? Who were the eminent people in this field? What are their contributions.
4. What are tridoshas? How are they caused? What is the result of this?
5. Explain the concept "Culture". What are the components of it?
6. What is Method of Science? Explain.
7. Technology is considered as an extra-corporeal organ. Explain.
8. Bring the interrelation between Science, Culture and technology.

4.7 GLOSSARY

Laprotomy	:	Surgical cutting of abdominal wall.
Logician	:	A person who studies and knows about logic.
Metaphysics	:	Any type of thinking at a high level which is hard to understand.
Metallurgy	:	A process of extracting metal from its ore.
Pharmacology	:	The science dealing with the nature and properties of drugs.
Pyramid	:	A solid structure with a flat base.

Phonetics	:	The science of speech sounds.
Prosody	:	The science of writing of poetry.
Seminal	:	Pregnant with consequences.
Sidereal	:	Referring to a quantity such as time to indicate that it is measured in relation to the apparent, motion of the stars.
Sublimation	:	The process of conversion of a solid directly to vapour.
Spiritual	:	The non-material of the nature.
Teleology	:	View that developments are to the purpose or design served by them.
Tanning	:	A chemical process used to preserve animal skins.

UNIT-5 MODERN SCIENTIFIC REVOLUTION

Contents

5.1 AIMS AND OBJECTIVES

Aims

You learn in this unit-5, about 1) Method of Science, 2) Scientific developments in pre and post Renaissance periods, 3) Industrial revolution and 4) the growth, and maturity of modern science.

Objectives

After you completed the unit you must be able to

1. Understand what is meant by method of science.
2. know how scientific and industrial revolutions took place in the modern times.
3. get an idea about science and its developments in the pre and post Renaissance periods.
4. understand what is meant by Industrial Revolution.

5.2 INTRODUCTION

Many important developments took place in different branches of science during second phase of scientific revolution. You learn in this unit about these developments together with the origins, growth, and maturity of modern science. You also learn about method of science.

5.3 METHOD OF SCIENCE

There is not a single aspect of life that has not been influenced by Science. Science is something more than just learning how to increase industrial or agricultural production or inventing better tools, gadgets, machines, materials or drugs. Science is a way of thinking. It involves observation, insight, reasoning and intuition. Systematic planning and execution of work is very necessary. It gives rise to an attitude of mind. Science gives us culture and philosophy which lead to the pursuit of truth without any bias and pre-judgement.

Science was at one time a personal and a social pursuit. Scientific developments were always influenced by social conditions and demands. Science has a powerful impact on society. It is a vehicle of social change. Scientific knowledge is gained systematically. There is a special method of obtaining scientific knowledge. It is different from the way in which we generally perceive the world around us. You read in unit-4 about method of science in brief. We elaborate in this unit some of the aspects of method of science.

Observations

Every one of us makes so many observations every day from morning till we go to bed. For example we observe that the sun rises in the east and sets in the west. Artists are very keen observers of the world around us. But all these observations can not be called scientific observations. In science we go just beyond the common observation and experience and try to understand how a phenomenon occurs and why it occurs. Scientists therefore decide "what" to observe and "how" to observe. Scientific observations must be unbiased and free from sentiments. Facts must take higher place than the personal views. It is in these respects scientists differ from artists or even lay people. Scientific observations may be about normal events. Observations can be also about man made processes to improve them. Observations can also be concerned with designing and development. This probably may be the major areas where observations are very essential. Observations are also necessary about social phenomena to solve some socio-economic problems. All these observations are made in a systematic and scientific fashion by carefully designed experiments or surveys. The systematic observations are then put to careful analysis. For this purpose the observations are classified, carefully recorded in the form of tables or graphs. The analysis of observations provides us with regularities & patterns present in these observations. Science always progresses through constant questioning. Hence questioning occupies a special place in making observations.

Hypothesis

From the observations we make hypothesis. It is a statement put forward on the basis of reasoning about the results of analysis of observations. The hypothesis is formulated by taking into account all the observations that a scientist makes about a phenomenon. This hypothesis will help to explain the known features of the phenomenon and also to predict the unknown features. Both inductive and deductive logic will be used to formulate hypothesis. If we can infer about the features of the whole phenomenon or the entire elements of a phenomenon through the direct evidence, we obtained, about a part of the phenomenon, we call this as inductive logic. Inductive logic can sometimes mislead us. Suppose we see some fair skinned persons in one part of India and we infer that all Indians are fair skinned, it would become an incorrect inductive logic. Inductive statements may have different degrees of credibility and reliability.

Deductive logic can be considered as the opposite of inductive logic. Here the reasoning is more direct. If we know a statement about a whole phenomena, we can logically deduce the same statement about one part of the whole phenomenon. For example, animals have four legs. Therefore tiger being an animal must have four legs. Deductive logic may also mislead us some times. For example unless we are sure that tiger comes under the family of animals, our deductive logic will fail. Therefore we have to first establish that the part about which we are talking is really a part of the whole about which we made observations.

Thus, whether it is inductive or deductive, logical analysis takes us from the known to unknown. Hence the hypothesis formulated from both kinds of logic or reasoning have to be tested before they are accepted. Therefore we have to specially design experiments to test the hypothesis.

Experiments

Experiment is the main and essential component of method of science. Experiments may be artificially created ones or contrived situations designed to make certain observations under strictly controlled conditions. The objective of an experiment may sometimes be to observe phenomena more minutely by the use of very sensitive instruments. Cause and effect relationships are studied through a great variety of experiments. Great care and intutive abilities are required to design such experiments. The experiments must be such that they give maximum information and reliable information. Such experiments alone may prove or disprove an hypothesis. Sometimes, the results of the experiments may force you to completey reject the old hypothesis and formulate a new hypothesis. At other times experiments give additional information or data which help us to refine or modify an hypothesis. Thus observations, hypothesis and experiments play important roles in method of science.

Laws and Theories

From observations and the results of experiments we obtain a good amount of scientific knowledge. Scientific knowledge is not simply a list of results. A relationship that is arrived at logically between the things covering the results of experiments and observations over a wide range of individual cases is known as Law. Hypotheses are accepted as "Laws" if they are supported by experimental evidences and if there are no exceptions. We know many laws. For example Kepler's laws of planetary motion, Laws of chemical combinations, Laws of thermodynamics etc. We all know about Newton's law of gravitation. A theory is a set of few general statements that describe correctly or explain all experimental observations about the properties and behaviour of varied objects, phenomena, situations or systems. A law or theory can also predict observations. Experiments either validate theories or reject theories.

Thus "method of science", is a chain of operations such as observations, analysis, formulation of hypothesis, experimental observations to verify, modify or reject hypothesis, further analysis and formulation of theory.

The scientific method described above is not restricted to the domain of scientists alone. These characterise an approach called scientific approach to solving problems whether scientific, economic, social or personal. These attributes reflect an attitude of mind which is rational and can be adopted by any one. These scientific approaches form the basis even for solving problems of everyday life.

5.4 PRE AND POST RENAISSANCE PERIODS - AN INTRODUCTION

Renaissance was the transitional movement in Europe between medieval and modern times. It began in Italy in the 14th century and lasted into 17th century. It was marked by the beginning of modern science. It marked a definite and deliberate break with the past. The medieval forms of economy, art and literature were replaced by a new culture, a capitalist economy and a scientific approach. The feudal system dominated by the lords and the church had given way to nation-states. Scientists were patronised by the kings or princes. So scientists did not depend any more on the Church. The ages of faith gave way to periods of hope marked by a frank admission of physical enjoyment. Arts such as weaving, pottery, spinning, glass making, mining, metal-working etc. became respectable.

The pre-Renaissance, that is the period from the tenth century to about the fifteenth century is generally called the middle ages in Europe. In this period Church was the centre of power. It was the common basis of authority. It was an instrument for intellectual expression. All the intellectual activity was carried out by people who were part of the church. Thus the Church dominated all walks of life. Hence Church people needed training to think and write in order to take up missionary work. Hence cathedral schools were set up. These later on in the 12th century had grown into universities. The first university came in this period at Paris in 1160. Then came the Oxford University in 1167 and Cambridge University in 1209 in England. Other Universities such as Padua (1222) and Naples (1224) in Italy, Prague (1347) in Czechoslovakia and several others came later. All these universities were only training people of the Church. Books were not available and hence only lecture methods were followed. The subjects taught were grammar, logic, arithmetic, geometry, astronomy, music, philosophy and theology. There was little teaching about nature or the practical arts. Even the so called "scientific investigation" was undertaken by the people of the Church. This was mainly to justify religious beliefs.

You have read in the units 3 & 4 about the scientific advances made by the *different* traditions in the medieval ages. The medieval European astronomers could not go much beyond the Arab contributions in astronomy. The Arabic algebra and the Indian numerals were the most important in mathematics. Crosseteste (1168-1253) a Bishop and Chancellor of Oxford University was a leading scientist of the middle ages. He considered science as a means of illustrating theological truths. The middle ages as you had learnt in Unit-3 were an era of faith and sentiments. The feudal society was a stagnant society. Therefore its contribution to science was limited. However the feudal society was definitely on a higher scientific and technical level than the slave society of the metal ages. Thus many technical developments took place in medieval europe in the pre-Renaissance even though most of them came from the east especially from china.

Post Renaissance Period

The period lasting between 1540-1760 is considered as post-Renaissance period. This period was marked by great triumphs of experimental approach in science. This new approach together with scientific and technological developments led to "Scientific Revolution". Many technological developments took place during this period. European science grew to maturity in this period only. The first teaching institute of science, The Gresham College was established in England in 1579. The telescope invented around this time proved to be the greatest scientific instrument of this period. Galileo and Kepler could formulate mathematical descriptions of the motions of bodies. Algebra, geometry, decimal system in mathematics and the introduction of logarithm by Napier (1550-1617) greatly simplified astronomical calculations. There were also many other important developments in science in this period. For example theories about magnetism, discovery about the circulation of blood in the humanbody were some of the important achievements. The first well established scientific societies are the Royal Society of London (1662) and the French Royal Academy (1666). The great triumph of the seventeenth century was the completion of the general system of mechanics. Newton's gravitational theory and Darwin's theory of evolution were other great additions to the development of science in this period. There were other developments too in the fields of optics, pneumatics, biology, physics and chemistry. You learn in some more detail about the origin, growth and maturity of science during the period 1440-1830 and after, in the next subsections.

Check your progress.

1. Which factors among the following are responsible for very little advance in science in the european society in the middle ages.
   a) Only church was engaged in scientific investigations.
   b) Expansion of cultivable land.
   c) Shortage of labour due to absence of slaves.
   d) Religious beliefs dominated scientific beliefs.
2. What is Copernican Revolution.

   ....

   ....

3. Name the significant scientific and technological developments during the Renaissance.

   ....

   ....

5.5 MODERN SCIENCE — ORIGINS

Introduction

The period between 1440 A.D. and 1540 A.D. falls in the period of 'Renaissance'. Economic regeneration accompanied intellectual regeneration. A small and conscious minority of scholars and artists called 'Humanists' rejected the pattern of medieval life and created a new pattern of life. The humanists encouraged the appreciation of the beauty and sublimity of the classical works of art and philosophy. This humanistic movement opposed all authoritarian tendencies including that of organised religion. It emphasized the free development of the individual. The humanists thus created a climate that was helpful to the birth of the most creative ideas of science.

The Renaissance thinkers made a clear break with the past. Of course, they looked to the past for inspiration and guidance and sometimes actually got it. But instead of imitating the past they made a creative response to it. In this process they got the best out of introduction. Since theirs was creative relation with the tradition they could not be hampered or stifled by it. It is because of this they surpassed not only the medieval scientific tradition, but even the great Arabic tradition of science. They, in fact, inaugurated a new era. Moreover, the pursuit of science was closely followed by its practical application. The importance of the realisation of the scientific theories in practice was widely acknowledged. Thus the Renaissance thinkers by their equal emphais on theory and practical application of science laid the foundation for the unity of theory and practice. This is characteristic of science in modern times.

Scientific Revolution - Birth of Modern Science

The period 1440 - 1540 A.D. is considered to be the period of birth of Modern Science. During this period revolutionary changes have taken place in the fields of science and technology. Now we will study how the foundations were laid to the different branches of science and technology in this section.

Astronomy

Astronomy made a decisive break with the past. The astronomer responsible for this new view was Nicholas Copernicus (1473-1543). He put forward a system of spheres centred round the sun rather than the earth. Assuming the rotation of the earth he showed in detail how the new picture could account for almost all astronomical observations.

The history of astronomy in the West brought out three views regarding the movement of heavenly bodies. 1. The theory of Eudoxes improved by Callippus. 2. The theory of Hipparchus improved by Ptolemy and 3. The theory of Aristarchus. 1 and 2 were geostatic and geocentric theories while 3 was heliocentric theory. Theory 1 postulates a system of concentric spheres. Each - the sun, the moon was considered to be fixed on the equators of separate spheres. These spheres rotated upon their axis. The ends of the axis of rotation were fixed in another sphere which was also rotating with a different period and a different axis. Eudoxes and his followers attributed the different types of motion exhibited by some planets to their being able to exist in more than one sphere. By postulating a suitable number and proper combination of spheres, Eudoxes and his followers accounted for the variety and irregularity of the motion of heavenly bodies. In this scheme the earth was at the centre and at rest.

The second theory was set forth by Hipparchus although it came to be known after Ptolemy who ably elaborated it. This theory too is geocentric and geostatic. It made use of techniques like 'epicycle' and 'deferent' in place of concentric spheres to explain the irregular motion of planets. Thus Ptolemy explained the observed irregularity of planetary motion choosing proper sizes for the epicycle and deferent and the relative speeds of rotation of the two circles. All his followers upto the time of Copernicus concentrated on making proper adjustments so that the picture conformed to the observed irregularities of planetary motion. In the process, the theory became too complex and too cumbersome to be practicable. The scholars thus were required to choose between theory of Eudoxes and the theory of Ptolemy which held the field till that time. But, in the course of time Ptolemy's theory became the more dominant of the two and astronomy became Ptolemic astronomy. Later Copernicus replaced the theory of Ptolemy by his heliocentric theory. In doing so, he was reviving the theory of Aristarchus who as early as the third century B.C. has put forward a similar view.

Copernicus did not publish his work when he completed it in 1530, since he was afraid of being punished by the Church which had firm faith in Ptolemy's theory. The work was, however, published in 1543, the year of his death. This theory of astronomy was the first product of Renaissance and the difficulties experienced in respect of it later were resolved by Kepler and Galileo.

Geography

A break through in geography was due to the enormous improvement in navigation. The impetus to navigation was provided by the increase in trade, which was in turn stimulated by the opportunities created by navigation. The result was the undertaking of great voyages by famous navigators of which **Columbus and Vasco de Gama** were the best known.

Ship-building became a huge industry and navigation schools were also established. Both in theory and practice navigation made extraordinary progress which contributed to the development of the science of geography. The accounts of Americo Vespuchi and Pigafetta would be found interesting even today. The new geographical knowledge of the world created a great enthusiasm among the geographers. **Jean Fenal** who was the first in modern times to measure the degree of the meridian declared that his age far surpassed even the classical world of Greeks because of the newly won knowledge of unknown regions of the world.

Chemistry

The progress in chemistry was no less extraordinary. Chemistry developed on account of the smelting of metals. Metals like zinc, cobalt and nickel were studied and the chemical studies of oxidation, reduction, distillation and amalgamation paved the way of a general theory of chemistry. The most important chemist of the times was **Von Hohenheim** or **Paracelsus** (1493-1541). He learned both medicine and chemistry. He founded the new school of 'latro chemists' (chemical doctors). He showed his opposition against tradition by openly burning the books of **Galen** and **Avicenna**. He was undoubtedly benefited by the works of Arab chemists and the medieval chemist, **Raymond Lull**. But he modified their views considerably. The old chemistry following the Arab chemist, **Gaber**, held that all metals were made out of sulphur and mercury. **Paracelsus** added neutral salt to the list and put forward "The Three Primary Substances Theory" as the basis of his spagyric chemistry. He is one of the great figures in the history of chemistry. Though his views on chemistry were somewhat mystical and animistic, he emphasised the medical purpose of chemistry, which gave a new direction to the story of chemistry. Thus, he helped in the abandoning of the search for gold in favour of the search for health as the aim of chemistry. In this way, he freed to some extent, chemistry from the clutches of alchemy.

Check your Progress.

1. Renaissance had its effect on ____________
2. Copernicus put forward ____________ theory.
3. How did Paracelsus differ from other chemists at that time?

Medicine

The achievements in medical science were as impressive as those in astronomy. It is significant that the bilogical work during the Renaissance period centred on medicine. The universities, especially those in Italy, had very able medical scientists. The medical scientists of that time rejected all 'authorities' of the past and adopted a totally experimental approach. This fresh approach brought into being a new anatomy, physiology and pathology. Two scientists were responsible for this breakthrough in medical science, **Jean Feshel,** who was both a geographer and a doctor, and **Adreas Vesalius.** The later stands out as the father of modern medical science. Significantly, his work **"De Humani Corporis Fabricus"** was published in the same year as the great work of **Copernicus.** Like the work of Copernicus this is an important one. It has given a complete description of all the organs of the human body. He founded a medical school at Padua in 1537 and it had become a radiating centre for medical ideas. Judged by any standards his work is outstanding because of its accuracy of description, richness of observation and beauty of exposition.

Technology

The Renaissance period 'capped' its glory in science with equally glorious achievements in technology. Mining, metallurgical and chemical technology progressed by leaps and bounds. The knowledge gained in power transmission and pumps laid the foundation for the formulation of significant mechanical and hydraulic principles. The most outstanding technologist of those times was the great **Leonardo da Vanci.** He is undoubtedly one of the greatest painters, architects and engineers of all times. Without an account of his outstanding achievements the story of Renaissance will be incomplete. His note books reveal the keenest observations of the operation of metal workers and engineers. He was a great master of mechanics and hydraulics. He even conceived the idea of mechanical flight. His work in this connection is a classic of engineering research, combining observation of birds and their flight with the making of mechanical models and calculation. **Leonardo** constructed many machines, but not one of them worked because at that time there was no prime mover like steampower. **Leonardo** did not have the quantitative knowledge of statics and dynamics needed for success in this regard. But he had a clear conception of the idea of machine and a firm grasp of the form of anything he encountered. His treatise on painting and his painting themselves are unsurpassed even today. His profound study of anatomy and physiology of every part of the body including the brain and internal organs as reflected in his paintings will be found amazing even today. He personified the creative spirit of the whole age of Renaissance and stands out in the whole galaxy of Renaissance thinkers as the most original and creative.

Check Your Progress

1. ____________________ is considered to be the father of modern medical science.
   (a) Jean Feshel
   (b) Andreas Vasalius
   (c) Raymond Lull
   (d) Vasco de Gama
2. ____________________ personifies the spirit of whole age of Scientific Revolution.

5.6 MODERN SCIENCE - GROWTH AND DEVELOPMENT

Introduction

The second phase of the history i.e. roughly from 1540 to 1650 A.D. of modern science began in the middle of the 16th century and continued till the middle of 17th century. It is characterised by many important developments in science. The most important are the development of the Copernican system by **Kepler** and **Gelileo**, the discovery of circulation of blood by **Harvery** and the path-breaking work in the study of magnetism. And above all the expressing of the method of science by **Becon** and **Descartes** is the significant fact, prominent developments occured in astronomy and physics.

Scientific Revolution - Growth and Development of Modern Science

During the period 1540 to 1650 AD important developments have taken place in the fields of science and technology. Remarkable achievements were made in the fields of astronomy and physics. We will discuss them in detail in this section.

Astronomy

The astronomical theory of **Copernicus** began to attract the attention of the other astronomers of the time. Some astronomers were attracted to it because it was simpler and neater than that of **Ptolemy**. It was more helpful to the drawing of astronomical tables. They rightly interpreted that the universe was infinite and not finite as **Aristotle** and his followers thought.

The Copernican theory needed strengthening, refinement and even reformulation. The theory lacked in its first form (given by Copernicus) an accurate description of the orbits of the planets and convincing arguments to justify the imperceptibility of the motion of the earth. The former task was achieved by **Tycho Brahe** (1546-1601) and his assistant, **Johannes Kepler** (1571-1630). **Tycho** had his own theory of astronomy according to which the sun moved around the earth and the planets around the sun. He adopted this theory because he thought that it did justice to the most important observation of his. He was a keen observer of astronomical phenomena and made brilliant observations. These shattered the old theory to which he partly subscribed in-so-far as he was believer in geo-static theory. They also helped Kepler in making his great contribution.

Kepler analysed Tycho's meticulous observations of mars and found that the path of mars was elliptical rather than circular. Copernicus shared the ancient belief that the heavenly bodies ought to move in circles, since the circle is the most perfect figure. **Copernicus** theory with its circular orbits created difficulties because many astronomical observations could not be fitted into it. So Kepler who had a fine mathematical sense and who drew on Tycho's meticulous observations of planetary motion worked out a new system of orbits, viz., the system of elliptical orbits. He gave three laws of planetary motion which are known as **Kepler's laws**. These laws are :

1. All planets move in elliptical orbits having the sun as one focus (the law of orbits).
2. A line joining any planet to the sun sweeps out equal areas in equal times (the law of areas).
3. The square of the period of any planet about the sun is proportional to the cube of the planet's mean distance from the sun (the law of periods).

The next great figure is Galileo, one of the greatest scientist of all times. Galileo completed the revolution started by Copernicus, making use of the telescope. The telescope brought heavens down to earth so that sun, moon and stars could be more closely examined. He provided new observational evidences against Aristotle and Ptolemy. He found on the moon what resembles seas and mountains. As per his observations, the planet venus showed phases like the moon, saturn looked like a divided 'body'. The sun exhibited spots on its body. The changes in the position of the spots indicated the sun's rotation on its axis. Most importantly, jupiter appeared to be circled by three stars or moons and looked like miniature representation of the Copernican system. Again, so many new stars were found that the solar system appeared to be just a small portion of an infinite universe.

All these observations went against the old theory. Aristotle's whole physics appeared to be falling like a house of cards. The heavenly bodies looked farless heavenly. Our moon did not seem to be alone and unique. The universe itself did not appear finite. But Galileo understood that however damaging these observations were to the basic principles of Aristotle, they were insufficient to fulfill the real need of the Copernican system. It was necessary to explain how the rotation of the earth could occur without a mighty wind blowing in the opposite direction. This led him to the consideration of the problem of motion of bodies and enabled him to make seminal contributions to dynamics (the study of motion due to force). He performed many experiments, sometimes for the purpose of illustrating (for explaining to other) and sometimes for the purpose of explaining it (for ascertaining the truth of what he thought). More than that, he gave a mathematical orientation to his findings. According to him, the language of nature was mathematics. In applying his mathematical knowledge to the problem of falling bodies, he faced a number of difficulties. He had to work out new ideas almost at every step. Galileo studied the problem of the falling bodies. He showed that in the absence of air, bodies which are thrown up come down following a parabolic path. In doing so, he used the methods of science.

Galileo showed, in opposition to the theory of Aristotle, that the velocity of falling bodies was independent of their weight. Interestingly, Aristotle and all the other scientists till then thought that the velocity of falling bodies was dependent on their weight. The refutation of this old theory was important to the Copernican theory. Its opponents argued that if the earth were moving then things on earth which are far less in weight than the earth would be left behind, since velocity is proportional to weight. Galileo met this objection by showing that the weight of the body has nothing to do with the velocity. He answered another objection to the Copernican view. The opponents of the Copernican theory asked what the reason was that they did not experience the effects of the tremendous speed with which the earth was said to move. In answering it, Galileo gave the example of a ship. In a room below the deck, people sit and eat, move and jump, fish swim in tubs, gnats fly and smoke ascends while the ship is motionless at anchor. The things won't change it. The opponents of Copernicus challenged his followers to explain how the earth which is made of dead matter could move continuously without a pusher. He was asserting that motion was as much a natural state of matter as 'rest' and there is nothing 'dead' about matter. In doing so, he was erasing the sharp line drawn by Aristotle between the 'heavenly' world and the 'earthly' world. Galileo was indeed, laying the foundation for the conception of one world made up of the same stuff. The idea of 'inertial motion' was to become an important part of the basis for the great system of Newton. Newton himself acknowledged that Galileo was one of the foundning fathers of modern physics.

Physics

The developments in physics and astronomy received a tremendous impetus from the brilliant studies on the magnets made by **William Gilbert**, who was a physician by profession. **Gilbert** published his great work **De Magnete** (The Magnet) in 1600. This work broke new ground in the attempt to understand the properties of the magnet. Gilbert's work exhibits both his experimental ingenuity and his theoretical insight. The most significant contribution of Gilbert was his recognition that it was the magnetic virtue of attraction that kept the planets on their courses, thus Gilbert paved the way for the physical explanation of planetary order.

Mathematics

The achievements in astronomy and physics during this period were, obviously, due to the great strides made in mathematics. **Galileo** and **Kepler** were themselves brilliant mathematicians. They had mastered the new mathematics that had emerged through the work of the outstanding mathematics of period. **Vieta** (1540-1603) found the way of symbolically representing equations with known and unknown quantities in algebraic and trigonometric arguments. **Gardan** and **Tartaglia** further helped the algebraic methods to be used for solving problems involving numerical quantities. **Simon Stevin** (1548-1620) introduced decimals and **Napier** (1550-1617) the logarithms in 1614. These contributions enormously helped the physicists and the astronomers in simplifying and shortening their computations.

Cneck Your Progress

1. Mention the names of the scientists who developed the heliocentric theory of Copernicus.
2. Mention Kepler's laws on the motion of planets.
3. Galileo invented __________________________.
4. The velocity of falling bodies is _______________________ of their weight.
5. Match the following :

(a)	William Gilbert	( )	1. Equations of known and Unknown quantities in algebra and trignometry.
(b)	Napier	( )	2. Decimal system
(c)	Simon Stevin	( )	3. De Magnete
(d)	Vieta	( )	4. Logarithms

Chemistry

In chemistry there was not much progress during this period though there were routine improvements in connection with the measurement and observation of chemical phenomena and distillation. But the period was noted for the contribution made by an outstanding chemist, **Von Helmont** (1577-1644). He made studies on the nature of gas and his extraordinary insights paved the way for the birth of modern chemistry.

Biology

This age was marked by perceptive studies in biology particularly of the human body. Just as the heavens had lost their spiritual character and become amenable to mechanistic explanation, the human also began to be understood in a mechanistic manner. The scientists came to regard the human body not as one influenced by mysterious forces and unseen spirits but as a machine endowed with mechanical parts like bellows, pumps and valves. Galen had left a valuable account of the human body. But his picture of the body was aministic. It was **Vesalius**, the father of modern anatomy, who disclosed the real structure of the human body. The scientists began to give mechanistic explanations for the human body which was stripped of its animistic character by Vesalius. The most important of such medical scientist was **William Harvery** (1578-1657). He attempted to give mechanistic explanation for the movement of blood in the body. His book on the circulation of the blood published in 1628 was ahead of the work of Vesalius. Vesalius had only given a description of body through meticulous dissection. Harvery claimed that the blood must circulate because it went out of one side of the heart and came back through another. Harvery thus drew his picture of the human body on the lines of a hydraulic machine.

Views on Matter

Science in this period progressed not in respect of the infinitely vast celestrial world, but also in that of the infinitely small world of atoms. The exploration of the micro-cosm began with a French priest who was a genius in both physics and mathematics. His name was **Gassendi** (1592-1655). **Gassendi** revived the atomic theory of **Democritus**. He thus refuted the Aristotle's view that matter was continuous and not discrete. He asserted that matter was made up of discrete particles called atoms. The atoms, are capable of continuous motion for which God is not needed except for the initial impulse. Thus he showed that the world did not need the continuous intervention of God but only the initial move after which the material bodies, i.e., atoms, would look after themselves. Gassendi's definition of atom was so perfect that Newton borrowed it word for word.

Check Your Progress

1. According to Gassendi the matter is made up of ______________________.
2. Mention the chief contribution of William Harvey in the field of medicine.
3. Von Helmont conducted the studies on ______________________.

Views on Scientific Method

Apart from the most significant breakthroughs in individual sciences, the period under consideration produced two important philosophers, **Francis Bacon** and **Rene Descartes.** These two expressed very ably the new spirit of science.

Bacon's Views

Bacon gave the slogan "knowledge is power". He urged upon his contemporaries to give up dogmas of all kinds, including the theological ones. He identified the merit of the new science with the importance it gave to observation and experiment rather than to authority. He thus identified and named what he thought to be the method of science. According to this method one should start with observational data, suggest a hypothesis on the basis of these data and verify the hypothesis with the help of observation. If the observation does not go against it, it becomes a law. The importance of this law is in the fact that it enables one to go from the observed to as yet unobserved facts. The collection of observations and formulation of laws connecting them was the cherished aim of Bacon.

Descartes Views

Descartes is that of modern philosophy. Descartes reduced the whole world into two independent substances, matter and spirit. According to Descartes, matter has only one property extension. He claimed that the other properties like colour, taste, odour, etc., were not inherent properties of matter. In this, he helped in the formation of the theory of matter which is the basis of modern physics. According to this theory, matter is made up of particles which have no qualities like odour, taste, colour etc., but have only extension or magnitude. Descartes made considerable contributions to mathematics and physics. His major mathematical contribution was the founding of coordinate geometry. He showed how a curve could be completely represented as an equation relating the values of the co-ordinates of its points referred to as fixed axes. Even to-day these co-ordinates are called 'Cartesian co-ordinates' after Descartes. Descartes advocated a method of science that was different from the one advocated by Bacon. He urged the scientists not to stop at observation but go deeper into reality to explain the observed in terms of the unobservable. Modern science followed both Descartes and Bacon. It combined both methods though sometimes it titled towards the one or other of them.

Check Your Progress

1. In the scientific world Bacon and Descartes are remembered for their views on ______________________.
2. Who said "knowledge is power".
   (a) Garden
   (b) Rene Descartes
   (c) Tartaglia
   (d) Francis Bacon
3. State Bacon's view on the method of science.

....

....

....

....

4. According to Descartes matter consists of ________________________ and has the property ______________________________ .

5. Descartes was the founder of
   (a) Mathematics
   (b) Physics
   (c) Co-ordinate geometry
   (d) None of the above

The scientists came to realise that human body is not influenced by mysterious forces and unseen spirits. They looked at it as a machine endowed with mechanical parts like bellows, pumps and valves. It was **Vesalius** who disclosed the real structure of the human body. **William Harvey**, the medical scientist began to give mechanistic explanation for the movement of blood in the body.

There was not much progress in chemistry. Chemical processes such as distillation were greatly improved. **Von Helmont** was the noted chemist of the times. He studied the nature of gases. His extraordinary insights paved the way for the birth of modern chemistry.

The period has produced two important philosophers, Francis Bacon and Rene Descartes. These expressed the new spirit of science. Bacon gave the slogan "Knowledge is Power". But he used science to bring about material changes in life. He thus laid the foundations for use of science in industry.

5.7 MODERN SCIENCE - THE PERIOD OF MATURITY

Introduction

During this period (1650-1700) modern science passed from the stage of adolescence to the stage of full-blown adulthood. This was the result of an extraordinary outburst of scientific activity. The scientists most responsible for it were **Boyle, Hooke** and, most importantly, **Sir Isaac Newton**. Moreover to encourage this activity scientific societies like the Royal Society of London and the Royal Society of Paris came into existence. Many enthusiastic groups and individuals started organisational establishments for the propogation and practice of science. Science became a recognised activity in the society.

Scientific Revolution - The period of Maturity

The period 1650-1700 AD is considered to be the period of maturity of modern science. During this period the modern science has taken giant strides. Let us discuss these developments in detail, in this section.

Astronomy

The astronomers of this period faced two problems : (1) the determination of longitude and (2) explanation of the planetary motion. The first one was immediate importance to navigation. The second was of fundamental significance to the theoritical understanding of the astronomical world.

As navigation played an important role in both military and trade pursuits, its needs became all the more pressing. An important need of navigation was the determination of the position of a ship at sea. The question of determining longitude is essentially one of determining 'absolute time' at any given place. Today 'absolute time' is called 'Greenwich mean time'. By comparing it with local time we get a time-interval which can be converted to longitude. But the question was how to determine the Greenwich mean time at a given place. Before the invention of radio, there had been two methods. One, by the help of the clock in the sky, viz., the motion of moon and other by an accurate clock set at the time. The first method needed the preparation of the accurate astronomical tables and the second the development of accurate clock mechanism. Again, the machines must not be upset by the motion of the ship. **Hooke** invented the spring-controlled balance wheel for the pendulum and thus cleared the path for the invention of clock. But still, there was the need for understanding the laws of motion of bodies in oscillation (like pendulum). **Huyghens** solved the problem. He made an indepth study of the principle of pendulum clocks. On the basic of the theoretical work of Huyghens and practical invention of scientists like Hooke, sophisticated clocks came to be invented. Significantly, the other method of measuring the absolute time by using the celestial clock viz., the moon, was also pursued. This called for an understanding of the celestical bodies. So many scientists began to explore the ways of explaining planetary motion. **Kepler** did not have the concept of force. Later, scientists began to attribute the motion of planets to some sort of a force, which produces elliptical motion of the planets. The final explanation came from **Newton** and **Hooke**.

In the meantime **Newton** was engaged in the investigation of terrestrial motion, the motion of bodies near the surface of earth. He was thinking about the reason for the tendency of the bodies to move towards the earth when they are thrown up or when they are left in space without support. Till then it was thought that the bodies have a natural tendency to move towards the earth. But Newton was not satisfied with such explanations as those in terms of 'natural tendency'. He and Hooke thought there is a force of attraction that the earth and the bodies exert on each other and that this force has something to do with the weight of the body. It is important to note that by that time Gilbert had spoken of the earth as a magnet. Hooke proposed that force of attraction between two bodies depends upon the distance between them. In the light of these views, Newton was able to formulate the idea of gravitation and mathematically express it as a law. He was convinced that this law held good not only for the motion of bodies near the surface of the earth but also for the motion of heavenly bodies as well, but it needed a great deal of mathematics to establish itself as a substantial scientific idea.

Newton derived Kepler's laws of planetary motion from his three laws of motion and his law of gravitation. He also explained on the same basis the laws that govern the fall of bodies on the earth's surface. This system of Newton is called classical mechanics. This grand system is a synthesis of terrestrial mechanics and celestial mechanics. It was set forth in his Principles of Natural Philosophy, published in 1687. This work is the Bible of modern science. Thus Newton may be regarded as the father of modern physics in the strictest sense of the term.

Physics

The glorious success of physics in mechanics was accompanied by less glorious but very important successes in other fields of physics. The most important of such fields is optics-the science of light. The discovery (or rediscovery) of telescope in the beginning of 17th century has give rise to a renewed interest in optics. The scientists needed to improve the quality of the telescope. To accomplish it, it was necessary to understand the principle underlying the 'telescope'. Scientists like **Snell** made impressive progress in this regard. But the telescopes in use could not be improved upon beyond a certain point. The images of stars produced in the telescope were surrounded by coloured halo which testified to the fundamental imperfection of the existing telescopes.

Newton made further study of colours. His inquiry into various aspects of light led him to the conclusion that light, like matter, was made up of grains, or particles or corpuscles. But another scientist, **Grinaldi** (1618-1663) put forward a different view of light. According to him light had a wave like character resembling the ripples in water. **Huyghens** developed Grinaldi's idea mathematically and presented his wave theory of light as rival of Newton's corpuscular theory of light. For some time Newton's theory prevailed. But later it was replaced by a theory of light similar to that of Huyghens.

Another important achievement of the optics of the period is the invention of microscope. Men like **Malpighi, Hooke** and **Leeuwenhock** opened the doors of microscope world. The microscope revolutionised the biological sciences.

Apart from these brilliant achievements in optics, the period witnessed penetrating studies of elasticity, vacuum and gas. **Hooke** studied 'elasticity' and discovered what is called Hooke's law according to which extension is proportional to force. But the main impetus to the development of pneumatics, the science of vacuum was given by Boyle. He was led to the study of vacuum because of his interest in the atomic theory of which he gave his own version. The decisive step in the development of pneumatics was taken with the actual production of vacuum. This feat was achieved by **Torricelli** who constructed the barometer and gave a bold explanation of its working in terms of vacuum and air pressure. It was a bold explanation because the ancient physics had no room for the concept of vacuum. Toricelli's explanation was experimentally confirmed by **Pascal**.

One of the most significant events of the history of pneumatics was the creation of vacuum by Von **Guericke** who invented a special device called air-pump for the purpose of producing vacuum. It was improved upon by Hooke and Boyle. Using the air-pump Boyle discovered very important scientific truths. For instance, he showed that air was needed for sound to travel but not for light and magnetic effect.

Check Your Progress

1. Greenwich mean time is ________________________________.
2. Hooke's work on spring controlled balance led to the invention of ________________.
3. Newton's laws explain
   (a) the motion of heavenly bodies
   (b) the fall of bodies on the earth's surface
   (c) both (a) and (b)
   (d) none of the above.
4. Newton is considered to be ________________________________.
5. According to Newton, light is made up of ________________________.
6. According to Grinaldi and Huyghens light has ____________________ property.
7. Match the following :

(a) Hooke	( )	(1) Science of Vacuum
(b) Boyle	( )	(2) Elasticity
(c) Torricelli	( )	(3) Air pump for vacuum
(d) Von Guericke	( )	(4) Barometer

Chemistry

It was the same Boyle who made great strides in chemistry. In his classic, **The Sceptical Chemist**, he made a vigorous attack on alchemy and thus freed chemistry from the tyranny of alchemic superstitions. Boyle was first in the history of chemistry to formulate the idea of a chemical element as a basic substances that cannot be broken down further by any means. He also knew that the number of such basic substances was much smaller than that of compounds composed of these basic substances. He laid the foundation for modern chemistry. This is responsible to turn chemistry into a modern science and a most formidable one at that time. The inroads made by the new atomic theory into chemistry brought chemistry very close to physics. They came in the course of time so close to each other that today they together determine our inquiry into the nature and structure of the physical world. Chemistry has another significance. The discovery of the chemical basis of life brought chemistry very close to biology. Biology and chemistry together form a twin-inquiry into the nature of life. Hence, chemistry remains in the fore-front of the inquiry into both physical world and biological world. It is bound to play pivotal role in our attempt to come out with a picture of the world which combines matter and life within a single unity. The foundations for such a pivotal role were laid in the 17th century by freeing it from the tyranny of alchemy.

He also showed that combustion was impossible in vacuum which was a discovery of great significance to chemistry. Boyle also worked out his law concerning the behaviour of gases. He showed that the product of the pressure and volume of a gas was constant for any given temperature. Therefore, the pressure is inversely proportional to the volume.

Biology

This invention of microscope helped the science of biology to develop. Just as telescope pushed the frontiers of astronomy further, the microscope made the progress of biology possible. The biologists began to see microscopic life which were until then unseen by man. Insects, the minutest parts of plants, the unseen creatures living in water, the invisible bacteria, the spermatozoa (the principles of reproduction) became objects of wonder. The recognition of the role of spermatozoa in reproduction was a critical advance. Also, there occured another breakthrough in the understanding of the structure of the living matter. Hooke in his "Micrograpia" gives the first systematic account of the microscope world including the discovery of the cells. Other important achievements of the period were (a) confirmation of Harvey's theory of circulation of blood by Malpighi. He showed that blood flowed through fine capillary (hair-like) vessels, (b) Borelli's explanation of the movement of limbs in terms of mechanical principles, (c) the laying of the foundations of plant physiology by Nehemiah Grew and (d) the scientific classification of plants and animals by John Ray. Significantly, the biological science has since the birth of modern science continuously been attempting to free itself from semi-animistic notions. With the passage of time it came closer and closer to physics and chemistry.

Views on Matter

Newton formulated another theory called the atomic theory. Many scientists like Descartes, Gassendi and Boyle had advocated the atomic theory of matter. Newton improved upon their views. He came out with a theory of atoms according to which atoms have hardness and mass and are endowed with the force of attraction and repulsion. With this, Newton completed the new picture of the world which replaced the old picture of Aristotle. In spite of all the criticisms made against it, Aristotle's picture of world had continued to hold good because there was no other picture as complete as his. With Newton, a new completed picture emerged and got established. Newton gave a unitary picture of the world which fused all phenomena, terrestrial and celestial, into one. The four laws and the atomic theory had the effect of bringing the whole world into one unity. It appeared as one huge machine, running like perfect clock. The finite, hierarchical and teleological cosmos of Aristotle gave place to the infinite, unitary and mechanical universe of Newton.

Check Your Progress

1. Mention briefly the contributions of Boyle to the Chemistry.

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2. Biology made tremondous progress due to the invention of ____________________ .

3. Match the following :

(a) Hooke	( )	(1)	Blood circulation through capillaries
(b) Malpighi	( )	(2)	Foundation to plant physiology
(c) Borelli	( )	(3)	Discovery of Cells
(d) John Ray	( )	(4)	Mechanistic approach to the movement of limbs
(e) Nehemiah Grew	( )	(5)	Classification of plants and animals.

4. State Newton's atomic theory.

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5.8 INDUSTRIAL REVOLUTION

Industrial revolution took place during 1760 and 1830 and after. By the middle of the eighteenth century, the slow and gradual changes in the production of goods gave way to rapid changes. The new methods of experimental science that emerged from the scientific revolutions of the sixteenth and seventeenth centuries have been extended to the whole range of human experience. Their applications in the fields of material production led to what we call Industrial Revolution. The industrial revolution came from the major industries such as textile industry, metal and metal-alloy industry etc. The textile industry paved the way for textile machinery industry as well as iron and chemical industries. All these industries required coal as a fuel. Therefore new developments in coal mining and transport took place. The use of steam engine for power in textile industry really created the industrial complex of the modern world. The principle of mechanization rapidly spread to areas such as mining metallurgy and agriculture. As the industrial production of materials reached its maximum height it became necessary to have new means of effective and quick transport to cover long distances. Therefore the steam engine which was used as a static device was put on rails to draw heavy loads over long distances. Thus railways came into existence and linked the industries and also helped in the distribution of furnished products far and wide. Thus 18th century was considered as the century of "production" and 19th century was named as the century of "communications". Electricity was used till 1737 to send messages for distances of few kilometres. But it is very essential that communications reach very long distances. To meet this requirement telegraphy was invented in 1837. Soon wires were laid for special communications between towns separated by long distances and also between the countries. In 1866 telegraphic links between Britain and America were established by using cable wires. Within hundred years from the beginning of Industrial Revolution, factory towns had come up and even the rural areas registered great changes. The lives of millions of people changed completely in the industrial countries such as Great Britain, France, Germany, Holland and America. Mechanization paved ways for "division of labour", but at the same time increased human drudgery, reduced requirement of mental involvement and made human beings work like machines. Industrialisation increased the production multifold. More surplus yields brought more profits. The capital got multiplied very rapidly. This helped to put up more machines for more production. All that is produced must be sold and hence market expanded enormously. But home markets suffered in the process because they did not have money to buy the products. Hence came the problems of "Supply and Demand" and "Production and Sale". Moreover in early industrialisation workers were exploited. This eventually gave rise to trade unions and workmen's struggle to improve their lot. With increase in production, the cost of production came down. Goods were sold cheaply and this indirectly ruined local industry. The colonial governments also went out of their way and demanded that people should buy imported goods only for the sake of quality. But with all this, Science did not play as as much in industry as the technology played. But technological understanding and design of machines depended on science. It would be therefore very interesting to explore the relation between science, technology and society in the present day world. Hence to achieve this, one should be exposed to the knowledge about different branches of science.

In this context the study of problems of health, food, agriculture and industry occupies an important place. You learn about these things in the units covered in other Blocks.

Check Your Progress

1. Mention the names of the scientists who developed the Heliocentric theory of Copernicus

2. What are Kepler's laws of motion of planets.

3. Galieleo invented ____________

4. Match the following :

(a)	William Gilbert	( )	(1)	Equations of known and unknown quantities
(b)	Napier	( )	(2)	Decimal system
(c)	Simon Stevin	( )	(3)	De Magnete
(d)	Vieta	( )	(4)	Logarithms

5. According to Gassendi the matter is made up of ____________ .

6. What are the chief contributions of William Harvey in the field of medicine.

7. Von-Helmont conducted the studies on ____________ .

8. In the scientific world Bacon and Descartes are remembered for their view on ____________ .

9. State Bacon's views on the method of science.

10. According to Descartes matter consists of ____________ .

11. Greenwich mean time is ____________ .

12. Explain Newton's laws.

13. According to Newton, light is made up of ____________ .

14. According to Grinaldi and Huygens light has ____________ property.

15. Match the following :

(a)	Hooke	( )	(1)	Science of Vacuum
(b)	Boyle	( )	(2)	Elasticity
(c)	Torricelli	( )	(3)	Air pump
(d)	Von Guericke	( )	(4)	Barometer

16.What are the contributions of Boyle to chemistry.

....

....

....

17.Biology made tremondous progress due to the invention of ________________.

18.Match the following :

(a)	Hooke	( )	(1) Blood circulation
(b)	Malpighi	( )	(2) Plant Physiology
(c)	Boreli	( )	(3) Discovery of Cells
(d)	John Ray	( )	(4) Mechanistic approach of limb
(e)	Naherniah Grew	( )	(5) Classification of plants and animals

5.9 SUMMARY

1. The period between 1440 AD and 1540 AD falls in the period of Renaissance.
2. Renaissance thinkers made a clear break with the past.
3. The feudal society did not allow significant growth of science in europe in the middle ages.
4. The hallmark of Renaissance was the rejection of medieval thought.
5. The Copernican revolution was an important scientific development of the period.
6. The post-Renaissance period was a period of the emergence of a new method of science, that of observation and experiment.
7. The foremost advances in science in this period were due to Galielo, Harvey and Newton.
8. The industrial revolution in Great Britain radically changed the means of production.
9. With this a transition took place from a feudal society to capitalist economy.
10. Nation-State concept replaced the social system existing.
11. There was a great departure from the past in the field of astronomy. Nicholas Copernicus was responsible for this and he putforth his heliocentric theory.
12. There were three views regarding the movement of heavenly bodies in the west. These were (1) Theory of Eudoxes, (2) Theory of Hipparchus and (3) Theory of Aristarchus.
13. Metallurgical processes were mainly responsible for the progress in chemistry. The most important chemist was Paracelsius. He was mystical and animistic.
14. Experimental approach was adopted in place of authoritarian approach. Anatomy, physiology and pathology developed to a great extent.
15. Lean Feshel and Andreas Vesallins were responsible for the break through in medical science.
16. The second phase of the history of modern scince began in the middle of 16th century and continued till 17th century.
17. The Copernican system was devloped and improved by Kepler and Galieleo.
18. Kepler's laws of motion were introduced.
19. Human body was understood in a mechanistic manner. Scientists realised that human body was not influenced by mysterious forces and unseen spirits.
20. Von Helmont was the noted chemist of the times. He studied the nature of gases. He paved way for the birth fo modern chemistry.

21. The period produced two great philosophers. Francis Bacon and Rene Descartes. These explained the new spirit of science. Bacon gave the slogan "Knowledge is Power".
22. The period between 1650-1700 was considered as the period of modern science. There were significant developments in astronomy, physics, chemistry and biology.
23. Navigation became very important because of its importance in both military and trade pursuits.
24. Hooke invented spring controlled balance wheel for the development of accurate clock mechanism.
25. Huyghens invented the principle of pendulum.
26. Hooke and Newton made great contributions in the fields of attraction between earth and its bodies.
27. Hilbert had spoken of earth as magnet.
28. The important fields of physics which experienced great progress were optics, elasticity and vacuum.
29. The efforts of Malipighi led to the invention of microscope.
30. Microscope helped the study of tiny objects and organisms. This brought great revolutions in the field of Biology.

5.10 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. Explain the term "Scientific Revolution"? Mention the important achievements in the period 1440-1540 AD.
2. Describe the conditions briefly that existed in the Pre-Renaissance period in the fields of science and technology.
3. The period between 1540-1650 AD is considered to be the period of growth and development of modern science. Substantiate this statement.
4. Mention the contributions made by the different people to the field of astronomy during this period 1540-1650 AD.
5. Galileo was considered to be one of the greatest scientists of all times. Elaborate.
6. The period between 1650-1700 AD is considered as the period of maturity of modern science - substantiate this statement.
7. Mention the contributions made to the fields of Physics and Chemistry by the different people.
8. Discuss the progress made in the field of Astronomy during this period 1650-1700 AD.

Answer the following in about 15 lines each.

1. Define scientific Revolution and explain briefly.
2. Explain briefly the contributions of different people to the fields of Astronomy during the first phase of Scientific Revolution.
3. Leonardo da Vinci is considered as one of the greatest painters, architects and engineers. Explain.
4. What were the different views on matter during the period 1540-1650 AD.
5. Mention the important contributions of Vesalcis and Harvey to the field of Biology.
6. Mention the distinctive contributions of Bacon and Descartes to scientific method.
7. Write briefly about the different views on the nature of light.

8. Mention briefly the contributions made by Boyle, Hooke, Toricelli and others to the field of Physics.

9. The invention of microscope was a great break through in the development of Biology. Explain.

5.11 GLOSSARY

Amalgamation	:	The process of separating metal from ore by alloying it with mercury.
Bellows	:	A device which is used to suck in air through a valve and blow it out through a tube.
Capillary vessels	:	Small vessels or tubes through which blood reaches the cells.
Co-ordinates	:	Linear or angular quantities which designates the position of point in a given reference frame or system.
Dynamics	:	The study of motion due to force.
Hydraulics	:	The branch of science and technlogy concerned with the mechanics of fluids.
Mining	:	The technique and business of mineral discovery and exploitation.
Microsocpe	:	An instrument through which miniature objects are enlarged by means of a lens system.
Optics	:	Science of light and vision.
Pendulum	:	A rigid body which rotates under the influence of gravity.
Renaissance	:	Renewal of interest in some particular kind of art, literature etc.
Smelting	:	The heating of ore mixtures with other substances to high temperatures beyond the melting point.
Theology	:	The science of God and His attributes and relations to the Universe.
Trigonometry	:	Branch of mathematics that treats the relations between the sides and angles of the triangles.
Valve	:	Device used to regulate the flow of fluids in pipe systems and machinery.
Vacuum	:	Space with no mass or pressure created by exhausting process.

BLOCK-II SCIENCE AND TECHNOLOGY IN SERVICE OF HUMANITY-I

This block will give you how modern science and technology in the broad areas of physical sciences namely physics and chemistry served the human race for its development and prosperity. The block consists of 5 units and these are

6. Electricity, light, magnetism and electromagnetism.
7. Semi conductors and electronics.
8. Atoms, molecules and compounds.
9. Industrial carbon compounds.
10. Molecules of life.

In modern times industrial growth has become more and more inter linked with society's economic development. There is a need to develop tecnnologies suited to *socio-economic* conditions of the societies. The developments in science and technology have led to a tremondous growth in modern industries the world over. These demands in industries inturn paved way for many new developments in science and technology. Therefore this block is developed in such a way that it explains you the basic principles, concepts and laws of physics and chemistry which led to great developments in science and technology. These units are not formulated in the conventional way to teach you physics or chemistry but are designed to focuss your attention on some basic concepts and principles of physics and chemistry. Some of the important commercial products and modern instruments and gadgets that emerged as a result of modern developments in physics and chemistry are briefly listed giving the underlying principles. After you completed the study of this block-II, we are sure that you would.

1. certainly appreciate how modern physics contributed to the human society great many instruments and gadgets to make human life, a better and a comfortable one compared to that of medievel times even.
2. come to know about the various principles and concepts of chemistry and also how these are responsible for the development and production of various synthetic chemical compounds of vital importance to human race. For example resins, plastics, polymers, synthetic fibres, medicines and drugs.
3. understand the role of macro molecules such as enzymes, vitamins, proteins DNA, RNA, etc., in life processes.

UNIT-6 ELECTRICITY, LIGHT, MAGNETISM AND ELECTROMAGNETISM

Contents :

6.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about

1. the basic concepts of electricity, light, magnetism and electro-magnetism.
2. their applications in the construction of some instruments and gadgets
3. and the usefulness of these gadgets and instruments in the modern developments of science and technology.

Objectives

After you completed the unit, you will be able to

1. understand the basic principles and laws of electricity, light, magnetism and electro-magnetism
2. learn the construction, importance and applications of optical and electrical instruments.

6.2 INTRODUCTION

Products of modern science have become a part and parcel of our daily life. We come across these products whether we live in remote villages or in the busy cities. You have read about the inter-relations between science, technology on one hand and the culture on the other.

Exciting developments that took place in semi-conductors, computers, robotics, optical and electrical instruments have brought in unimaginable changes in man's life.

Therefore you learn in this unit and the next unit about the basic scientific principles, laws and theories underlying these modern developments.

Man began thinking about the nature and causes of the phenomena such as heat, light, magnetism and electricity even from 15th century A.D. You learn in this unit about the nature and applications of electicity, magnetism, light and electromagnetism.

6.3 BASIC CONCEPTS OF ELECTRICITY

Discovery and early views

The inquisitiveness of Gilbert, a great scientist led him to the rubbing of amber and to find that the amber aquired a new property of attracting small bits of straw, thread and other light articles. He coined the word "Electricity" from "Elektra", the greek word for amber. The amber got charged and something was produced in the form of flash sparks flashing out of it. That was the begining of electricty. Many centuries passed. **Du Fay** (1698-1739) again found by experiment that large number of bodies could be electrified through rubbing or friction. He recognised two kinds of electricity, which were called **"positive"** and **"negative".** Electricity was considered to be a weightless fluid that could be collected in approriate Jars. "Leyden Jar" is one such Jar in which electricity was stored. But this could not give rise to a steadily flowing electric current. Hence they called it "static electricity".

The discovery by **Volta** (1745-1827) that two disimmilar metals in contact with a liquid capable of conduction produced an electric current is of supreme importance. A simple form of the device called **Voltaic cell** discovered by Volta consisted of a **copper rod** and a **zinc rod** dipped in a dilute acid and contained in a vessel.

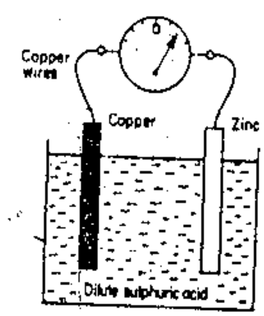


Fig. 6.1 Voltaic cell

At that time it was not clear whether the **voltaic** current and the **static** current were the same or not. This was cleared by Erman in 1802 who showed that both the currents have the same effect on the electroscope, a small device useful to detect electric charges. The apparent difference between the static and the voltaic currents was attributed to "high potential" or the **"level being high"** in the static current and the quantity of **"passing being high"** in the voltaic current. **Benjamin Franklin** (1706-1790) took such an instrument in determining the nature of lightning and thunder. He exposed himself to an electric discharge from a cloud. For this he sent up a kite into the clouds during a storm and observed the effects of electric discharge on the ground due to the passage of electricity through the wet string to the ground. This enabled him to produce "lightning conductors". One end of the conductor is fixed (grounded) at the bottom of a high building. The other end of the conductor is fixed higher than the building. Any electric discharge tending towards the building easily passes to the ground through the conductor and the building is protected from destruction by lightning. Thus the oneness of the static, voltaic and the lightning electricity was proved.

Electric Cell

An electric cell or an electric generator is a device which maintains a constant potential difference between two points, and functions as a source of electrical current. It provides the necessary energy to drive the electrical charges through a conductor between whose ends potential difference is maintained. The energy is provided by a chemical action in the case of a voltaic cell and mechanical work in the case of a generator (dynamo).

The flow of electrons through the conductor between whose ends potential difference is maintained with the help of a **cell** or **generator** is called **electric current.** Ohm a great scientist, discovered that the current (i) passing through a conductor is proportional to the potential difference (E) between its ends.

$$i \propto E \text{ or } i = KE$$

K = Constant. This "K" is later equated to 1/R, where "R" is called the electrical **resistance** of the conductor.

E = i R is thus known as the mathemetical representation of **Ohm's law**

6.4 ELECTRICAL DEVICES

Batteries

To maintain electric current in a wire ie to make the electric flow continuous along a wire, a continuous supply of electrons must be available at one end and a continuous supply of positive charges at the other end. This is done by a battery.

Batteries generally are of two types namely primary and secondary. The battery is thus a device which converts chemical energy of a spontaneous chemical reaction taking place in it into electrical enegy. The battery we use in our torch lights, calculators, transistor radios etc., is one type of battery. The battery we use in our plysics laboratories or in cars and buses is another type of battery.

Now we have batteries which function or generate electric power with the help of solar energy. These are called **solar batteries.**

The Common Dry Cell

This is the battery or cell which we use in our torch lights, transistor radios, calculators and watches etc. The container of the dry cell is a **Zinc Can.** It serves as one electrode. The can is filled with slightly acidic, moist paste of ammonium chloride, and manganese dioxide. Centered in the paste is a carbon (graphite) rod which serves as the other electrode.

The chemical reaction that supplies the required chemical energy for conversion into electrical energy is

$$Zn + 2NH_4Cl + 2MnO_2 \rightarrow ZnCl_2 + Mn_2O_3(s) + 2\ NH_3 + H_2O$$

These cells can not be used when once they are discharged. **Nickel-Cadmium dry cells** are now used as rechargeable cells. These cells make use of a reversible chemical reaction such as

$$Cd(s) + NiO_2\,(s) + 2\,OH^- + 2H_2O$$

$$\Leftrightarrow Cd\,(OH)_2\,(s) + Ni\,(OH)_2\,(s) + 2OH^-\,(aq)$$

which can be reversed and the discharged battery can be put into operation again.

Lead Storage Battery

This is the battery which we use in physics laboratories or in cars and buses.

The lead storage battery consists of voltaic cells that use a redox chemical reaction involving Pb^{2+} Ions and PbO_2 paste. One electrode is a **lead** plate. The other electrode consists of PbO_2 packed into a **lead grid.** Both are covered with a dilute solution of sulphuric acid.

The chemical rection taking place in the cell is

$$Pb(s) + PbO_2(s) + 2H_2SO_4 \rightarrow 2\,Pb\,SO_4(s) + 2H_2O$$

This reaction can be reversed and the discharged battery can be charged again and put into operation.

Solar Cells

These generate electrical energy when sun light falls on them. These are prepared using semiconductor junction diodes. Two doped semiconductors, one providing 'n' junction and the other 'p' junction are combined together and connected in series with an electrical resistance as shown in the figure 6.2. One of these is a very thin one compared to the other. This is an emitter and the other is called base.

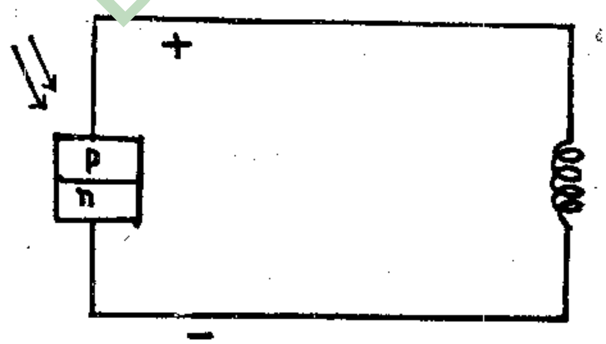


Fig. 6.2 Solar cell circuit

When light falls on this p-n type semiconductor device, electron flow takes place and a voltage difference of about 0.6v is established. Such solar cells can be combined in large numbers in a solar battery. The doped semiconductors are prepared using silicon. Silicon is doped with chemical elements such as In, B, Al to give 'p' type ones and with chemical elements such as As, Sb, P to give 'n' type ones. These 'n' type and 'p' type are combined to get a n-p type diode.

Potentiometers

These are useful to measure electric potentials in electrical circuits. The wire potentiometer consists of 10 uniform wires of high specific resistance, each of one metre, stretched and laid parallel to one another on a wooden board. They are joined in series by thick copper strips at their ends. A metre scale is fixed parrellel to the wires. A battery (B), a rheostat (R) and a plug key (K), are connected in series to the ends of the wire. This is called primary circuit. To one end of the wire is connected the positive pole of a standard cell (whose potential is kuown) W. and the negative of the cell is connected to a Jockey (J) through a galvanometer (G) and a high resistance (HR) This is known as secondary circuit. The jockey is pressed at different points along the wire and the balance point (null current point) J is obtained. The length MJ gives the measure of the potential across the required two terminals.

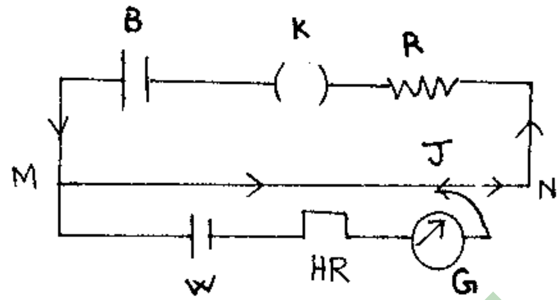


Fig. 6.3 Potentiometer

Rheostat

A Rheostat is a device useful to alter the value of current flowing in an electrical circuit. This helps in the continuous variation of resistance. This consists of a resistance wire wound on a hollow cylindrical bad conductor tube. The wire is fixed between two binding screws. A & B , C D is a brass rod parallel to the tube. A slider touching the coil slides along the brass rod. By moving the slider(S) the length of the wire through which the current in the circuit passes can be altered. Rheostats are constructed for ceartain ranges of current.

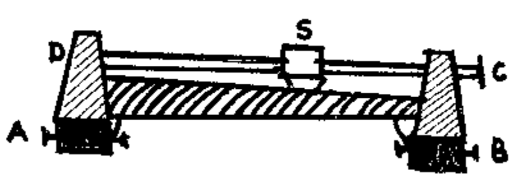


Fig. 6.4 Rheostat

Check Your Progress

1. What is static electricity

2. Who discovered static electricity and how.

3. What is voltaic cell.

4. Name the electrical devices useful in current measurements of circuits.

5. Explain the principles & working of battery, potentrometes and rheostat.

6. What is Ohm's law.

6.5 BASIC CONCEPTS OF LIGHT

We all know that we get natural light from sun and stars. In stars hydrogen atoms are fused to form helium atoms by a nuclear process called nuclear fusion. In this fusion process large quantitres of enesrgy are released and a part of this energy takes the form of light. There are many artificial sources of light as we are all aware of. These include matches, candles, electric lamps, kerosene lamps etc.

We know from our daily experience that some materials allow light to pass through them while others do not. Such materrals which allow light to pass through them, say glass, are called transparent substances. Those which do not allow light to pass through them are known as opaque bodies. This is called opacity of bodies and it depends both on the nature of the body and the colour (or wavelengh) of the light.

Reflection

Part of the light that falls on a surface bounces or is reflecfted. Mirrors and smooth polished metal surfaces reflect the light. This is called regular reflection. The reflection occurring on rough surfaces is termed as diffused reflection. On the basis of these phenomena of reflection, many useful optical instruments were designed and developed.

Refraction of light

Bending of light beam when passing from one transparent meduim to another, for example from air to water or from air to glass, was observed. This bending of light is termed as "refraction" The amount of the bending depends on the medum into which the light beam passes from another meduim.

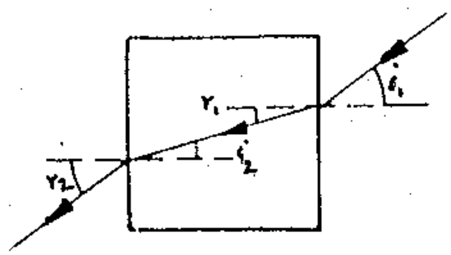


Figure 6.5 Refraction of light

Dispersion

After a shower of **rain**, very often we see a coloured **bow** like thing in the sky. This is known as **rainbow.** Looking at this we may ask ourselves where do these colours come from? Sir Isac Newton performed a simple experiment and observed a multicoloured bands of light coming from white light. The colours of the band varied from violet to red and they are seven in numbers. Violet, Indigo, Blue, Green, Yellow, Orange and Red usually remembered as VIBGYOR.

This arrary of bands of colours is know as light dispersion. The experiment conducted by Newton consisted of passing a beam of while light through a glass prisom. The phenomenon responsible for the formation of this spectrum was named as **dispersion.** The experiments proved that white light consists of seven coloured lights and these are formed as a result of dispersion of white light.

Nature of Light

Visible light is a small part of a large electro-magnetic spectrum. Thus visible light is known as an electro-magnetic radiation. But what this radiation is consisted of? was a big question for several years. The simple questions that were puzzling many scientists were : what is the nature of light? how does it travel?

Two different theories were proposed to answer these questions, of course, at different times. These are **corpuscular** theory, and **wave** theory.

Corpuscular Theory

According to Newton, light is composed of minute particles called **corpuscles.** A luminous body shoots out streams of corpuscles in all directions. When they strike a mirror they get reflected. When they encounter a transparent medim, some of them are reflected and the rest are refracted.

Wave Theory

Huyghens (1629-1695) put forward a different theory to explain the nature of light. This is known as wave theory. Light comes from a Luminous body in the form of waves unlike in the forms of particles. They travel in all directions and get reflected and refracted according to the same laws as in the corpuscular theory.

Diffraction and Interference

Light exhibits other properties such as diffraction and interference besides reflection and refraction. The bending of light waves around small objects or at the straight edges is known as **diffraction.** Interaction of two similar light beams producing **bright** and **dark** fringes is known as **interference.**

The waves of light vibrate in all planes. The confining of these vibrations to one plane is called **polarization.**

Wave theory could explan more successfully all the phenomena than the corpuscular theory. Hence with passage of time wave theory gained strength. The wave theory requires that the velocity of light in optically denser media like water, glass to be less than the velocity of light in optically rarer medium such as air. The corpuscrular theory however demands the reverse. But this issue could have been easily settled if the velocity of light in air and water was determined experimentally. But at those times, the velocity could not be determined by terrestrial methods because its value is very high 3,00,000 k.m./sec.

6.6 OPTICAL INSTRUMENTS

Besides phenomenon such as reflection at plane surfaces, refraction, diffraction and interference, light exhibits phenomenon such as total internal reflection, and refraction at curved surfaces (Lenses). Many optical instruments were designed and constructed based on one or the other properties of light mentioned earlier. Some of these instruments are cameras, microscopes, telescopes, spectrometers and lasers.

We will discuss about these instruments in the next few sections very briefly.

Camera

A photographic camera is a simple optical device useful to record the pictures of still objects or objects in motion. Still object picture recording cameras are well known to every one of us. It consists of a converging lens system at one end of a light proof box and a light sensitive film at the other end of the box. A real inverted image of the object will be formed on the film. The exposure time of the film is very important to obtain a clear and sharp picture. The normal exposure times used in cameras are 1/500 & 1/250 & 1/125 & 1/60 & 1/30 s etc., The aperture size and the film speed are other parameters which determine the sharpness of the picture or image. The apertures generally used in the cameras are $f/2$, $f/2.8$, $f/4$, $f/5.6$, $f/8$, $f/11$, $f/16$ etc. These apertures denote the diameter of the "aperture" or "opening" through which light passes. The film speed is a measure of how quickly the film is exposed when in use. A "fast" film needs relatively short exposure time, while a 'slow' film needs long exposure time. The cameras used to record the pictures of objects in motion are called "motion cameras". These are used in cinematography.

Microscope

This is an optical instrument which enables smaller objects to be seen clearly in a magnified form. Broadly the microscopes are clasified on the basis of the constructional principle into **simple microscope** and **compound microscope.** Simple microscope is similar to a magnifying lens. But the microscopes used in biological laboratories and in hospitals are known as compound microscopes.

Simple Microscope

A simple microscope is a converging lens of short focal length. This is held slightly nearer the object than one focal length. The eye is positioned close to the lens on the other side. A virtual errect magnified image of the object is seen (figure 6.6 simple microscope) The magnification is equal to image size divided by the object size

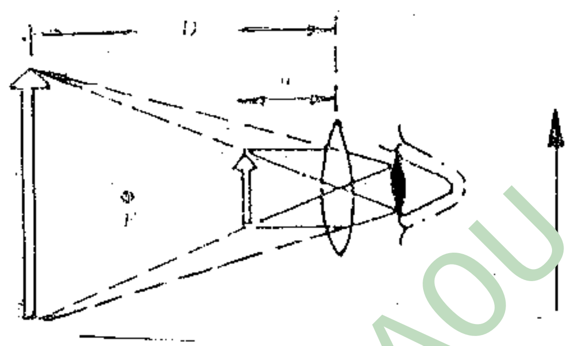
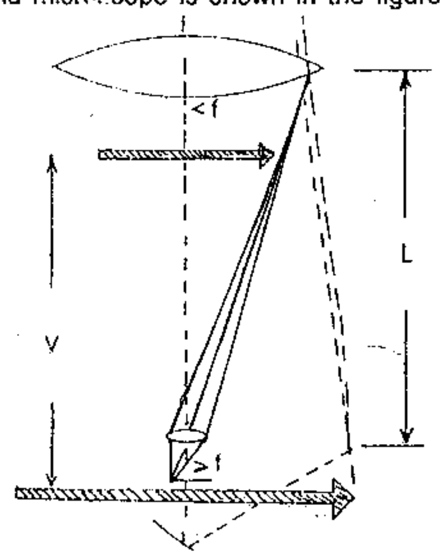


Fig 6.6 optical ray diagram of simple microscope.

Compound Microscope

This consists of two converging lenses . These are called **objective lens** of very short focal length and **eye piece** of moderate focal length. This objective lens forms an enlarged real image of the object within the tube. This is then magnified by the other lens called the eye priece. The final image seen by the eye is **virtual** and very much **enlarged.** The optical ray diagram for the compound microscope is shown in the figure 6.7.



6.7 optical ray diagram of compound microscope

Telescope

Telescope is a device or optical instrument which enables us to see distinct objects nearly and clearly. It provides an angular magnification of distant objects. It consists of an **objective lens** and an **eye price** lens. But here the objective lens will have a large focal length. Light from a distant object enters the objective and a real image is formed in the tube. The eye piece magnifies this image producing a final inverted image. Hence in telescopes we see the inverted images of the objects. Therefore if we want to use these telescopes to observe distant terrestrial objects such as big buildings, towers etc. we have to use another pair of lenses to make the final image errect. But in the case of telescopes used to observe astronomical objects such as stars etc. thus additionial pair of lenses is not necessary since the inverted images do not create any problems. The optical ray diagram of a terrestrial telescope is presented in the figure 6.8.

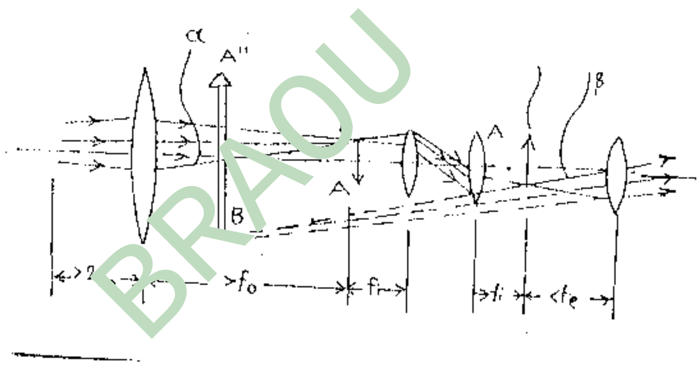


Figure 6.8 : optical ray diagram of terrestrial telescope

Spectrometers

These are instruments used to disperse light of different colours into lights of individual colours and study their wave-length and other properties. These are used in many scientific laboratories to study the properties of many types of chemical substances. The simplest and the most common type instrument is the **prism spectroscope.** It contains two assemblies and a prism in between them. The tube A is called **collimator.** This helps the light coming from the source whose nature is to be investigated enter in parallel beams when it passes through this collimator. These parallel beams pass through the prism, get dispersed and enter the tube B called telescope. The prism is mounted on a rotating platform. The collimator and telescope can be rotated about the common axis perpendicular to the prism platform. A circular scale enables the positions of the collimator and telescope to be read. If the spectrometer is provided with a recording camera it is called **spectrograph** (fig. 6.9) For each wavelength of the light coming form the source (substance investigated) a real image of the slit is formed. These images are either continuous or consist of separate lines depending on the nature of the source. This pattern of image is called spectrum.

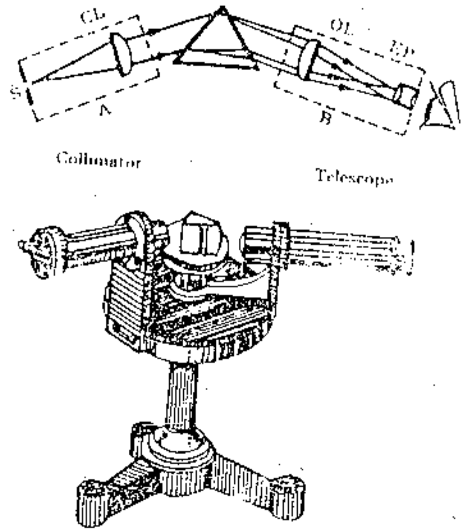


Fig 6.9 : Spectrometer

There are simple devices which are known as direct vision spectroscopes. In these a number of thin prisms of crown and flint glasses are alternately placed in a small tube with refracting edges turned opposite to each other fig 6.10.

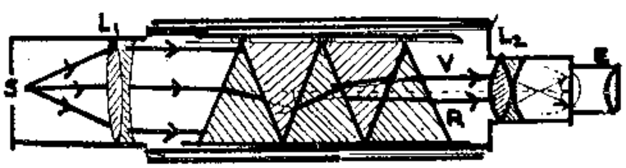


Fig. 6.10 Direct vision spectrograph

Check your Progress

1. What is the nature of light?

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2. Explan the terms, reflection, refraction, interefererice, and diffraction.

....

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3. Name the common optical instruments.

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4. Bring out the uses of camera, microscope & telescope.

....

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Lasers

LASER stands for Light Amplification by Stimulated Emission of Radiation. Lasers produce very special properties and this make light of laser light different from ordinary light. The lasers therefore can be put to different kinds of work. The difference between normal light and laser light can be simply explained. The light coming from the sun or from any lamp or incandescent source is a mixture of lights of many wavelengths. Each wavelength produces a different colour. Therefore these coloured lights get mixed and form ordinary white light. The light waves travelling, from an ordinary source of light are all jumbled up and exhibit uncoordinated movement. But laser light is made up of waves of the same wavelength. But all the waves in a laser beam are organised to proceed in phase with each other. The light from an ordinary source and the laser beam are in the figures 6.11 a) & b).

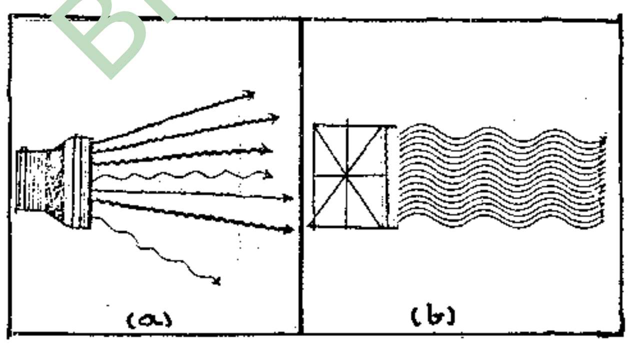

Fig 6.11 (a) Ordrinary light source
(b) Laser beam

Thus property of lasers is know as coherence. Because of this property, the waves of a laser beam can travel large distances without spreading into various directions. Because of this, there is large concentration of energy per unit area on the object on which the laser beam falls.

Uses of Lasers

Because of high concentration of energy, a laser beam can put holes even in steel strips. We can cut any kind of material using lasers. For example papers, plywood, plastic goods, hard metals, ceramics and glass can be cut with lasers with efficiency and accuracy.

Lasers are also used widely in wars. A whole of laser weaponry has come into use for war purposes on land, on sea and in space. The same lasers could be used to destroy factories, forests, farms and habitation. It is really very unfortunate and a matter of concern for all of us that the human effort and money spent in developing laser technology are wasted and turned laser technology into instruments of destruction.

Lasers are used with perfect precision to conduct operations. It can be used to burn away diseased tissues without damaging the healthy tissues nearby. Lasers are used in eye surgery to treat detached retinas and to destroy abnormal blood vessels that form in the retina of diabetic patients. Lasers are also used to measure the huge distances like the distance of moon from the earth. Lasers are also now used in environmental pollution studies.

Optical Fibre Instruments

Optical instruments made of optical fibres are called endoscopes. These are used to see the internal organs of the body such as interior of stomach or bronchial tubes. Some fibres inserted in to the body carry light and the internal organs are lit up. Other fibres are used to carry the returning light. Thus the image of the internal organ is carried to the outside observer. These endoscopes are generally connected to cameras or TV monitors . These fibres are so thin that they can be easily inserted into the body. The images are very useful in brain and heart surgeries. In telecommunication signals of voices or music or pictures, transmissions are superimposed on laser beams. These modulated laser beams are guided along optical fibres to various points where they are received. Therefore at the receiving end we can hear the sound or music or see the picture. The light waves travelling in fibres can carry thousands of different signals. For example, a pair of glass fibres can carry 1300 telephone calls at the same time as against 24 through copper wires. Optical fibres are light but sturdy. These are less expensive than copper wires.

Check your Progress

1. What is fibre optics?

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2. How is this an advantage over classical optics?

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3. Name the applications of the fibre optics in telecommunications?

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6.7 MAGNETISM AND ELECTRO MAGNETISM : BASIC CONCEPTS

Magnetism

A shepard named Magnes who was wandering along the country side with his sheep found that the iron tip of his staff clung tightly to large black rock. It took a mighty tug to put it loose.

Magnes's trouble was caused by a lodestone, a rock that has the strange property of attracting Iron. This lodestone found in nature in various parts of the world is called natural magnet. Earth is regarded a huge magnet. Willam Gilbert proposed that the earth magnetism is due to these lodestones. But as time passed on scientists found that iron can be converted into a magnet artificially. These are called artificial magnets. A magnetic needle freely suspended always lies in the north-south direction only. Even when disturbed it comes back to the same position. This property of a freely suspended magnetic needle was used to construct magnetic compass used by navigators to find the direction.

Electromagnetism

But soon scientists realised that electricity and magnetism are two forces that are intimately connected with each other. Electrical and magnetic forces pervade all matter determining much of its structure. Roughly speaking electricity and magnetism give rise to each other. For example light is one example of electro-magnetic phenomenon.

As early as 1802, Gian Domenico Romagnosi, an Italian jurist found that an electric current flowing in a were affected a magnetic needle. This astounding effect was rediscovered in 1820 by Hans Christian Oersted, a Danish physicist. He also noticed that reversing the direction of current rearly reversed the direction in which the needle pointed ie N-S turned to S-N. From these observations he concluded that a magnetic field is associated with an electric current. A French physicist Francois Arango showed that a current acts like an ordinary magnet and attracts iron filings. Soon many laws governing the inter relation between the current flowing in a wire and the magnetic field developed were formulated by many scientists.

The Cyclotron

A device in which charged particles are accelerated to high energies is called cyclotron. It consists of two evacuated semicircular hollow flat metal cyclinders called "dees" [D shaped DD regions] These are placed in a uniform magnetic field. A beam of charged particles is introduced into the dees near their centre in a plane perpendicular to the magnetic field. An A.C. voltage is applied between the dees. The charged particle starts off on a circular orbit. When it is between the dees, there is an electric field on it and it is accelerated by the applied voltage. It has a higher speed now and therefore executes a circular orbit of larger radius.

For example if the voltage between the dees is 1000 V, and a proton goes through the dees 1000 times at the correct time, it is accelerated to an energy of 10^6 eV (= 1 meV). These devices are not in wide use but many others based on this principle are in use.

6.8. ELECTRO MAGNETIC DEVICES

GALVANOMETERS

The common current measuring device is called galvanometer. This is generally a moving coil galvanometer. The phrase moving coil is used because the current loop or coil rotates in a magnetic field as a result of torque on it. It was shown that a closed current loop placed in a magnetic field experiences, a torque.

The galvanometer consists of a coil of wire, often a rectangular one carrying the current to be measured. There are many turns in the coil to increase its sensitivity. The coil is attached to a spring which winds up as the coil rotates. This winding up produces a torque on the galvanometer coil which is proportional to the angle of deflection. The deflection is proportional to the current. Currents as low as 10^{-11} A can be measured.

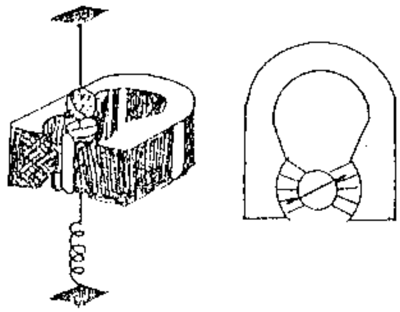

Fig. 6.12 Galvanometer

A.C. Generator

The most important one is the one designed by Nicola Terla, Yugoslav scientist. It consists of a loop of wire rotating in the field of a permanent magnet. (fig. 6.13).

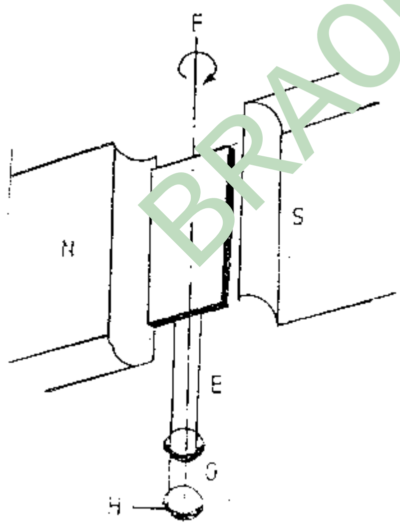

Fig 6.13. A.C. Generator

The loop is rotated about the axis. E, F, G, H are sliding contacts. The current and voltage vary sinusoidally with time.

This is the basis for the construction of electrical power generators used in our houses.

A.C Transformer

This is another electrical device which makes use of the principle of electro-magnetic induction. This is shown in the figure 6.14.

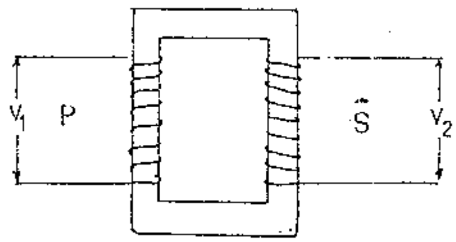

Fig 6.14. Transformer

Two coils are wound around a closed magnetic core. These are primary and secondary coils. If A.C current flow through primary, the magnetic flux in the secondary coil changes. An induced EMF is set up across the terminals of the secondary coil. The voltage across secondary is different from that of the primary. The secondary voltage can be higher or lower than that at the primary. Based on this transformers are called "stepup" or "stepdown".

Check Your Progress

1. What is magnetism ?

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2. Who first observed this phenomenon and how ?

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3. What is magnetic needle ?

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....

4. What is electro magnetism ?

....

....

5. Name few electro magnetic devices ?

....

....

6. Explain how a galvanometer works ?

7. What is the principle underlying the construction of galvanometers and transforms?

8. What is cyclotron ?

9. What is the importance of cyclotron ?

6.9 SUMMARY

1. Gilbert discovered static electricity and the name electricity was coined by him from greek word "ELEKTRA"
2. Du Fay observed that large number of bodies could be electrified through friction.
3. The discovery of voltaic cell by Volta is of supreme importance.
4. It was not clear at that time whether the voltaic current and the static current were the same or not.
5. Banjamin Franklin's experiments on lightning showed the oneness of the voltaic and static current in nature.
6. An electric cell or electric generator is a device which maintains a constant potential difference between two points and functions as a source of current.
7. The current (I) potential (E) and resistance (R) of an electrical circuit are related by Ohms law $E = I R$.
8. Batteries are the electrical energy producing devices. The common batteries in use are dry batteries, lead storage batteries and solar batteries.
9. The device useful to measure potential difference between two points in an electrical circuit is called potentiometer.
10. The device useful to change the resistance of a circuit is called rheostat.
11. Light is considered as electro-magnetic radiation.
12. Reflection, refraction, interference and diffraction are some of the properties of light.
13. Many devices such as cameras, spectro meters, microscopes, telescopes are constructed making use of basic properties of light.
14. Lasers are devices designed to produce special kind of light with useful properties.

15. Laser light is found more energetic than ordinary form of light.

16. Lasers find many uses in industry, in hospitals and in measurements.

17. Fibre optics is another advancement in the field of optics. The optical fibres find great applications in medical and telecommunications.

18. Magnetism is a phenomenon first noticed by Magnes, a shepard in lode stone.

19. Magnetism showing iron needles are called magnetic needles. These find applications in the construction of magnetic compasses used by navigators.

20. Gian Domenico in 1802 observed that an electric current flowing in a wire affected a magnetic needle. This phenomenon is known as electric magnetism.

21. Electromagnetism find wide applications in industry and in various fields of daily life.

22. Some of the devices developed on the basis of electromagnetism are cyclotron, galvanometers, generators and transformers.

23. Thus light, magnetism, and electromagnetism find wide applications in the designing of many gadgets, instruments and devices of vital importance in daily life, industry and medicine.

6.10 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each:

1. What are the different views concerning the nature of light?
2. Give the construction and functioning of microscopes and telescopes.
3. What are Lasers? What are their applications?
4. Explain the phenomenon of electromagnetism. How is it useful in the industry?
5. Explain how the following are constructructed : galvanometers and transformers.
6. What are batteries? Describe any two types of batteries.
7. Discuss the importance of fibre opties in medicine and in telecommunications.
8. What is a spectrum of light? How is it recorded?

Answer the following in about 15 lines each:

1. Explain the wave nature of light.
2. Explain the terms - refraction and diffraction.
3. Explain the terms - reflection and interference of light.
4. What are LASERS?
5. Give two applications of Lasers.
6. What is electro magnetism? What is its applications?
7. Explain the construction and functioning of
   1) Galvanometers
   2) Transformers
   3) Batteries
8. What is Ohm's law? Give its mathematical form.

6.11 GLOSSARY

Amber	:	A transparent yellow or reddish brown fossil resin derived from coniferous tree.
Capacitor	:	Device having ability to store charge, usually conductors separated by insulator.
Coherence	:	The property of waves in phase with each other.
Dynamo	:	A device to generate electricity.
Endoscope	:	Instruments for viewing internal parts of a body.
Electroscope	:	An instrument for detecting the presence of electric charges.
Fibre optics	:	Transmission of images through optical fibres by total internal refliction of light.
Optical fibre	:	A optical fibre used to carry signals of light beam.
Laser	:	A light device which produces most energetic light.
Galvanometer	:	Device to measure the strength of current flowing in a circut.
Transformer	:	An instrument useful to step up or step down the potential.

UNIT-7 SEMI CONDUCTORS AND ELECTRONICS

Contents

7.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about

1. Semiconductors — what they are and what are their useful properties.
2. The devices in which semiconductors are used namely Transistors, Integrated circuits, Computers etc.,
3. The meaning of artificial intelligence and the technology of robotics.

Objectives

After you studied the unit, you must be able to appreciate.

1. The role of semiconductors and semiconductor physics in human life at present times.
2. The place of semiconductor devices in the fields of defence, telecommunications and even in the house hold gadgets.

7.2 INTRODUCTION

You learnt in Unit-6, how modern technology is helpful to design lasers, optical instruments and many other devices used in space and biotechnology. Yet another area in which modern technology played an important and significant role is electronics. Semiconductors play the key role in this field of electronics.

We see around us many electronic devices and gadgets every day. For example, radios, televisions, video recorders, taperecorders, calculators, computers, and so many other devices that we see every day are all machines prepared using transistors, microchips, integrated circuts etc., You learn in this unit some basic aspects of these semiconductors and their applications in the fields of computer technology and robotics.

Robots are the computerised machines which look like human beings and also do many jobs that a human being can do.

7.3 SEMICONDUCTORS

The gadgets that every one of us comes across in our daily-life are radio, television, tape recorders, video cassette recorders and players and many more of similar type. All these are the products of semiconductor technology.

Semiconductors are the basis of all the sophisticated electronic devices we use to-day. For example digital watches, calculaters, telephone exchanges, cellular phones, lasers, computers and many more devices have components or equipments madeup of semiconductors. There is no tool or appliance or item used in this high-tech world which did not use a semi conductor device or technology. Thus semi conductor science and technology brought unimmaginable changes even in the out looks of individuals. Semiconductor devices created great impacts on many aspects of our social, cultural and economic developments.

What is a semiconductor?

Metals like copper, aluminium, iron etc. are all good **conductors** of electricity. They allow electric current to pass through them. Materials such as wood, plastics, or quartz do not conduct electric current through them. These are called **insulators.** A class of substances other than these two classes is known as **semiconductors.** So in an elementary way we can say that materials whose ability to conduct electric current lies in between those of conductors and insulators can be called **semiconductors.** But this is not an accurate scientific definition of a semiconductor. Generally the conducting ability of conductors decreases with rise of temperature ie their resistance to electric current increases with temperature rise. But in the case of semiconductors this resistance decreases with rise of temperature and hence the conductance ability of electric current increases with rise of temperature in semi conductors. The chemical elements silicon (Si) and germanium (Ge) are the naturally occuring semiconducting elements. These are called intrinsic semiconductors. But now a days we make use of other compounds such as gallium arsenide, indium antimonide etc., as also semiconductors.

A pure crystal of germanium or silicon acts as a very poor semiconductor or more or less as insulator. But if an impurity is added or doped it functions as a good semi conductor. But these impurities are introduced in very very minute quantities. For example an impurity of 1 mg of a chemical element in a ton of silicon, makes silicon a useful semi conductor. This added impurity may supply electrons to the semi conductor element silicon, on the other hand an impurity like element boron would cause a different effect and it receives electrons from silicon. Intrinsic semi conductor elements silicon and germanium belong to group IV in the periodic table of chemical elements. So the impurity added or doped is usually an element belonging to V group (eg arsenic) or III group (boron). The semi conductor obtained by doping a V group element is know as **n-type** semi conductor and the one obtained by doping III group element is called **p-type** semi conductor.

Check your Progress

1. What are semiconductor elements?

   ....

   ....

2. Name semiconductor devices you know.

   ....

   ....

3. What is meant by doping?

....

....

4. What are n-type and p-type semiconductors?

....

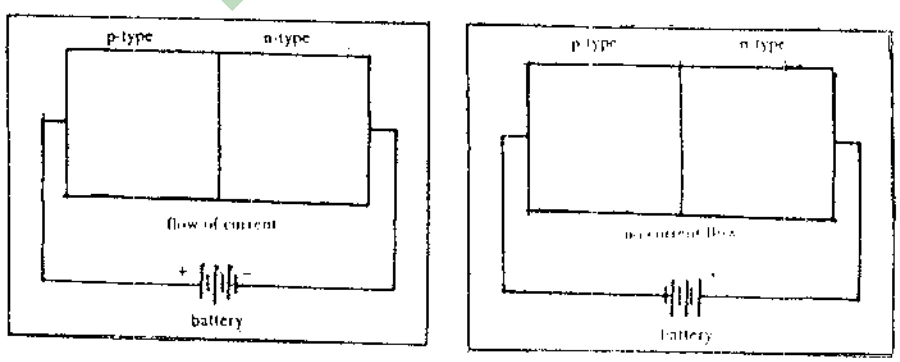
....

7.4 SEMICONDUCTOR DEVICES

Semiconductor doped with different impurity atoms are used in many devices. These devices or components are transistors, microchips, integrated circuits, computers etc.,

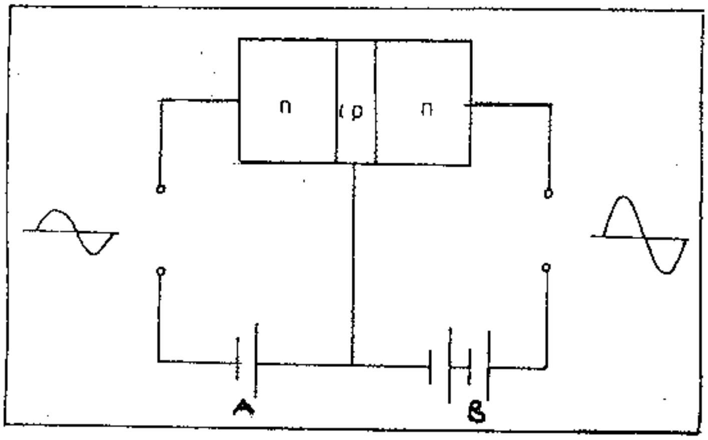
Transistors

By joining a p-type semiconductor and an n-type semiconductor, we get a junction diode. For example if p and n-types semiconductors form a junction, it is called p-n junction diode. It conducts current in one direction only. Hence it is used to converting alternating current (A.C) into direct current (D.C). The junction diode is connected to a battery and depending on the manner in which these are connected, there will be flow of current or no flow of current. If the p-end of junction diode is connected to positive end of a battery, current flows in the p-n junction diode. If the connections are reversed, no current flows.



7.1 : p-n & n-p junction diodes

If two such devices are joined together we get transistors. Thus complex devices obtained by using n-p-n or p-n-p combinations of semiconductors are called **transistors.** These will have interesting and useful properties. These can be connected to batteries such that a small variation of current on one side produces a large variation on the other side. This means that a transistor can amplify small signals. The transistors on connection to other electrical components such as resistors produce alternating current of high frequency. Out of these n, p, n parts, one n functions as emitter and the other "n" function as collector. "P" functions as a base. This can be illustrated simply as



7.2 A n-p-n transistor

Thus the junction transistor is a three terminal device. These can be connected in either p-n-p configuration or n-p-n configuration using the doped semi conductor layers. The layers are called the emilter, the base and the collector. If the emilter and collector are p-type, the base will be n-type. Simlary if the emilter and collector are n-type, the base is p-type. The emilter and the collector sandwitch the base region. Even though emilter and collector belong to same type, they differ in their level of doping. The doping level in the emitter is higher than that of the collector. The area of base-collector region is greater than base-emitter region. The sandwitch region is thin and lightly doped.

Transistors are used as amplifiers and oscillators. But these are used very extensively in the most rapidly developing area of electronics, digital computers. Logic gates are the next important applications of semi conductors. A "gate" is a digital circuit that follows certain logic relationships between the input and output voltages. These are therefore called **logic gates.** There are three basic logic gates called OR, AND, NOT.

Microchips

Semiconductor devices are extremely small in size. Their properties can be easily controlled and altered. Such changes in properties are achieved by enlarging the number of sections of p-type or n-type on the same crystal or by increasing the amount of doped elements. A large number of junctions in desired patterns can easily be produced on a non-conducting surface. This is called a chip. In view of their micro size they are also referred to as micro chips.

Integrated Circuits

In transistor devices such as amplifier the signal (current or voltage) will be in the form of continuous time-varying voltage or current. These signals are therefore called continuous signals or analog signals. However in computations a binary signal is more convenient. In digital electronics low levels of voltage are used. These are digital signals. A gate is a digital circuit that follows certain input, output relations. By using two NOT, two, AND and one OR gate an XOR gate is made. Each of these gates is made from NAND gates. These logic gates are realised using semi conductor devices. A half adder, binary digital device will require 11 NAND gates. Each NAND gate has three resistors, two diodes and one transistor. Hence to make a half adder we need 33 resistors, 22 diodes and 11 transistors. If we connect them separately, they will occupy a lot of space. However it is now possible to make a complete circuit on a small silicon wafer. These are called integrated circuits.

Computers

These is no one these days who has not heard about the name "Computer". You may not have seen computers or you may not have worked with computers but their presence in your life is a fact that can not be ignored. A decade ago there were only a few computers in our country. They were very big and also very expensive machines. They were used only for special scientific purposes. Thus common man had very little impact with them a decade back. Things have changed now. Thousands and thousands of computers varying in their size as well as cost are now available. Their cost varies now from few thousands to few lakhs. Now we find computers in schools, colleges, offices, banks, railway stations, airports, hospitals, factories and in even homes. Now every nook and corner (including villages) of our country even is equiped with computers which are linked through satellite communication with a large central computer. By the turn of the century computers become a way of life with us. They would tremondously increase our capacity to exchange information. Teaching at school levels even will be computer aided. Even cinema industry is using widely computers in the production of important scenes consisting of trick photography.

What is a computer ?

It is a simple machine which accepts information, stores it, then processes it and gives out the results in the form of outputs. For example it receives numbers, performs the required mathematical operations such as addition, multiplication etc., and gives the results as output in a printed form or on a screen. All these operations are carried out in very very short time. So computer is like our brain. We absorb information through our senses, store them in our brain and the brain processes them in the required fashion and gives out the result as an output from the brain. But computer does all these tasks much faster than our brain. Calculations, paper work that would take long times (weeks or months) for us to do are done on a computer in few seconds or minutes. An average individual can do 5 to 10 simple calculations per minute. But an average computer can make 10,000 complex calculations per second. Fast computers can make millions of complex calculations in a second. There will not be also a single error in these calculations.

There are two major aspects of computers. These are **Hardware** and **Software**. All the complex electronic circuits, magnetic and mechanical devices etc., make up hardware. All machinery aspects thus constitute hardware. The set of instructions or programmes which run the computer hardware is called software. A programme is a set of instructions which the computer executes step by step. These are described in brief below.

Computer Hard-ware

The computers available now are many in their types or in performance abilites. But whatever may be the differences in their ablities, capacities and configurations every computer will have five basic units. These are : (1) Input devices, (2) Memory, (3) Central processing unit (C.P.U) (4) Permanant memory (5) Output devices

(1) You have to feed in your information and instructions using this **input device.** This is type writer like keyboard.

(2) The information and instructions (programme) will be lodged in **computer memory.** This is like a gramaphone record. This is called floppy or disk.

(3) The control unit selects the instructions, puts them in sequence and directs other units to carryout the operations. It acts like a central nervous system of a body. The arithmatic logic unit receives information regarding the mathematical operations such as addition, subtractiion, multiplication and division.

The control unit and the arithmatic logic unit together are called **Central Processing Unit** (C.P.U).

(4) Some information, if it is to be stored permanantly will be stored in permanent memory.

(5) Finally the control unit enables the output to obtain final results. These are displayed on a monitor or are printed on a paper by a printer. These can also be transferred to a floppy disk.

Computer Software

Computer is a machine. It can not do any operation until we tell it what to do. In other words we must give the instructions. These instructions are given in the form of a programme. A computer will do only those things that are included in the programme. There are two types of computer software. These are **application software** and **system software.**

Application software is a set of programmes to solve problems or produce information or data. These programmes are written in special code or notation or **language.** Some early programs which were in use were given the names as BASIC, FORTRAN, COBOL, PASCAL. Some are suitable for accounting, others for mathematical calculations and some others are for logical purposes. The system software provides the link between the machine (hardware) and application software. The code or programming language is converted into appropriate electrical signals necessary for the operation of the hardware. This system soft-ware is a unit in facility in the system. The user has no control over it.

Types of Computers

The sizes and the computing abilities of computers are varied. It is not easy to classify computers correctly on the basis of their size and performance capacities but yet computers for convenience are classified as micro computers, mini computers, main frames and super computers (monsters). This classification is only an arbitrary one. For example a computer classified as "mini" and sold in the market may perform complex functions, do more computations, store more data and also cost more than a small "mainframe" computer. Similarly a main computer may do better, job than a computer sold as "mini computer".

Micro computers used in offices, at homes are also called Personal Computers (P.C.). These Personal Computers are used for bill making, statements preparations etc., in offices with less effort and in short times. Personal Computers are also used as word processers to type and correct the manuscripts. The text thus prepared can be stored in on a floppy or disk and can be displayed on a screen at will. We can make corrections, additions, and deletions at will. PC's can be linked to mainframe computers. In future PC's will become inseparable part of our daily lives.

Computer Aided Instruction (CAI) helps students to master the subject. Students can also make their own computer programmes and run them on their own computers. Hospitals use computers for storing patient histories as well as for developing images of the parts like lungs, brain etc. Super computers are the largest, and most expensive computers made so far. There are used for weather forecasting. In short we can say that there is no area or field or institution where computers are not used in keeping personal data of employees, workers, students, teachers etc., in different institutions and places of work. In preparing nominal rolls for examinations, in declaring results of examinations and even in the preparation of question papers and valuation of answers scripts, these days computers are extensively used. The list of applictions is only an illustrative one but not an exhaustive one.

Check your Progress

1. What is a computer ?

....

....

2. What are the basic components of a computer?

3. Name the different main parts of a computer and give their function.

4. How many types are computers ?

5. Describe the main applications of computers ?

7.5 ARTIFICIAL INTELLIGENCE - ROBOTICS

Computers perform complicated calculations and solve logical problems. But a recent development in computer science is to provide computers with what is known as "artificial intelligence".

Artificial or computer intelligence requires a computer which first learns the rules of any specific signal processing and then apply them to solve the related problems. Learning and adaptive computers are therefore developed. Experiments are done by computer scientists and engineers to define intelligence and build it into the computers. Of course these will be for specific jobs. For example we can train a dog to do certain jobs. The dog will do these jobs even without our instruction at later date, when there is a need for such a job. A new person may think that the dog is intelligent. But the fact is, the intelligence is artificially put into the dog by its master. Thus the intellegence is first fed into the computers and the computer does use this to perform certain tasks.

Check your Progress

1. What is artificial intelligence ?

2. Are computers having intelligence ? Explain.

Robotics

Robots can be called simply computerised machines. These can be programmed to do a variety of jobs and tasks. For example a robot can be programmed to drill holes of several sizes. It can also be made to play chess, and even to assemble machine parts. A robot can also be made to perform more than one task in a sequence at definite intervals of time. For example an industrial robot can select its own tools from a shelf, drill holes and also make measurements of different parts in a sequence. Therefore a robot can be defined as a computerised, multi functional and reprogrammable machine that performs a large variety of tasks. Thus by suitable programming and artificial intelligence systems robots can be given a wide range of human abilities. The science of designing, building and using of robots is therefore called **robotics.** But one should not wrongly think that robots are mechanical men who can see, hear, feel, walk and talk like human beings. Perhaps it may be possible to have such robots at a future date.

But robots can be made to see. Optical sensors in a robot record the varying brightness of light coming from the object. This recorded brightness, the computer compares with the brightness at different points in a image stored in the memory. If the brightness matches, robot sees the object and carries out the task programmed. These are called seeing robots. They are used in industries to perform specific jobs like fixing glasses for windows or verifying whether bottles are completely filled or not etc. Robots are also used in wars to carry missiles and drop them on targets with great accuracy.

Robots with hands and legs which can function as those of human beings are also prepared. But these robot eyes, ears, hands and legs may not attain human ability. It may take many years probabily to achieve this perfection and ability.

Robots are generally unsensitive to excessive heat, cold, dust, radiation and toxic chemicals. They are therefore not afraid of environmental pollution. They can work in places where there is no oxygen unlike living creatures. Robots can do jobs which are very risky and hazardous for human beings.

Thus robot operated factory may be superior in quality and more efficient than human operated one. People also prefer goods manufactured by robots than by human beings. Developed countries are already using robots in many industries. They are now counting the robot population. But many people are worried about robots displacing human beings. But one should not feel that robots can do everything good and can replace human beings in many fields of work. Robots can create problems too. Robotic industry is counted as a source of unemployment in developed countries. Human beings are always essential for service. Machines can not do all jobs. Therefore it will be a misnomer if we think that robot can replace a man in life. Knowledge-workers are still a great necessity for any country, developed or developing.

Check your Progress

1. What is robot ?

   ....

   ....

2. Can a robot do everything that a man or woman does?

   ....

   ....

3. How many types of robots are known till now?

....

....

4. Mention few jobs or tasks that a robot can perform.

....

....

7.6 SUMMARY

1. Semiconductors are materials whose electrical conductivity is intermediate between that of conductors and insulators.
2. Semiconductors conduct electricity more at higher temperatures.
3. Semiconductors are mainly two types : Intrinsic and doped. Silicon and germanim are intrensic. These can be doped with V group element or a III group element giving rise to n-type and p-type semi conductors.
4. A combination of n-type and p-type semi conductors give transistors. These are n-p-n or, p-n-p transistors.
5. There will be enitter, base and collector in a transistor.
6. Many useful devices are made from semiconductors.
7. Computer is one machine that makes use of semiconductors.
8. Computers have 5 main parts. Input device, Central Processing Unit, Memory and Output device.
9. Computers are classified as micro, mini, mainframe and super computers.
10. Computers have two basic components of it, hard ware and soft ware.
11. Hardware is machinery and software are programmes & languages .
12. Robotics is an application of computer technology which is now used in industries.
13. Artificial intelligence is the principle on which a robot functions.
14. Printin computerised programming in a man - like machine (robot) is called artificial intelligence.

7.7 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. What are semi conductors ? Explain the preparation of different types of semi conductors and their functioning.
2. Describe with examples, the applications of semicondructors.
3. What are computers? Describe its components and mention the functions of these components.
4. What is robotics? How do robots function? Explain.

Answer the following in about 15 lines each.

1. Write notes on semiconductors.
2. Give a brief account of semiconductor's applications?
3. What are computers? How do they work?
4. Classify the computers? What is soft ware of computers?
5. What is artificial intelligence? Explain how a robot functions.

7.8 GLOSSARY

1.	Application Software	:	the set of progrmmes used by users to solve a problem.
2.	Artificial Intelligence	:	the ability of a computer to process signals and apply them to solve problems.
3.	Robot	:	Computerised machine which can do many jobs and be programmed for use in many kinds of jobs.
4.	Semiconductor	:	Solid substance, an element or a compound whose electrical conductivity is less at ordinary temperatures and increases with rise of temperature.
5.	Systems Software	:	Software built into the computer.
6.	Transistor	:	A semiconductor device with three junctions used to amplify signals.

UNIT-8 ATOMS, MOLECULES, COMPOUNDS

Contents

8.1 AIMS AND OBJECTIVES

Aims

In this unit you will learn about different forms of matter (a chemical classification), their properties and chemical behaviour.

Objectives

After you completed this unit, you must be able to

1. clearly understand the different chemical forms of matter.
2. know the importance and the properties of these different chemical forms of matter.
3. gain an insight into their internal structures and shapes etc.,
4. finally correlate their properties to the nature of chemical forms and their structures.

8.2 INTRODUCTION

Entire universe is made of only two types of entities namely **matter** and **energy**. It is easy to recognize matter because it occupies space and has mass. We see different kinds of matter around us. All these different kinds of matter are made up of substances. The composition, structure and reactivity of these substances are dealt with by a branch of sciences know as **Chemistry**. Materials found in nature are either single substances or they consist of two or more substances. Samples of matter having only one substance are called **pure substances.** Samples having more than one substance are called **mixtures.** Pure substances are two types - **elements** and **compounds.** Similarly mixtures are also of two types namely **homogeneous** and **heterogeneous.** The constituents of a heterogeneous mixture can be seen even with a nacked eye whereas in homogeneous mixtures the constituents are so well mixed that the constituents can not be seen even under a microscope.

The sample will have uniform composition. In this unit you learn about these constituents and their properties.

8.3 BASIC CONCEPTS ABOUT MATTER

Matter consists of chemical substances. Substances are recognised by their properties. These properties are basically two types — **Physical** and **Chemical**. Physical properties deal with state, appearence, odour, and solulitity in water or other liquids of the substances. Chemical properties are those that are observed when a substance reacts with another chemically. In the subsections given here under, you learn about the different chemical forms — atoms, molecules, elements and compounds of matter or chemical substances.

Most of the materials which we commonly encounter in our daily routine are not pure substances but are mixtures. For example soil, stones, wood, air, water etc., are all mixtures. They contain more than one substance. Properties of these materials therefore depend on the nature and the amount of the constituents. The substances are classified chemically as **atoms, molecules, elements** and **compounds.** You learn about these in the next subsections.

Atoms

It was observed that all chemical subtances obey certain laws in their chemical behaviour. These laws are generally referred to as laws of **chemical combinations.** This made the scientists to speculate about the ultimate particles of matter. The most famous speculations are due to John Dalton, a modern atomic scientist. You have learnt in unit-2 that it was proposed in even ancient times that matter was recognisable through its five qualities smell, taste, touch, colour and sound.

The oldest of Indian Philosophical system was **Samkhya.** This system envisaged that everything except consciousness evolved out of primordeal matter. This system Samkhya proposed a system of matter without the intervention of Gods. A diferent way to understand the nature or matter was later proposed and this stipulated the existence of fundamental building blocks of observed substances. These were named as **atoms.** A particular combination of these ultimate and fundamental particles of matter imparted characteristic properties and qualities to substances.

The Indian **Vaisesika** system was proposed about 600 BC. **Kanada** was the well known propenant of this system. He considered these smallest, fundamental particles of matter as dimensionless mathematical points. Thus the concept of "atoms" as fundamental particles of matter was proposed even in 600 BC by Indians and Greeks. But we can not consider the Greek or Indian **atomism** concept, purely as a part of scientific ideas, inspite of its great significance and brilliance. But Geek and Indian atomism did influence the modern atomic theories of Gassendi (1592-1655), Newton (1642-1727) and Dalton (1766-1844).

The most accepted and purety scientific theory of ultimate particles of matter is that proposed by **John Dalton.** Even now he is considered as the father of the atomic theory of matter. He proposed the theory known as **Dalton's atomic theory.** The most important postulates are.

1. Matter is discontinous and is made up of atoms.
2. Atom is the smallest (chemically) indivisible particle of matter.
3. It is atoms that take part in the chemical changes and reactions.

4. Atoms of an element are identical in size, shape, structure etc., but differ from those of other elements.
5. Atoms can not be created or destroyed.
6. Atoms combine in simple fixed ratios to give compounds.

Atom is so minute that it can not be detected even with the most powerful microscope. It can not be weighed by a balance. Hence only relative weights (how many times an atom is heavier than another) are proposed and used. These are know as atomic weights.

$$\text{Atomic weight} = \frac{\text{Weight of 1 atom of an element}}{\text{Weight of 1 atom of Hydrogen}}$$

Now this concept is revised and expressed as

$$\text{Atomic weight} = \frac{\text{Weight of 1 atom of element}}{\frac{1}{12} \times \text{Weight of 1 atom of C - 12}}$$

Atomic weight is thus a number. But it is expressed in grams and this is referred to as gram atomic weight. Some of these are given below.

		At.Wt
Hydrogen	—	1 g
Oxygen	—	16 g
Nitrogen	—	14 g
Carbon	—	12 g
Copper	—	63.5 g
Silver	—	108 g
Uranium	—	238 g

Check your Progress

1. What is an atom ?

2. Who proposed the atomic nature of matter in ancient India.

3. The name of the modern scientist who proposed the atomic theory of matter is

Molecules

Avogadro (1811) suggested that the fundamental chemical unit is not an atom but a **molecule.** This is considered as a **Cluster** of **two or more atoms** held together by some chemical forces.

Molecule is thus considered as the smallest particle of a chemical substance in the elemental state or compound state. This can exist free and also retains all the properties of the substance to which it belongs. For example hydrogen is an elemental substance in the gaseous state. Therefore this gas contains in it the smallest particles called **molecules** of **hydrogen.** Molecules of elementary gases such as hydrogen, oxygen, nitrogen, chlorine etc., contain diatomic molecules. These molecules, each contains two atoms of the gaseous substance. Hydrogen molecule contains two atoms of hydrogen, Oxygen molecule contains two atoms of oxygen etc., Hence these gaseous molecules are called **diatomic molecules** (H_2, O_2, Cl_2, N_2). But not molecules of all elemental substances need contain only two atoms. For example molecules of noble gases helium, neon, argon etc., contain only **one atom** each. These are **mono atomic.** Posphorus, arsenic and antimony molecules contain each four atoms. These are **tetra atomic** (P_4, As_4, Sb_4).

Ozone gas (O_3), contains 3 atoms of oxygen in its molecule (triatomic), sulphur molecule contains 8 atoms of sulphur (S_8 Octa-atomic). The atoms constituting a molecule may be same or different. If these are same, the substance is referred to as **element.** If these atoms are different, the substance is considered as compound. Thus H_2, O_2, O_3, P_4, S_8, considered above are all **elements.**

Substances consisting of molecules containing two or more different atoms are called compounds. For example water, ammonia, hydrochloric acid, carbon dioxide are some examples. The molecules of these substances contain atoms of different kind as shown below.

Hydrochloric acid	—	HCl
Carbon dioxide	—	CO_2
Ammonia	—	NH_3
Water	—	H_2O

The molecule of a substance is also a small particle like an atom. Its mass can not be determined absolutely by weighing it in a balance. Therefore in the case of molecules also the molecular weight is expressed as a ratio.

$$\text{Molecular weight} = \frac{\text{Weight of 1 molecule of the substance}}{\frac{1}{12} \times \text{Weight of 1 atom of C-12}}$$

Molecular weight expressed in grams is called gram molecular weight. The gram molecular weight is obtained by adding the gram atomic weights of the constituent atoms for example.

Water	—	H_2O	—	$2 \times 1 + 16 = 18$ g
Ammonia	—	NH_3	—	$14 + 3 \times 1 = 17$ g
Hydrochloric acid	—	HCl	—	$1 + 35.5 = 36.5$ g

Elements

All materials found in the earth are composed of chemical elements. Around two thirds of elements are metals. Some of the familiar metals used in our daily life are iron, copper, aluminium, tin, led, gold, silver, nickel, mercury. Few of the non-metals used are hydrogen, carbon, oxygen, nitrogen, sulphur, and phosphorus.

Some of the elements only occur in the free state or **Native State.** All others occur in the combined state as compounds.

The elements copper, gold, silver and lead were discovered and used even before 3000 BC although they were not recognised as elements until much later time.

The majority of other elements have been identified within the last 300 years. The distribution of elements in different regions of the earth is also different. About 80% of the earth's surface is covered with water. This is a major source of elements. The sea contains a large number of elements. The atmosphere contains mainly nitrogen, oxygen and other gases. The solid phase of the earth called lithosphere cantains major number of elements in the combined forms.

Elements are accumulated in living organisms too. The most familiar example is iodine in sea weeds. Vanadiun is present in sea cucumbers and potassium is present in plant life. Elements are also present in the combined state as complex materials in hemoglobin (iron) & magnesium in chlorophyl. Sea contains Cl, Na, Mg, S, Ca, K, C as major elements in the combined state, Br, B, Sr, Si, N, Li, Al, Rb as minor elements in the combined state.

Check your Progress

1. What is a molecule? Give two examples.

2. Name three molicules of importance in daily life.

3. How are atoms bound in a molecule ?

4. Give two examples of compounds of importance in daily life.

5. What are chemical elements ? Give examples.

Compounds

Elements combine with each other to form more complex forms of matter called compounds. Everyday examples of compounds include table salt, table sugar, alcohols, water and vitamins. The compounds identified so far extend to millions in numbers. Elements combine to give compounds and this combining force is a chemical force, generally referred to as **Chemical bond.** Thus chemical combination of elements to give compounds takes place as per certain laws. These are called laws of chemical combination. Further, elements combine in simple numerical ratios only to give compounds. All the minerals that exist in nature are good examples of chemical compounds. These compounds are mainly metal oxides, metal sulphides, metal carbonates and metal halides. These compounds, occur singly or as mixtures of compounds.

From the above examples you may perhaps wrongly conclude that compounds are always formed by the combination of metals and non-metalic elements. But many compounds present in living organisms such as plants, animals, micro organisms and human beings are mainly the compounds formed by the combination of non-metallic elements. (C, H, O, N etc.,)

For example water, carbondioxide, ammonia, carbohydrates, sugars, starch, amino acids proteins are all examples of such compounds. Now the synthetic compounds prepared in the laboratary by chemists may even out-number the naturally occuring compounds. These compounds formed by the chemical combination of non-metalic elements may be simple ones of low molecular weight or very large ones of very high molecular weights (ranging in lakhs of grams). These high molecular weight compounds consisting of large molecules are called **macro-molecular** or **polymeric** compounds. Most of the plastics, and the synthetic fibres you see in your daily life belong to this category. The naturally occurring proteins and poly saccharides (starch, cellulose) are also the examples of these polymeric macro molecular compounds.

Check your Progress

1. Name three compounds you know.

   ....

   ....

2. Classify these compounds into simple and polymeric.

   ....

   ....

8.4 CHEMICAL BONDING

Atoms combine chemically to give compounds. For example sodium chloride and water are compounds known to us. We use them daily in our life. You have learnt that there are millions of such compounds, natural or synthetic. Compounds are broadly divided into two categories based on the type of chemical bond involved in the formation of these compounds from their elements. For example the chemical bond involved in the formation of salt (sodium chloride) from its elements sodium and chlorine is different from the bond responsible for the formation of water from its elements namely hydrogen and oxygen.

Thus these compounds are classified as 1) ionic compounds or electrovalent compounds (sodium chloride) and 2) co-valent compounds (water). In the formation of either type of compounds, electrons of the atoms concerned take part in the combination of the atoms.

Ionic Compounds

The compounds formed between the elements of alkali or alkaline earth metals and elements of non-metal nature such as oxygen, sulphur and halogens are generally ionic compounds.

In this type of compounds, the metallic element loses an electron and forms a positively charged species called positive ion

(M^+) $\quad M \xrightarrow{-e^-} M^+ + e^-$

for example sodium atom

$$Na \xrightarrow{-e^-} Na^+ + e^-$$

This electron is accepted by the non-metallic element and forms the negatively charged species called negative ion. For example chlorine (Cl) atom gains this electron and forms Chloride ion (Cl^-)

$$A + e^- \rightarrow A^-$$
$$Cl + e^- \rightarrow Cl^-$$

These positive and negative ions (Na^+, Cl^-) are then bound by electro-static forces and give sodium chloride compound.

$$Na^+ + Cl^- \rightarrow Na^+ Cl^- \text{ compound}$$

Ionic compounds are solids, crystalline in nature, and freely soluble in water. In water solutions they allow electric current to pass through them. These substances are therefore called conductors of electricity or electrolytes. Ionic compounds generally possess *very high* melting points and boiling points.

Co-valent Compounds

The compounds formed between elements of less metallic character or of non-metallic character with other elements of non-metallic character are generally known as co-valent compunds. For example compounds formed between aluminium, boron, carbon with non metallic elements such as oxygen, sulphur and halogens are all co-valent compounds. In the formation of these type of compounds electrons are supplied by both the atoms involved in the bond and these are mutually shared between the two atoms. For example the compound hydrogen chloride is formed by sharing the two electrons (each suppled by hydrogen and chlorin) between them.

$$H\bullet + \bullet Cl \rightarrow H{:}Cl$$

(dot represents electron)

Similarly in the formation of water, oxygen atom supplies two unpaired electrons (single electrons) and two hydrogen atoms supply each one electron. These are mutually shared between O and H's to form **two** co-valent bonds (each shared pair is known as co-valent bond)

$$H. + .\dot{O}. + .H \rightarrow H : \ddot{O} : H$$

(water molecule is actually a bent molecule)

Co-valent compounds do not dessolve generally in water because these are non-iomc in nature. They do not conduct electricity through them. Hence these are not conductors of electricity. The melting, boiling points of these compounds are not very high.

Check your Progress

1. Illustrate Ionic bond formation with example.

....

....

2. Explain co-valent bond formation with one example.

....

....

3. Name a co-valent compound present in our body.

4. Name an ionic compound with out which we can not eat our food.

8.5 INDUSTRIALLY IMPORTANT INORGANIC SUBSTANCES

Chemical substances are generally classified into inorganic substances and organic substances Inorganic substances are also known as substances of mineral origin. Organic compounds are compounds of carbon. Most of these compounds are present in living organism. It is for this reason these were referred to as organic compounds in earlier days. Now these are generally called as carbon compounds. Both the types of compounds are industrially and otherwise very important. In this section of the unit, we discribe some industrially important inorganic substances. Some of these are metals,alloys, steel, cement, glass, chemical fertilisers and explosives. Many others are also there.

Metals and alloys

The discovery and use of metals by men started even in the Bronze age, named after the new alloy Bronze which replaced the stone during this period for making tools etc., Human beings were attracted by shiny gold and copper and they were using these metals for making ornaments Bits of metals were found in necklaces and other ornaments of stone age. The Bronze Age people found that copper metal was too soft to make tools. So they discovered an alloy of copper and tin called bronze. It was harder than both copper and tin. Bronze tools,containers, ornaments, toys etc., were found in the excavations at Mohenjodaro,Harappa and other nearby places.

Iron was extensively used in Iron Age to make tools. Greatest developments in the fields of metallurgy and metal working in India took place in Murya period. It is only in this period foundations were laid for the manufacture of. alloys. Iron tools and artefacts such as ladles,razors, axes, sickles were found in the Karimnagar and Nalgonda districts of the telangana region of Andhra Pradesh. Kanishka reign was, the most flourishing period in the history of use of metals in south India. Coins of lead, copper, bronge, silver and gold were found in the excavations.

These were mainly from Satavahana period. Thus use of metals and alloys for many purposes dates back to Brongĕ Age. It will not be an aggegeration. If we say that there is no industry or technological activity now, which do not use metals or alloys. Metals find wide applications in all areas of industry and technology including defence. Metals of highest purity (~ 100%) and alloys of highest tensile strength are known and found applications in industry as well as in defence activities. The properties of the metals can be changed to suit the needs by alloying them with other metals generally. In some special cases non-metals such as carbon are also used. For example steal is a combination of iron and carbon. An intimate mixture of two or more metals prepared by special methods is known as alloy. If the metal added is mercury (Hg), the alloy is referred to as **amalgam.** For example Zn-Hg, Cd-Hg, Cu-Hg etc., Similarly if the alloying metal is zinc, the process is known as galvanization. Generally iron is galvanised and used as galvanised iron in industry. The metal water-pipes you use in your house are galvanised iron pipes only. Some important alloys in use are lised below.

Alloy	Composition	Uses
1. Aluminium - Bronze	90% Cu 10% Al	Coins, Picture frames
2. Brass	70% Cu, 30% Zn	Utensils
3. Bronzes	75% Cu, 25% Sn + small amounts of Zn, Al etc.	Coins, Statues
4. Bell Metal	80% Cu - 20% Sn	Machine Parts, Bells, Gongs
5. Babbit Metal	Sn 88%, Sb - 7%, Cu 4%	Metal bearings
6. Constanton	4% Ni, 60% Cu	Thermocouples
7. Duralumin	95.0% Al, 4% Cu, 0.5% Mg 0.5% Mn	Aeroplane parts
8. Dutch Metal	Cu, Zn	Gold coverings
9. Elektron	Mg, Zn with small amounts of Al, Cu, Mn	Air Crafts
10. German Silver	50% Cu, 25% Zn, 25% Ni	Fancy articles
11. Gun Metal	88% Cu, 10% Sn, 2% Zn	Guns
12. Magnalium	90% Al, 10% Mg	Balances
13. Solder	67% Sn 33% Pb	Soldering
14. Stainless Steel	Steel + 11% Cr + 7% Ni	Surgical Instruments
15. Type Metal	82% Pb, 15% Sb, 3% Sn	Types for Printing
16. Wood Metal	25% Pb, 12.5% Sn, 12.5% Cd, 50% Bi	Automatic Sprinkles

Check your Progress

1. What is an alloy?

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2. Name any three alloys?

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3. What are Brass, Bronge and Steels?

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Cement

This ia a very important building material. It is called generally Portland cement because it resembles a famous variety of building stone available in Portland in England. Chemically cement is a finely ground mixture of calcium aluminates and silicates of different compositions.

On adding water cement becomes a hard mass. This was first discovered by Joseph Aspidin (1924). The essential raw materials for the manufacture of cement are **limestone** ($CaCO_3$) and **clay.** In the wet process the mixture is made into a slurry with water and it is heated to about 1500 C. The mixture is partly fused and gives grey mass. This is known as **clinker**. The clinker is powdered and gypsum (2-3%) is added to slow down the setting process. The process of hardening of cement on treatment with water is known as **setting**. The average composition of cement is CaO — 50-55% ; SiO_2 — 20-25%; Al_2O_3 — 5-10%; MgO — 2-3%; Fe_2O_3 — 1-2%.

A mixture of cement, gravel or small pieces of stones and water is called **concrete.** This is used in preparing the foundations for buldings, for making slabs and in the preparation of roads etc.,

Check your Progress

1. Give the raw meterials reqired for cement manufacture.

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2. What is the composition of cement?

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3. Name stone used as Cement.

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Glass

Glass is a transparent hard material prepared using quartz sand, soda ash, caustic potash, lime stone, magnesite, barytes or kaolin etc., It is considered not as solid but only as a super cooled liquid. The major ingradients of glass are sand, lime and soda ash. It will not have definite composition. Glass is not attacked by air and oxidising agents. Glass is resistant to acid but is attacked by alkalies. Hydrofluoric acid (HF) attacks glass. This process is known as **"etching"** and is used in marking glass. There are different types of glass. These differ in their composition. Some of these are

1. Ordinary glass (Soda glass) : Na_2O, CaO, 6 SiO_2.
2. Water Glass : Na_2SiO_3.
3. Fused Silica Glass (quartz glass) : SiO_2
4. Optical glass : Lead and Potassium Silicates.
5. Pyro Silicate glass : 13-28% B_2O_3 and 80-87% SiO_2.
6. Pyrex glass : Zinc and Barium Borosilicates.
7. Safety Glass :

   Laminated : A non-brittle plastic sheet is placed between two thin glass plates and the plates are pressed.

   Tempered glass : Strong and tough.
8. Crookes Glass : CeO_2 + Silicates.
9. Coloured glasses : Coloured Metal Oxides are added for obtaining necessary colours.

Colour	Added substance	
Violet	MnO_2	Manganese dioxide
Blue	CoO	Cobalt oxide
Green	Cr_2O_3	Chromium Trioxide
Red	SeO	Selenium oxide
Black	CuO	Cupric oxide
Yellow	CdS	Cadmim Sulphide

Uses : Glass is used in making.

1) Mirros
2) Scientific Instruments
3) Lenses
4) Glass Wear
5) Electric Bulbs
6) Window Pans
7) Automobile Windows
8) Coloured Spectacles.

Cheek your Progress

1. What is glass ?

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2. Name three glasses you know ?

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3. What are the uses of laminated glasses?

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Chemical Fertilizers

Plants require compounds of more than a dozen elements for healthy growth. Amongst these elements, nitrogen, phosphorus, and potassium are very important. Several others such as calcium, iron, manganese, copper, zinc, boron and iodine are needed in small amounts. These are called nutrients. These are absorbed by plants from soil. Soils may not contain these elements in sufficient amounts for continuous supply to plants. Hence these are supplied to soils in the form of chemical compounds called **fertilizers** or natural mannures (compost, biomass etc.,). Chemical fertilizers should satisfy the following criteria. The fertiliser

1. should not make the soil alkaline.
2. should be soluble in water of the soil.
3. should be easily and uniformly distributed in the soil.
4. should be stable.

Fertilizers are classifed as

Nitrogen Fertilizers : These are
1) Calcium Cyanamide $CaNCN$. It contains 20.6% nitrogen.
2) Ammonium Sulphate $(NH_4)_2 SO_4$. It contains 21% nitrogen.
3) Urea $NH_2 CO NH_2$. It contains 47% nitrogen.
4) Calcium Ammonium Nitrate (CAN). It contains 35% nitrogen.

Phosphorus Fertilizers : These are

1) Superphosphate of lime Ca $(H_2PO_4)_2$ H_2O + $CaSO_4$ $2H_2O$. Available phosphate is 20%.
2) Triple Super phosphate 3 Ca H_4 $(PO_4)_2$ 3), Calcium Superphosphate Nitrate or Nitro Phosphate Ca $(H_2PO_4)_2$ + 2 Ca $(NO_3)_2$

Potassium Fertilisers : These are

1) Potassium Chloride KCl. It contains 52% K.
2) Potassium Sulphate K_2SO_4. It contains 44% K
3) Potassium Nitrate KNO_3. It contams 39% K.

Complex Fertilizers : These are mixtures of the above three types. These are known as NPK fertilizers. The fertilizers are added to the soil after the nutrient deficiency is established only. For this the farmers should consult the agrecultural scientists and also get the soils tested by the relevent authorities of soil testing.

Check your Progress

1) What is a fertilizer?

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2) Classify fertilizers and name them.

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3) What is complex fertilizer?

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Explosives

Explosives are chemical compounds or mixtures of chemical compounds which under the influence of thermal and mechanical shock decomposes rapidly and spontaneously with evolution of great amount of heat, sound and large volume of gases.

The first real explosive was discovered by Roger Bacon (1800). It is called **gunpowder** or **blackpowder.** It is a mixture of sulphur, charcoal, and salt petre. This consists of 15% charcoal, 10% sulphur and 75% salt petre, you are all familiar with this mixture because you use it in the preparation of rockets on festive occasions such as Deevali.

All explosives generally contain nitrogen and oxygen in chemical combination in the form of nitrate ($-NO_3$) or nitro groip ($-NO_2$). Generally inorganic explosives contain nitrate salts and organic explosives contain nitro organic compounds. Explosives are used for civil purposes and also for military (defence) purposes. Hence these are also classified as military explosives and industrial explosives. In non-military purposes these are used to explore mineral oil and water resources present under the land or under the sea.

An organic explosive called Gun Cotton was discovered in 1846 by C.F. Schonbein. It consists of cellulose (wood pulp) and a nitro derivative of it called nitro cellulose. This is obtained by the action of a mixture of conc H_2SO_4, and conc HNO_3 on cellulose.

Nitro Glycerine another explosive was discovered by Alfred Nobel in 1862. Mixed with

Kieselghur. The nitro glycerine is called **dynamite.** The fortunes Nobel got by the sale of the explosive are used now in the form of Nobel Prize. This is an highest academic award for any one who contributes outstanding work in the fields of literature, sciences, medicine and social sciences. In our country C.V.Raman Rabindranath Tagore, Hargobind Khurana, Chandra Sekhar and Amrityasen got this highest award. A more powerful explosive than dynamite is a mixture of 8% nitro cotton and 92% nitro glycerine. This is called blasting explosive. Gelatine cordite is another explosive obtained by mixing a paste of gun cotton (65%) with nitroglycerine, acetone and vaseline. In inorganic type of explosives the following can be quoted as examiplels.

1) Ammonium Nitrate + Al powder (Ammonal)
2) Ammonium Nitrate + TNT (Ammatol)
3) Ammonium Nitrate

Under common and simple organic explosives, Tri Nitro Toluene (TNT) and Tri Nitro Phenol (Picric acid) can be cited.

It is generally said that all ferlfitizer factories in peace time become explosive factories in war time.

Explosives are also classified as per their chemical structure. These are

Nitro explosives : TNT
Nitramine explosives : Cyclonite RDX (Research Development Explosive)
Diazo Explosives : Divol, Tetracene

On the basis of applications, explosives are classified as

Military explosives : Picric acid, Lead azide, TNT, RDX, Nitrocellulose.
Industrial explosives : Black powder, Dynamite, Nitroglycerine.

Check your Progress

1. What is an explosive ? Name three ?

2. Name three scientists who discovered explosives ?

3. Name the scientist, whose name is associated with an academic award.

4. How are explosives classified ?

5. Name the persons who got Nobel Prize in India ?

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8.6 SUMMARY

1. Entire universe is made of only two types of entities namely **matter** and **energy.**
2. Anything that occupies **space** and has **mass** is known as **matter.**
3. Matter is made up of **chemical substances.**
4. Chemistry is the branch of sciences, that deals with composition, structure and reactivity of chemical substances.
5. Samples having more than one substance in them are called **mixtures**.
6. Samples having only one substance in them are called **pure** substances.
7. Pure substances are either **elements** or **compounds**.
8. Mixtures are classified as **homogeneous** and **heterogeneous.** In the former cases the constituents of the mixture can not be seen with the nacked eyes.
9. Chemical substances are classified as atoms, molecules, elements and compounds.
10. Atoms are the ultimate fundamental particles of matter.
11. The concept of "atom" was proposed by Kanada, an Indian Propenant of **Vaisesika** system even in 600 BC.
12. The atomic nature of the matter was proposed during the period of modern science by John Dalton. He is considered as the father of modern atomic science.
13. Datton's theory proposed that
    1) Atoms are indivisible.
    2) Atoms only take part in chemical reactions.
    3) Atoms of an element are identical in shape, size, structure and properties.
14. The ratio of weight of an atom to the weight of 1/12 of weight of one atom of C-12 is know as **atomic weight.** It is a ratio.
15. A clustre of two or more atoms bound by chemical forces is called **molecule.**
16. Molecule containing the same atoms are called **homo atomic molecules** and those containing different atoms are called **hetero atomic molecules.**
17. Molecule is the ultimate entity of a substance and its properties are the properties of the concerned substance.
18. The number of atoms present in the molecule is called **atomicity.**
19. The ratio of weight of one molecule of a substance to the weight of 1/12 of the weight of one atom of C-12 is known as molecular weight. It is a ratio.
20. All chemical substances are formed out of elements. There are about 105 chemical elements known.
21. Atoms of elements combine to give molecules.
22. Elements are present in the earth's crust in the combined state (compounds). These are called minerals.
23. The minerals are generally either oxides, sulphides, carbonates, halides or silicates.

24. Compounds based on their structure and properties are classifed into inorganic and organic (carbon) compounds.

25. Carbon compounds are generally present in living organism and inorgainc compounds are mostly present on earth's crust (non-living origin). But there are exceptions.

26. Atoms are bound in molecules by chemical forces known as chemical bond.

27. Chemical bond is of two types. These are **ionic bond** and **co-valent bond.**

28. In general (there are exceptions) salts contain ionic bond and organic compounds contain co-valent bond.

29. Ionic compounds are soluble in water, possess high melting and boiling points. These are good conductors of electricity in water solutions.

30. Co-valent compounds are insoluble in water. They possess low melting and boiling points. These are not generally good conductors of electricity.

31. Many inorganic compounds are industrially important. For example metals, alloys, cement, glass, chemical fertilizers, and explosives are all inorganic substances.

32. Alloys are obtained by the chemical reactivity or by fusion of different metals. Alloys are more useful than the individual metals. Some examples of alloys are bronze, brass, steels, german silver, bell metal, gun metal etc.,

33. Cement is a chemical substance formed from lime and clay. This is a building material. Its composition is indefinite. It resembles a stone in Portland in England.

34. Glass is a super cooled liquid obtained by fusing silica (sand) and some salts. It is a mixture of oxides of metals and silica with indefinite composition.

35. Fertilizers are the chemical compounds added to soil to supply the major nutrients namely N, P, K.

36. Explosives are chemical substances which on ignition reacts violently releasing large amount of heat, sound and large volumes of gases . RDX is the most powerful explosive.

37. The most important explosives are ammatol, ammonal, TNT, dynamite, gun cotton and RDX.

38. Alfred Nobel invented dynamite and made large profits in its sales. These profits are used to institute the Nobel Prize.

39 The highest academic award is the Nobel Prize.

40. C.V.Raman, Rabindranath Tagore, Hargovind Khurana and Amrit Sen are the Indians who received the Nobel Prize.

8.7 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. Explain the terms : atoms, molecules, elements and compounds with suitable examples.
2. What is a chemical bond ? Explain the same with examples.
3. Discribe the compositions and applications of alloys in our daily life.
4. What is cement ? How is it prepared ?
5. Explain the term "glass" ? How is it prepared ? Give its uses type wise.
6. What are chemical fertilizers ? Why they are needed for plants ? Name some important fertilizers.

7. What is an explosive ? Name the different explosives, their chemical formula and uses.
8. Discuss in brief the importance of inorganic chemical compounds in industry and daily life. Give examples.

Answer the following in about 15 lines each.

1. Differentiate between atoms and molecules.
2. Distinguish between elements, compounds and mixtures.
3. What is cement ? Give its compositon and uses.
4. What is glass ? Name the different types of glasses and their composition.
5. What are chemical fertilizers ? Give their chemical formula and uses.
6. Explain the term "Explosive". Name three explosives and their chemical formulas.

8.8 GLOSSARY

Atom	:	The smallest particle of an element.
Compound	:	Substance formed by the chemical combination of different atoms.
Cement	:	A binding material prepared by fusing lime and clay. It resembles a stone in Portland in England.
Dynamite	:	Nitroglycerine, an explosive, invented by Alfred Nobel.
Explosive	:	A chemical sample which on detonation gives large heat, sound and large volumes of gaseous products.
Fertilizer	:	A chemical substance or a mixture of chemical substances added to the soil to enrich it with N, P, K elements urea, NH_4NO_3, KCl superphosphate etc.
Fission	:	Melting.
Glass	:	A transparent super cooled liquied prepared by fusing sand with some salts (alkali and alkaline earth salts)
Guncotton	:	Cellulose nitrate, an explosive.
Mixture	:	A sample of chemical substance with no definate composition.
Molecule	:	A particle composed of two or more atoms bound by chemical forces.
Physical property	:	Charateristic that do not involve a charge in composition of the material.

UNIT-9 INDUSTRIAL CARBON COMPOUNDS

Contents

9.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about an important class of chemical compounds called organic compounds or now called as carbon compounds in respect of the following.

1. What are carbon compounds?
2. How are these classified?
3. Their occurrence and uses.
4. Their role in man's life.

Objectives

After you completed the unit you must be in a position to

1. understand the nature of bonding in carbon compounds.
2. appreciate the advances made in the field of synthetic carbon compounds.
3. know the compositions, properties and uses of plastics, polymers and fibres.

9.2 INTRODUCTION

The chemistry of carbon compounds (excluding the carbonates, carbides, cyanides, carbondioxide, carbon mono oxide etc.) was known as organic chemistry. The name originated with early chemists who believed that organic compounds are formed only through the action of vital forces found in living organisms. They were believing that these compounds occur only in living organisms such as plants, animals, micro organisms and human beings and that these cannot be prepared in the laboratory from the inorganic, mineral resources or inorganic compounds. But in 1828, Friedrich Wohler synthesised an important organic compound, **Urea** (NH_2 CO NH_2) by heating an inorganic compound ammonium cyanate (NH_4CNO) without the involvement of any vital force. From this point onwards many organic compounds were prepared in the laboratory. Chemists have already identified several million carbon compounds and new ones are being added to the list almost daily. The organic chemist has by study of natural organic compounds learned how to prepare a host of other organic substances of common use in everyday life. These include synthetic fibres, drugs, plastics, synthetic leather, synthetic rubber, paints, varnishes, insecticides and other agrochemicals.

Therefore we try to learn about some of these organic compounds in this Unit.

Carbon forms vast and varied types of carbon compounds. No other chemical element is capable of forming this large number of compounds possessing different types of properties. This capability of carbon to form varied type of compounds is attributed to the following properties of carbon.

1. Carbon exhibits a valency of 4.
2. Carbon combines with itself and forms long chains or big rings. This property of carbon is known as **Catenation.**
3. Carbon is capable of forming multiple bonds (double and triple bonds) between any two atoms of it.

In a single statement, we can say that from the time we get up from our bed to the time we go to bed again in the night, we use a large variety of carbon compounds. For example the soap we use, the clothes we wear, the house hold articles we use are all made from organic compounds.

9.3 TYPES OF CARBON COMPOUNDS (FUNCTIONAL GROUP WISE)

Carbon compounds show characteristic properties. These properties arise out of a specific **atom** (halogens, sulphur, oxygen) or a specific group of atoms bound chemically (eg. OH, CHO, CO etc.) present in the molecules of the compounds. These atoms or group of atoms responsible for the characteristic properties of organic compounds are known as **functional groups.**

The organic compounds are therefore classified into different types based on the nature and structure of the functional groups. The simplest type of organic compound that possessed no functional group in it is known as "hydrocarbon" type. This type of compounds contains only carbon and hydrogen in them and hence the name **hydrocarbon.** For example methane (CH_4), cooking gas (butane), blow pipe gas (acetylene). All other types of carbon compounds possess one or more functional groups and are considered as derivatives of these hydrocarbons. One or more atoms of hydrogen in the hydro carbon are substituted by other atoms or functional groups. Based on the functional group present in the carbon compounds, they are named specifically. The functional group present and the name of the type of the compound possessing the functional group are listed below in the table 9.1

9.1 Classification of carbon compounds on the basis of the functional groups.

Functional Group	Name of the Compound	Compound Formula	Example
– OH	Alcohols	CH_3OH	Methyl alcohol
– CHO	Aldehydes	CH_3CHO	Acetaldehyde
$>$CO	Ketones	CH_3COCH_3	Acetone
– COOH (Carboxyl group)	Acids	CH_3COOH	Acetic acid
– COOR	Esters	$CH_3COOC_2H_5$	Ethyl acetate
– CO NH_2	Amides	CH_3CONH_2	Acetamide
– CO Cl	Acid Chlorides	CH_3COCl	Acetyl chloride
– NH_2	Amines	CH_3NH_2	Methyl amine

$-NO_2$	Nitro Compounds	CH_3NO_2	Nitromethane
$-O-$	Ethers	CH_3OCH_3	Dimethyl ether
$-Cl$	Chloro Compounds	CH_3Cl	Chloro methane or Methyl chloride
		$CHCl_3$	Chloroform

An organic compound may be a long chain compound (aliphatic) or a ring compound (alicyclic or aromatic). For example $CH_3CH_2CH_2CH_2CH_2CH_2CHO$ is an aliphatic aldehyde containing 7 carbon atoms.

C_6H_5CHO is an aromatic aldehyde containing the same 7 carbon atoms.

The bond between two adjacent carbon atoms in a long chain compound may be a single bond or a double bond or a triple bond as shown below.

$H_3C - CH_2 - CH_3$ — Single bonded compound

$H_3C - CH = CH_2$ — Double bonded compound

$H_3C - C \equiv CH$ — Triple bonded compound

The compounds containing the double or triple bond in them are known as **unsaturated** compounds. For example the simplest double bonded compound is ethylene ($CH_2 = CH_2$). Similarly the simplest triple bonded compound is acetylene ($CH \equiv CH$) and the simplest saturated two carbon compound is ethane CH_3-CH_3. Organic compounds may be simple compounds containing measurable number of carbon compounds and possessing a definite chemical formula and a definite molecular weight. Such compounds can be called generally as **monomers**. For example ethylene of formula $H_2C = CH_2$ is a monomer $HC \equiv CH$, acetylene is a monomer.

But there are many natural as well as synthetic organic compounds which contain very large number of carbon atoms and whose chemical formulas and molecular weights are indefinite. Such compounds are known as **polymeric compounds** or **macro molecular compounds**. For example the naturally occurring proteins, starch, cellulose, rubber are all natural polymeric compounds. Similarly polythene, poly vinyl chloride, polyesters are all synthetic polymeric compounds.

You learn about these compounds in more detailed fashion in the next sections.

Check Your Progress

1. What are carbon compounds ?

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2. What is a functional group ?

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3. Name three functional groups.

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4. Write the formulas of simple compounds containing triple bond, -CHO group, $-CONH_2$ group, $-NH_2$ group.

5. What are polymers ?

6. Name two natural polymers.

7. Name three synthetic polymers.

9.4 MACRO ORGANIC MOLECULES

Molecules containing large number of carbon atoms and exhibiting very high molecular weights are known as **macromolecules.** In these molecules the carbon atoms will be in very large numbers (10-100) linked to each other. The molecular weights also will be in the range of thousands (10000-100000). These macromolecules are called **Polymers.**

A **polymer** is defined as a high molecular weight compound formed by the combination (chemical) of a large number of more units of simple molecules of low molecular weight. The unit substance of which a polymer is made is called a **monomer.**

Many polymeric substances occur in nature in different forms in living organisms (plants & animals). For example **cellulose, starch, rubber, proteins** and **resins** are few examples. Polymeric substances of desired nature and properties are extensively prepared in the laboratory these days.

Polymers are synthesised from monomers by a chemical process known as polymerization. The polymerization process is of two types mainly (1) **addition** polymerization and (2) **condensation** polymerization. (1) **Addition Polymerization** is considered as a chain process resulting in the formation of long chains of polymers. In these, monomers are linked by addition process to each other in large numbers.

The primary molecule (monomer) reacts with another in presence of a catalyst to form first a **dimer** This in turn reacts with another monomer and gives a **trimer.** This process continues until this addition process is terminated by a chain terminating process or till the stock of monomer is exhausted. For example, you might have heard of the polymer 'Polythene'. This is an addition polymer of the monomer ethylene ($H_2C = CH_2$). Its formation can be represented as

$$H_2C = CH_2 + H_2C = CH_2 \longrightarrow -CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2-$$

Monomer Monomer Dimer

$$-CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2- + CH_2 = CH_2 \longrightarrow -CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2-$$

Dimer Monomer Trimer

The process continues and finally the polymer is formed. This is represented as $-(CH_2\text{-}CH_2)_n-$

(2) **Condensation Polymerization :** In this process, two different monomers react with each other (condense) and a simple molecule such as water (H_2O), ammonia (NH_3) is eliminated in the process. For example, you heard about Nylon. This is a condensation polymer. It is formed by the condensation of a **diamine** (1, 6 hexane diamine) and a **diacid** (adipic acid) with elimination of water molecules.

$$n\ HOOC\ (CH_2)_4\ COOH + nH_2N\ (CH_2)_6NH_2 \xrightarrow[-nH_20]{\Delta} [OC(CH_2)_4CONH(CH_2)_6NH]n + nH_2O$$

We have large numbers and varieties of polymeric substances now synthesised in the laboratory. Based on their properties, these are called by different names in the commercial sector. Some of them are Resins, Plastics, Polymers and Fibres.

Resins

The term "Resin" was applied originally to naturally occurring amorphous solids such as **amber, copal, shellac, rosin** and **sandarac.** These can be easily moulded & casted into different shapes. These can be used for surface coatings. Now we could synthesise a large number of polymers which have similar properties as those of the natural resins. For example in 1909 Backeland introduced **phenol-formaldehyde** *resin*, *known* as **Bakelite.** Later formal dehyde is substituted by another aldehyde known as **furfural.** These are called **phenol-furfural** resins. Resins have good strength, heat stability & high resistance to chemical corrosion and moisture penetration. It is for these reasons, resins are widely used in the preparation of break making materials, ruler resins, electrical components, laminates, glues and adhesives. These are generally considered as thermosetting plastics. *Epoxy* resins are made by polymerization of ethylene oxide. Carbowax is one such resin. Silicone resins were introduced in 1937. These resins are prepared from alkylated silicon compounds. These find wide application in making greases, lubricants, polishes and defoamers.

Check Your Progress

1. Name the two types of polymerization processes.

2. Give one example of addition polymerization.

3. Give an example of condensation polymerization.

4. What are resins?

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5. Name some natural resins.

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6. Name two synthetic resins and give their uses.

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Plastics

Plastics are polymeric substance and these are classified into two classes. (1) Thermo setting plastics and (2) Thermo plastic materials. Thermosetting plastics are those which change into hard and rigid materials on heating. They cannot be again converted back into plastic materials. Examples of these are the resins mentioned earlier namely bakelite, epoxy resins, silicon resins etc.

The thermo plastic materials are those which soften on heating and regain their original properties on cooling. For example many polymeric materials used in fibre making and textile industry come under this category : cellulose nitrate, cellulose acetate, (Rayons), poly acrylates, poly vinyls, polystyrenes, polyamides (Nylon), polyethers and poly ethylenes. Now we are able to prepare polymers which are as strong as steel. Some of the human organ replacements like heart valves and artificial limbs are being manufactured from polymeric substances.

Check Your Progress

1. How are plastics classified?

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2. Name two polymers which find application in textile industry.

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3. Which human body parts are made from polymers now?

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Fibres

Chemical substances, natural or synthetic which can be drawn into fibres (threads) from their melts or from their solutions are known as fibre producing substances. Fibres were originally made from naturally occurring materials such as cotton, jute, wool and silk. But fibres are now extensively made from synthetic polymeric materials. Hence fibres are classified as **synthetic** and **natural**. But fibres are derived from polymeric substances only. There are also semi-synthetic fibres which are obtained from partially modified natural materials such as cellulose. Viscose rayon and cellulose acetate fibres are of such category.

There are three important properties of fibres. These are **length, crimp** and **denier**. On the basis of length, these are classified as (a) fibres of infinite length and (b) fibres of short and uniform length. For example silk, rayon, nylon have continuous filament forms. But cotton and wool possess staples or short length filaments.

Climp is the waviness placed in the synthetic fibre by chemical or mechanical means. Cotton and wool possess natural climp.

Denier is the measure of weight per unit length. A fibre will have a cross-section of one denier of 9000 metres if it weighs one gram.

Some important and popular synthetic fibres are given below.

Rayons	:	Artificial silks. These are derived from cellulose. There are four important types, nitro cellulose - pyroxilin, cuprammonium rayon, acetate rayon, viscose rayon.
Nylon 66	:	This is a polyamide prepared from a **six** carbon diamine and a **six** carbon dicarboxylic acid. It is for this reason it is called Nylon 6, 6.
Terylene or Dacron.	:	This is a polyester prepared from terephthalic acid and ethylene glycol.
Orlon	:	This is a poly acrylonitrile fibre.

Check Your Progress

1. What are fibre producing substances?

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2. Name the natural substances from which the fibres are made.

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3. Give two synthetic polymers which can be used for fibre making.

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Some important plastics and polymers are presented in the table 9.2.

Table 9.2 Important Plastics and Polymers

NAME	PREPARED FROM	USES
Acrylic	Acrylic acid	Fibres and Paints
Bakelite	Phenol +Formaldehyde	Switches, Combs, Pens
Buna-S	Styrene and 1, 3 butadine	Synthetic Rubber
Celluloid	Cellulose nitrate and camphor	Photographic films
Neoprene	Chloroprene	Synthetic Rubber
Nylon 66	Hexa methylene diamine + adipic acid	Synthetic fibre
Orlon	Acrylonitrile	Synthetic fibre
Terylene	Ethylene glycol + teriphthalic acid	Synthetic fibre
Teflon	Tetrafluoro ethylene	Non-stick pans
Polythene	Ethylene	Films, Bags, Containers, Pipes
Poly Vinyl Chlorides (PVC)	Vinyl Choloride	Electrical and Water tubes.
Poly Vinyl Acetate	Vinyl Acetate	Adhesives
Poly Urethanes	Isocyanates	Plastic foams and Adhesives
Perspex	Methyl Methacrylate	Substitute for glass
Rayon	Cellulose	Synthetic fibre
Rubber	Isoprene	Insulations, Tyres

9.5 SUMMARY

1. Carbon forms a large number of different varieties of carbon compounds. These were originally called organic compounds. But now these are called as carbon compounds.
2. Carbon compounds occur in nature in living organisms (plants, animals, microorganisms and human beings). These are now synthesised in the laboratory in large numbers and in large varieties.
3. Carbon compounds contain characteristic functional groups and the properties of the compounds depend on the nature of these groups.
4. The functional groups and the names of the compounds containing these groups are as follows.

Functional Group	**Name of the Compound**	**Example**
Nil	Hydro carbon	Methane
-OH	Alcohols	Ethyl alcohol
-CHO	Aldehydes	Acetaldehyde
>CO	Ketones	Acetone
-COOH	Carboxylic acids	Acetic acid

$-CONH_2$	Acid amides	Acetamide
$-COCl$	Acid Chlorides	Acetyl chloride
$-COOR$	Esters	Methyl acetate
$-NH_2$	Amines	Methyl amine
$-NO_2$	Nitro Compounds	Nitro methane
$-O-$	Ethers	Dimethyl ether

5. The chemical bonds between two carbon atoms may be one, two or three. Accordingly these are called single, double and triple bonds.
6. The compounds containing single bond only are called saturated compounds and those containing the double and the triple bonds are called unsaturated compounds.
7. Organic compounds may be simple compounds containing a limited number of carbon atoms or polymeric compounds containing a large number of carbon atoms.
8. Polymeric compounds exist in nature and they are as well prepared in the laboratory.
9. Natural polymeric substances are cellulose, starch, proteins, resins etc.
10. Synthetic polymeric substances are obtained from simple organic molecules by two types of chemical reactions namely addition reactions and condensation reactions. In the later, simple molecule such as H_2O, or NH_3 is eliminated.
11. Polymeric substances are classified as thermosetting plastics and thermoplastic resins.
12. Polymeric substances from which fibres (threads) can be drawn from their melts or solutions are called fibre producing substances.
13. Natural fibre producing substances are cotton, wool and silk.
14. Synthetic fibre producing substances are polyamides (Nylons) and Polyesters (terylenes).
15. Some polymeric substances on heating get softened and on cooling regain their original properties. These are called thermoplastic resins.
16. Some polymeric substances on heating change irreversibly into hard and rigid materials. These are called thermosetting plastics. Bakelite is a popular example. Epoxy resins and silicon resins are synthetic resins.
17. Some important polymeric substances and their uses are as follows.

Name	**Uses**
Acrylics	Fibres, Paints
Bakelite	Pens, Combs, Switches etc.
Celluloid	Photographic films
Neoprene	Synthetic rubber
Nylon 66	Fibres
Terylene	Fibres
Teflon	Non-stick pans
Polythene	Films, Bags, Containers etc.
Polyvinyl Chloride (PVC)	Electrical and Water tubes
Poly urethenes	Plastic foams
Polystyrenes	Plastic foams, Table tennis balls
Perspex	Substitute for glass
Rayon (artificial silk)	Fibre
Rubber	Tyres

18. Fibres are now obtained from natural polymers or synthetic polymers. Accordingly these are called natural fibres and synthetic fibres.

    cotton, wool, silk --- natural fibres.

    nylon, terylene, orlon --- synthetic fibres.

19. Length, crimp and denier are the three important properties of fibres. Cotton and Wool possess natural crimp. Crimp is artificially produced in synthetic fibres mechanically or chemically.

20. Epoxy resins and silicon resins now find wide applications in making laminates, adhesives, surface coatings, greases, lubricants and polishes.

9.6 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. What are organic compounds. How are they classified on the basis of functional groups. Give examples.
2. What are polymeric substances? How are polymers synthesised? Illustrate your answer.
3. What are fibres? Name the substances which are useful to make fibres. Give their chemical names.
4. Distinguish between thermosetting plastics and thermoplastic resins with suitable examples. Name the resins which find wide application in the industry.

Answer the following in about 15 lines each.

1. Name the functional groups present in alcohols, aldehydes, ketones and acids. Give one example for each.
2. What are polymers? How are they formed?
3. Name any three additional polymers with chemical formulas and uses.
4. Mention three condensation polymers and their uses.
5. What are resins? Give three examples with uses.
6. Explain the term 'fibre'. Mention **three** natural and **three** synthetic fibres.

9.7 GLOSSARY

Bakelite	:	Phenol-Formaldehyde resin
Cellulose	:	A polysaccharide present in wood.
Functional group	:	A characteristic group present in organic compounds and is responsible for its properties -OH, -CHO, >CO, -COOH etc.
Nylon	:	Polymide formed from hexamethylene diamine and adipic acid.
Neoprene	:	Polymeric chloroprene, a synthetic rubber.
Orlon	:	Poly acrylonitrile, a synthetic fibre.
Polythene	:	Poly ethylene used for preparation of bags.
PVC	:	Poly Vinyl Chloride used in making water tubes.
Polyurethane	:	Poly isocyanates used in making plastic foams.

Perspex	:	Poly methyl methacrylate, a substitute for glass.
Rayon	:	Cellulose derivative, a synthetic fibre.
Rubber	:	Poly isoprene.
Terylene	:	Polyester formed from teriphthalic acid and ethylene glycol, a synthetic fibre.
Teflon	:	Poly tetrafluoro ethylene used for preparing non-stick pans.

UNIT-10 MOLECULES OF LIFE

Contents

10.1 AIMS AND OBJECTIVES

Aims

In this unit you will learn about the macro organic molecules present in living organisms including human beings. The types of macro molecules, their structures and their role in life processes will be dealt with some detail so that, we can understand the importance of these molecules in the maintenance of good health.

Objectives

After you completed this unit you will be able to understand that

1. carbohydrates, proteins, enzymes, vitamins and harmones are very important for human life processes.
2. any deficiency in these molecules will lead to malfunctioning of the life processes.
3. these substances must be supplemented from outside through foods and drugs in case of deficiencies.

10.2 INTRODUCTION

Living systems are composed of many macro organic molecules. Many of these molecules are familiar to us. Each one of these substances has a specific role to play in our life processes. Therefore their presence in the required amounts is very essential for an healthy life process. You will learn in this unit about these molecules namely carbohydrates, amino acids, proteins, enzymes, nucleic acids, vitamins and harmones. Human beings are like factories which need the required raw materials. Human beings too require food for the sustenance of life like other living organisms (plants and animals). But human beings can not prepare their food in their body unlike plants which prepare their own food. Human beings depend therefore on plants and animals for their food. Just as machines are used in factories, enzymes are needed to cause biochemical processes in living organisms. Enzymes encourage chemical changes which convert food into body parts such as tissues, muscles etc. Factories need energy or fuels to get themselves run. Similarly human beings use food constituents namely carbohydrates, fats, proteins as fuels. These will also provide raw materials for building our tissues. Thus human body is like a factory which requires raw materials, fuels and know hows to run itself healthily. We therefore need to know about the chemical nature, properties and some important reactions of organic compounds that make us.

10.3 MOLECULES IN LIFE PROCESSES

Many types of organic compounds are essential for running the human factory efficiently and healthily. The chemical reactions, these compounds undergo in our human body are generally known as **Bio-chemical** processes. The chemistry underlying the reactivity of these compounds is known as **Bio-chemistry**. You learn about these in the following subsections.

The important compounds are carbohydrates, amino acids, proteins, enzymes, nucleic acids (DNA, RNA), vitamins and harmones.

Carbohydrates

Carbohydrates are polyhydric aldehydes, polyhydric ketones and polymeric molecules which can be broken down to polyhydric aldehydes and polyhydric ketones. These compounds include sugars, glycogen, starches, cellulose and some gums. Carbohydrates are mainly obtained from plants. These are prepared by plants by photochemical synthetic processes. Carbohydrates are classified as per our need into different kinds. On the basis of the hydrolysis reaction they undergo in presence of HCl these are classified as monosaccharides, disaccharides, oligosaccharides and polysaccharides.

Monosaccharides

There are many mono saccharides and these may contain carbon atoms ranging from 3 to 6. Some of the important mono saccharides are

Glucose (a 6 carbon aldehyde sugar)
Fructose (a 6 carbon ketone sugar)
Galactose (a 6 carbon aldehyde sugar)

Disaccharides

These on hydrolysis with HCl give two units of monosaccharides. Some important examples.

Sucrose (12 carbon sugar containing glucose and fructose). It is cane sugar or beet sugar.
Maltose (12 carbon sugar containing two glucose units).
Lactose (12 carbon sugar containing glucose and galactose sugar units). It is called milk sugar.

Oligo saccharides

These on hydrolysis with HCl give 3-9 mono saccharides.

For example **Raffinose** is an oligo saccharide which gives glucose, fructose and galactose.

Polysaccharides

These on hydrolysis gives a large number of mono saccharides. Some examples are starch, cellulose and pectins.

Carbohydrates are classified as per their taste into sugars and non-sugars. Those which are sweet are sugars. Fructose is the sweetest sugar. The relative sweetness of sugars is as follows.

Lactose	13
Maltose	32
Galactose	32
Glucose	74
Sucrose	100
Fructose	173

Carbohydrates supply the required calories for human body. You learn in unit-20 the nutritional values of different types of foods we eat. Energy is produced in the body from food by a process called metabolism which is comparable to combustion or burning of fuel. Oxygen is used up in this combustion and carbondioxide is produced. If the body does not get atleast a minimum of energy, it will not be able to carry on its normal functions or undertake external work. Carbohydrates supply 4.0 K cal/g.

Carbohydrate Metabolism

In living cells glucose is oxidised in several steps to obtain finally carbon-dioxide and water. The energy released is used in the synthesis of a very important compound called ATP (Adenosine Triphospate). This reaction gives cellular energy. Glucose oxidation can be divided into two main steps. The first step is known as glycolysis. This occurs in cytoplasm of cells and requires no oxygen. The second step is cellular respiration and this requires oxygen. During the oxidation of glucose into carbon dioxide and water, one mole of glucose gives 2868 KJ of energy. Theoretically this energy should convert 100 ADP molecules into 100 ATP molecules. But only actually 38 molecules of ATP are produced. Thus the efficiency is only 38%. The remaining energy (62%) is liberated as heat and is used to maintain body temperature.

$$\text{Glucose} + 38\ \text{ADP} + 38\ P_i + 6O_2 \longrightarrow 6\ CO_2 + 38\ \text{ATP} + 44\ H_2O$$

Check Your Progress.

1. What are carbohydrates?

2. How are carbohydrates classified?

3. What is the importance of carbohydrates in human life.

4. Name the carbohydrates you know.

5. Give the sources for these carbohydrates.

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Amino Acids

Amino acids are carbon compounds possessing the functional groups - NH_2 (amino) and - COOH (acid) in the same molecule. These are classified as α, β and γ amino acids as per the position of $-NH_2$ group with respect to the carboxylic acid group (-COOH). If the amino group is on the first carbon attached to -COOH, it is α-acid, if it is on the second carbon atom, it is β-acid, if it is on the third carbon atom, it is γ-acid. Amino acids chemically react and give proteins. These are also called polypeptides since two amino acids react and give a peptide molecule.

$$H_2N\ CH_2\ COOH + H_2N\ CH_2\ COOH$$
$$\downarrow -H_2O$$
$$H_2N\ CH_2 - \mathbf{CONH} - CH_2\ COOH$$
$$\text{peptide}$$

There are about 20 commonly occurring amino acids in proteins and about 6 are found in special tissues. The human body can synthesise only 10 out of 20 amino acids. Others must be supplied in the diet (see Unit 20). These are called **essential amino acids**. Lack of essential amino acids in diet causes Kwashiorkhar disease.

Amino acid metabolism

Amino acids are absorbed into blood from intestines. These are the dietary sources of nitrogen. They are useful in the formation of new cells or in the repair of old cells. Amino acids cannot be stored in the body and they are metabolised into pyruvate, acetyl COA and other intermediates. Energy is liberated in the breakdown process into carbon dioxide and water.

Some important amino acids are :

Glycine	-	Gly	-	H_2N-CH_2-COOH
Valine	-	Val	-	$H_2N-CH-COOH$ | $CH(CH_3)_2$
Leucine	-	Leu	-	$H_2N-CH-COOH$ | $CH_2-CH\ (CH_3)_2$
Threonine	-	Thr	-	$H_2N-CH-COOH$ | $CH(OH)CH_3$
Proline	-	Pro	-	-
Glutammic acid	-	Glu	-	$H_2N-CH-COOH$ | CH_2-CH_2COOH
Lysine	-	Lys	-	$H_2N-CH-COOH$ | $CH_2-(CH_2)_3-NH_3^+$
Histidine	-	His	-	

The above amino acids are present in the haemoglobin and hence these alone are given.

Proteins

Proteins are long polymers of amino acids linked by peptide bonds. Hence proteins are considered as polypeptides. Amino acids are arranged in a particle sequence in each of the proteins. This is called **primary structure.** This sequence only determines its functions and is critical to its biological activity. A change of the position of just one amino acid in the sequence may drastically alter the properties of proteins. Therefore determination of amino acid sequence in proteins is of vital importance in medicine. This is a difficult and cumbersome process. For the first time Frederic Sanger determined the sequence of amino acids in Insulin in 1953. But now the amino acid sequences are known for many proteins.

For example the sequence of amino acids is as follows for haemoglobin.

-Val-His-Leu-Thr-Pro-Glu-Glu-Lys-

If one 'Glu' is replaced by 'Val' as shown below, the haemoglobin becomes defective and the people having this haemoglobin suffer from sickle-cell anaemia (bloodlessness).

Sickle cell haemoglobin : -Val-His-Leu-Thr-Pro-Val-Glu-Lys-

Proteins are converted into amino acids and are absorbed into blood and these get metabolised as shown in10.3.

Proteins are classified as **simple proteins** and **conjugated proteins.** Simple proteins give only amino acids on hydrolysis. Examples are albumins, globulins and glutinins. **Conjugated Proteins** are proteins bonded with a non-proteinic prosthetic group. This acts as **Cofactor.** Examples : glyco proteins, phospho proteins and chromo proteins. On the basis of structure also these are classified as **globular** and **fibrous.**

Fibrous proteins are present in nails, horns, skin, wool, silk etc. Globular proteins are present in blood, milk, eggs and body fluids.

Properties : Proteins are colourless, amorphous solids. Some are coloured. Haemoglobin is red in colour. Proteins lose their physiological activity by the action of bacteria. This is called denaturation.

Detection : Proteins are detected by

1) Biuret Test : gives violet colour with alkaline copper sulphate

2) Xanthoprotein Test : gives yellow colour with concentrated nitric acid.

Check Your Progress.

1. What are amino acids? Name two?

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2. How are proteins obtained from amino acids?

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3. What is the chemical linkage in proteins?

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4. What is amino acid sequence called in proteins?

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5. What is the importance of the sequence?

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6. How are proteins metabolised?

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Enzymes

Enzymes are biochemical catalysts. These control biochemical reactions in living organisms (from virus to human beings). Their action is highly specific ie. a particular enzyme brings about a particular reaction only. Thus it is only enzymes that make biochemical reactions proceed at very high rates even under mild conditions of temperature and pH of living organisms. For example without the enzymes in our digestive tract it would take about 50 years to digest a single meal. About 3000 enzymes have been identified. Enzymes are proteins. Most active enzymes are associated with some non-protein component required for their activity. These are metal ions or smaller organic molecules called co-enzymes. The metal ions involved are Zn, Mg, Mn, Fe, Cu, K and Na.

How do enzymes work?

The steps in enzymes catalysed reactions can be outlined as follows.

Step 1. Enzyme (E) gets bound to the substrate (S) and forms a complex substance.

$$E + S \longrightarrow [ES]$$

Step 2. The complex then gives the reaction product in the form of complex (EP).

$$[ES] \longrightarrow (EP)$$

Step 3. Product is released from the complex (EP).

$$(EP) \longrightarrow E + P$$

The substrate is bound to the **active site** of the enzyme. The **active site** is so shaped that only a particular substrate fits into it. This is the reason for the specificity of the enzymes.

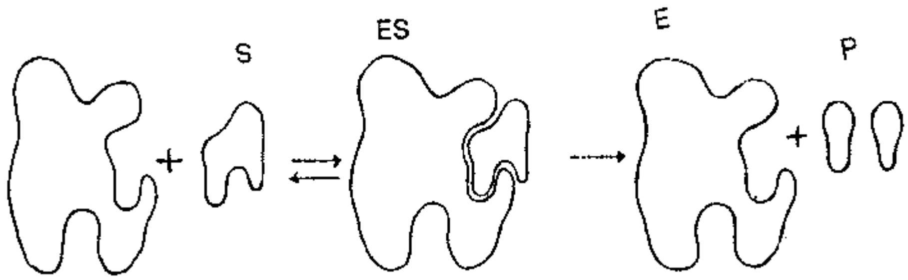

Fig. 10.1 Enzyme Action

Digestion of food in our body is a complex process. The carbohydrates, fats and proteins are acted upon by different enzymes to form simple substances. These are absorbed by small intestines.

$$\text{Starch} \xrightarrow[\text{Amylase}]{\text{Ptyalin}} \text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose}$$

$$\text{Fats} \xrightarrow[\text{Bile salts}]{} \text{Emulsified Fats} \xrightarrow{\text{Lipases}} \text{Fatty acid}$$

$$\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Peptones} \xrightarrow{\text{Trypsin}} \text{Peptide} \xrightarrow{\text{Peptidases}} \text{Amino acids}$$

Some Examples of Enzymes

Enzyme	**Reaction catalysed**
Amylase	Starch ⟶ glucose
DNA Polymerase	Deoxy nucleotide triphosphates ⟶ DNA
RNA Polymerase	Rebonucleotide triphosphates ⟶ RNA
Lactase	Lactose ⟶ glucose + galactose
Maltase	Maltose ⟶ glucose
Invertase	Sucrose ⟶ glucose + fructose
Pepsin	Proteins ⟶ amino acids
Urease	Urea ⟶ $CO_2 + H_2O$

Enzymes and Diseases

Certain diseases are caused by enzyme deficiencies. **Albinism** is a disease caused by deficiency of **tyrosinase**. Mental retardation in children is caused by the deficiency of **phenyl orlanine hydrolase** enzyme.

Check Your Progress.

1. What are enzymes?

2. Name three enzymes you know.

3. What is the role of enzymes amylase, maltase, urease?

4. What diseases are caused by enzyme deficiencies?

Nucleic Acids

These are vital components present in all living organisms. These are responsible for the storage and transmission of hereditary characters. Nucleic acids are two types. These are **R**ibo **N**ucleic **A**cid (RNA) and **D**eoxy Ribo **N**ucleic **A**cid (DNA). These acids contain long chains of alternating sugar and phosphate units with bases attached to sugar residues.

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-Sugar-Phosphate-Sugar-Phosphate-Sugar
   |              |              |
  Base           Base           Base
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Both DNA and RNA are polymers of a repeating unit called **nucleotide**. Nucleotide consists of a phosphate unit, a five membered sugar (furanose) and an organic base having ring structure containing nitrogen.

The sugar and base units present in the nucleic acids are

	Sugar	Base
RNA ——	D-ribose	uracil
DNA ——	D-2.deoxyribose	thymine

RNA molecules are smaller than DNA molecules. DNA molecules are found in the **cell nucleus.** RNA molecules are found outside the nucleus in the surrounding fluid called **cytoplasm.**

Fig. 10.2 DNA molecule

Protein synthesis and reproduction are the main functions performed by DNA. The genetic information for the cell is contained in the sequence of the bases in the DNA molecule. The genetic information thus coded in DNA is translated and expressed in the form of synthesis of proteins. This is done by RNA. Hence it is called **messenger RNA**. The DNA sequence that codes for a specific protein is called **Gene**. Thus every protein in a cell has corresponding **gene**. Protein synthesis in a body is a very fast process. About 20 amino acids are added in one second. With the discovery of a class of enzymes called "**restriction enzymes**", it is possible to cut DNA and these fragments can be rejoined in the required fashion using other enzymes to produce new DNA sequences. This is known as bio engineering (see Unit-21) or genetic engineering. By this process many congenital diseases are cured.

Check Your Progress

1. What are nucleic acids?

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2. Give the expansions of DNA & RNA.

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3. What is the role of RNA?

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4. Where does DNA present in the human body?

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5. What diseases are caused by defects in DNA?

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Vitamins

These are specific organic compounds required in small amounts by men, animals, bacteria and micro organisms for the maintenance and normal growth of life in addition to carbohydrates, proteins, fats, inorganic mineral salts and water.

Lack of vitamins may cause a number of diseases in man. (See Unit-20). Vitamins are classified as **fat soluble** vitamins and **water soluble** vitamins. Vitamins A, D, E and K are fat soluble, B-Complex and Vitamin C are water soluble. Vitamins are co-enzymes in nature. For example nicotinamide is present in co-enzyme I and II. Pentothenic acid is present in co-enzyme A.

Vitamin A	:	This is also known as Retinol. It occurs in animals in free state or in combination with fatty acids. Sources of vitamin A are liver, retina, lungs, kidney. It is found in butter, fat, milk, egg etc. Vitamin A is found in certain fish oils.
Vitamin B-Complex	:	A combination of nearly 8 components is collectively called B-complex. These are
Vitamin B_1 - Thiamine	:	This is found in rice and wheat and also in eggs, meat, peas and beans - Its deficiency leads to peripheral nervous system.
Vitamin B_2 - Riboflavin	:	This occurs in yeast, liver, milk, egg yolk, fish, meat and green vegetables. Its deficiency causes the skin rough and scaly.
Vitamin B_3 - Pentothenic acid	:	It occurs in all tissues and in green plants. Its deficiency causes burning sensation, muscular weakness and general depression.
Vitamin B_5 - Nicotanamide and Nicotimic acid	:	It is found in liver, yeast, meat, barley, maize and rice. Its deficiency causes rough skin.
Vitamin B_6 - Pyridoxine	:	Its deficiency causes pellagra or anaemia.
Vitamin B_7 - Biotin	:	It occurs in egg yolk, liver, kidney, milk and yeast and also in grains and vegetables. Its deficiency causes hair loss and paralysis.
Vitamin B_{12} - Cobalamines	:	It occurs in animal tissues and in the liver. It is found in egg, milk and meat. Its deficiency causes anaernia.
Vitamin C - Ascorbic acid	:	It is found in citrous fruits, grapes, apples and bananas and also in green vegetables. Its deficiency causes scurvey.
Vitamin D - Calciferol	:	It is found in cod liver oil and fish liver oils. Its deficiency causes rickets.
Vitamin E - Tocopherols	:	These are found in vegetables and seed germ oils. Its deficiency causes muscular degeneration and antisterility.

Harmones

These are chemical substances produced in small amounts by some specialised organs called ductless or endocrine glands. The harmones produced by the glands move to different parts of the body through blood stream. These are important in regulating metabolic processes and sex characters. (See Units 12 & 13). These are called chemical messengers. The communications among cells are mediated by harmones. Chemically these are classified into 3 types steroids, polypeptides, and amines. Sex harmones are steroid harmones. Testosterone is male sex harmone and estrogen is the female sex harmone. Some synthetic female sex harmones are used as oral contraceptives. Oxytosin is a peptide harmone and causes contraction of the uterus during birth. Octopeptide (Angio tensin II) is present in blood plasma of patients with high blood pressure. It is responsible for the constriction of blood vessels. Adrenaline and thyroid harmones are amines. Adrenaline stimulates the breakdown of liver glycogen into blood glucose.

Check Your Progress.

1. What are vitamins?

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2. Name the vitamins.

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3. Name the defects caused by deficiency of vitamins A, C, B.

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4. Where are the vitamins A, C, D found?

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5. What are harmones?

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6. How are harmones produced?

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7. What is the role of harmones in human life processes?

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8. Name some defects caused by harmonal deficiencies.

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10.4 SUMMARY

1. Living systems are composed of macro organic molecules. Each of these has a specific role to play in the life process.
2. These are carbohydrates, amino acids, proteins, enzymes, nucleic acids, vitamins and harmones.
3. Human body is like a factory. So it requires raw materials, fuels and energy to run itself smoothly. These macromolecules function therefore as the basic requirements for running the human factory efficiently.
4. Carbohydrates are the substances which supply the required energy for the human factory. But human body cannot prepare carbohydrates. These are supplied through food.
5. Energy is produced by the metabolic process of carbohydrates. 4.0 Kcals/g is produced. The efficiency of the metabolic process is only 38%. The remaining 62% energy is liberated as heat and is used to maintain body temperature.
6. Amino acids are chemical substances containing -NH_2 group and also -COOH group. Amino acids chemically react and give proteins.
7. Human body requires about 20 amino acids. But it can synthesise only 10. The remaining 10 are supplied through diet. These are therefore called essential amino acids.
8. Amino acids are absorbed into blood from intestines. These are dietary sources of nitrogen. They are useful in the formation of new cells or in the repair of old cells. These cannot be stored in the body.
9. The amino acids are bound to each other in a specific sequence in any protein. This sequence is very important. Any change in the sequence will make the protein defective or sick.
10. Proteins are long polymers of amino acids linked by peptide bonds. Proteins are therefore called poly peptides.
11. The sequence of amino acids in proteins is called primary structure.
12. Proteins bonded with a non-protenic prosthetic groups are called conjugated proteins.
13. Proteins are colourless generally (haemoglobin is red) and are of two types, globular and fibrous.
14. Proteins are detected by Biuret test and Xanthoprotein test.
15. Enzymes are biochemical catalysts. They control biochemical reactions in living organisms.
16. The actions are highly specific. They act at specific temperatures and pH only.

17. But for enzymes, the biochemical processes are very very slow. A single meal would require 50 years for digestion in the absence of enzymes.

18. Enzymes are also proteins.

19. Deficiency of enzymes leads to some diseases. For example albinism and mental retardation are some diseases.

20. Nucleic acids are vital components present in all living organisms. These are responsible for storage and transmission of hereditary characters.

21. The nucleic acids are of two types. These are RNA (Ribo Nucleic Acid) and DNA (Deoxyribo Nucleic Acid).

22. Nucleic acids contain three units joined as shown below.

```
Sugar - Phosphate - Sugar
            |
           Base
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23. DNA molecules are found in cell nucleus. RNA molecules are found in cytoplasma, a fluid outside the nucleus.

24. RNA is called messenger acid and DNA contains the genetic code.

25. Vitamins are specific organic compounds required in small amounts for healthy growth of life.

26. Deficiency of vitamins leads to different diseases. Vitamins are obtained from usual foods, vegetables and fruits.

27. Vitamins are designated as A, D, E, K and B-Complex and C.

28. Vitamin deficiency must be immediately rectified through diet modifications or through vitamin tablets.

29. Harmones are chemical substances produced in small amounts by ductless glands. These move to different parts of the body through blood stream.

30. Harmones are important in regulating metabolic processes and sex characters. These are known as chemical messengers.

31. Harmones are chemically steroids, peptides or amino acids.

32. Harmonal deficiencies cause many defects in the body.

10.5 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. What are the macro organic molecules that control the life processes? Give the function of each.

2. What are amino acids and proteins? What is their importance in the maintenance of good health and proper growth of the body.

3. Explain the action of enzymes in biochemical processes. Why enzymes are required?

4. What are nucleic acids? Discuss their role in human life process.

5. Explain the chemical nature of harmones and vitamins. Discuss their importance in life process.

Answer the following in about 15 lines each.

1. What are carbohydrates? What is their role in human life?
2. Explain the terms : amino acids and proteins with examples.
3. What are enzymes? How do they act in the human body.
4. How are nucleic acids important in living processes?
5. What are harmones? How are they useful in human life?

10.6 GLOSSARY

Metabolism	:	The chemical processes that occur in living organisms to digest the food components.
Enzymes	:	Biological catalysts
Harmones	:	Chemical substances produced by specialised ductless glands.
Nucleotide	:	The simple unit that is repeated in the formation of DNA and RNA.
RNA	:	Ribonucleic acid - a messenger nucleic acid.
DNA	:	Deoxyribo nucleic acid - a nucleic acid possessing the genetic code.
Primary structure of proteins	:	Amino acids sequence in proteins.
ADP	:	Adenosine Diphosphate
ATP	:	Adenosine Triphosphate

BLOCK-III SCIENCE AND TECHNOLOGY IN SERVICE OF HUMANITY-II

This block deals with the modern developments that took place in Biological Sciences. The basic and fundamental concepts of biological sciences are briefly mentioned so that you will be able to understand the structure of living cells and tissues, the theories of evolution and heridity and finally the regulatory systems operating in the human body. The block therefore consists of 4 units. These are

11. Living cells and Tissues
12. Evolution and Heredity
13. Human body and Regulatory systems
14. Clinical Biochemistry

After you completed this block you would be certainly able to

1. understand clearly the living cell structure, components and cell theory of life.
2. get an in sight into the aspects.

   What is evolution?

   What is heredity?

   What are the various theories proposed till now to explain evolution of life and human heridity?
3. realise that human body functions like a machine with so many inbuilt regulatory systems. Each regulatory system is important by itself and the co-operative functioning of the different systems is also equally important.
4. understand the reactions taking place in the living cell and how these biochemical reactions play an important role in human life processes.
5. know about the inherited disorders, their diagnosis and treatment.

Broadly we can say that after you completed the block successfully you will certainly know how your body functions and what precautionary steps you have to take to maintain the proper functioning of this human machine.

Therefore read the units in this block carefully and try to understand yourself, how your own body machine is functioning and what remedial steps you should take in case its functioning is not satisfactory.

You will also learn about some inherited diseases and how these can be avoided if some principles are followed in choosing your life partners.

UNIT-11 THE LIVING CELL AND TISSUES

Contents

11.1 AIMS AND OBJECTIVES

Aims

The Unit aims at providing you with an account of the structure and functions of cell and its components and also projecting to you the various tissues encountered in animals and plants.

Objectives

This Unit will enable you to

1. know the main attributes of the "Cell Theory".
2. explain the general structure of cell found in plant or animal and the differences between a plant and an animal cell.
3. distinguish between two types of cell divisions.
4. get acquainted with various types of tissues found in plants and animals.

11.2 INTRODUCTION

The biologist's interest in living things was at first limited to organisms (i.e. organismic biology). In those days biologists used to study only the form and structure (Morphology) of the organisms. To investigate the contents inside of the body, the biologists used to dissect the organisms and this in turn helped the development of the branch of study called **anatomy**. The invention of compound microscope by **Janssens** in 1590 and **Galileo** in 1610 ushered in a new era in the history of biology. The prominent scientists who contributed to the growth of biology in the early stages in this field were **Robert Hooke, Leewenhoek, Dutrochet, Schleiden and Schwann, Virchow** and **Flemming.** Invention of microscope made possible the study of section of tissues (histology) and new branch of biology **Cell biology** concerned with the structure and functions of cells developed in the nineteenth century.

11.3 CELL THEORY

One of the fundamentals of modern biology is the **cell theory**. The theory, first proposed by **Schleiden and Schwann** (1838-39), has undergone modification and developments during the last two centuries leading to the present day formulations of cell theory. *The theory* recognizes that 1) all organisms are composed of cells and cell products, 2) new cells are formed by the division of pre -existing cells and 3) there is a fundamental similarity between chemical composition and metabolic aspects of all cells. The activity of an organism is the sum total of the activities and the interaction of all cells present in that organism. Historically, this theory has started developing since the discovery of cell by **Robert Hooke** in 1665. **Dutrochet** (1824) stated that the tissues of plants and animals are composed of "globular cells of an extreme smallness" held together by adhesive forces. **Schleiden** (a botanist) and **Schwann** (a zoologist) put forward the cell theory. According to this theory all organisms starting from the simplest unicellular organisms to very complex higher plants and animals are composed of cells. Each cell can act not only independently but also as an integral part of the organisms. Schleiden and Schwann could clearly explain the importance of cell. **Rudolph Virchow** (1855) said that cells arise only from pre-existing cells. This process has come to be known as **Cell Division.**

Check your Progress

List out the points recognized by the present day formulations of cell theory.

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11.4 CELL STRUCTURE

Simultaneously with the developments in cell theory, the inside of the cells was always considered important. The nucleus was first observed by **Leeuwenhoek** in the seventeenth century, but it was **Robert Brown** (1931), first named it as nucleus. The discovery of nucleus has far-reaching consequences. Cells were divided into two types the prokaryotic cells and eukaryotic cells based on the presence or absence of nuclear membrane. The organisms whose cells are characterized by the *prokaryotic cells* and *eukaryotic cells* are known as *prokaryotes* and *eukaryotes* respectively. Prokaryotes are simpler in their structure than the eukaryotes. They lack a definite nucleus bounded by membrane, and they are the simplest of living organisms. The bacteria come under the category of prokaryotic cells. Eukaryotic cells, on the other hand, have a definite nucleus, which is surrounded by a nuclear membrane. These cells are the fundamental units of plants and animals.

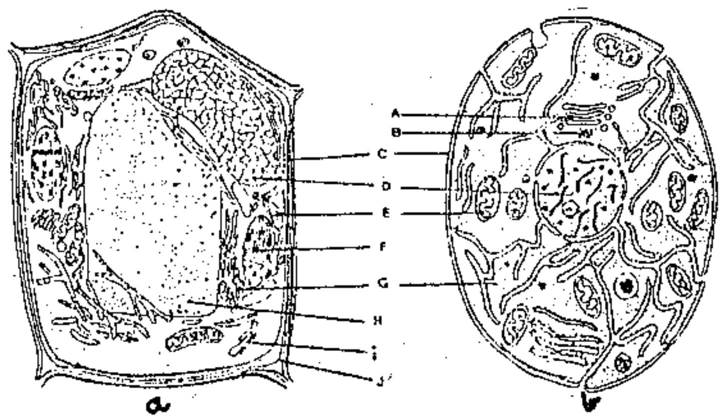

Fig. 11.1 a. Plant cell b. Animal cell A. Golgi body B. Centrosome and Centriole C. Plasma membrane D. Nucleus E. Mitochondrion F. Chloroplast G. Endoplasmic reticulum H. Vacuole I. Cytoplasm J. Cell wall

There are however, some differences between plant and animal cells (fig. 11.1). The plant cell is surrounded by a cell wall and contains (in mature state) a fluid filled vacuole. The plant cell wall is made up of cellulose and pectin. But animal cell does not contain a cell wall. Another major difference is the presence of chloroplasts in plant cells and absence of the same in animal cells.

A cell, whether belonging to plant or animal, contains an outermost plasma membrane which encloses various components (fig. 11.1). This membrane is made up of lipid and proteins. It is selectively permeable and regulates the flow of materials in and out of the cells. The various components of the cell are *mitochondria, golgi bodies, endoplasmic reticulum, ribosomes, centrioles* and *nucleus*. These structures are called **cell organelles**. There is a division of labour among these organelles i.e. each has definite function.

Fig. 11.2 Mitochondrion

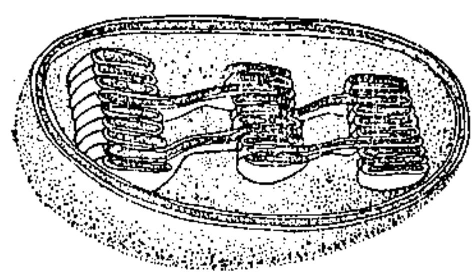

Fig. 11.3 Chloropast

The *mitochondria* (fig. 11.2) are the power houses of cells. They produce energy by oxidizing the food stuffs. The endoplasmic reticulum is an elaborate membrane system lying within the cytoplasm. It connects both the plasma membrane and the nuclear membrane. Apart from increasing the surface area of the cytoplasm for the chemical reactions to take place, it acts as a supporting platform for protein synthesis and also helps in the movement of material within the cells. The *Golgi complex* (Golgi body) appears in cells as a complex of flattened membranous sacs with a cluster of vesicles at its edges. They are involved in the secretion and packaging of carbohydrates. The ribosomes are very small dense particles which are found either free or attached to the membrane. They are involved in the protein synthesis of the cell. Lysosomes are fluid filled sacs. They contain hydrolytic enzymes. (i.e. the enzymes which break complex carbohydrates, proteins and lipids into simple sugars, amino acids and fatty acids by the addition of water molecules). They help in the intracellular digestion of food materials. Centrioles lie in the cytoplasm near the nuclear membrane. They play an important role in cell division. Chloroplasts (Fig 11.3) are the other important organelles which are found in the cytoplasm of the plant cells. They capture the light energy from sun light and synthesize carbohydrates from carbon dioxide and water. This process, called **Photosynthesis**, is an important starting point for energy flow within the living organisms. The presence of this organelle makes a plant cell functionally as autotrophic cell. Nucleus is an important organelle of the cell. It is separated from other cytoplasmic constituents by means of a membrane, the nuclear membrane. The nucleus contains within it one or more nuclei, which are rich in the ribonucleic acid (RNA) and protein, and the chromatin material which contains deoxyribonucleic acid (DNA) and histones. The chromosomes present in the nucleus store the genetic information. This information controls and regulates the metabolic activities of cells.

Check Your Progress

List out the cell organelles that are common in both plants and animals.

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11.5 CELL DIVISION

One of the important formulations of the cell theory is that new cells are formed by the division of pre-existing cells. This observation made by Virchow (1865) led to the search for mechanisms of cell division. The cell division is mainly of two types. They are (1) *Mitosis* and (2) *Meiosis.*

Mitosis

Walter Flemming (1882) was successful in following the sequence of events in the process of cell division. Because of the importance of chromatin threads in cell division, he called it Mitosis (Greek word for threads). Conventionally the events in cell division are divided into four stages (fig 11.4)

I. Prophase - chromatin is condensed to form shorter, thicker chromosomes; nuclear membrane and nucleolus disappear and the spindle is formed.

II. Metaphase - The condensed chromosomes are arranged at the centre of the spindle.

III. Anaphase - The chromosomes are pulled to opposite poles.

IV. Telophase - A nuclear membrane is formed around the chromatin material thereby forming the two daughter nuclei.

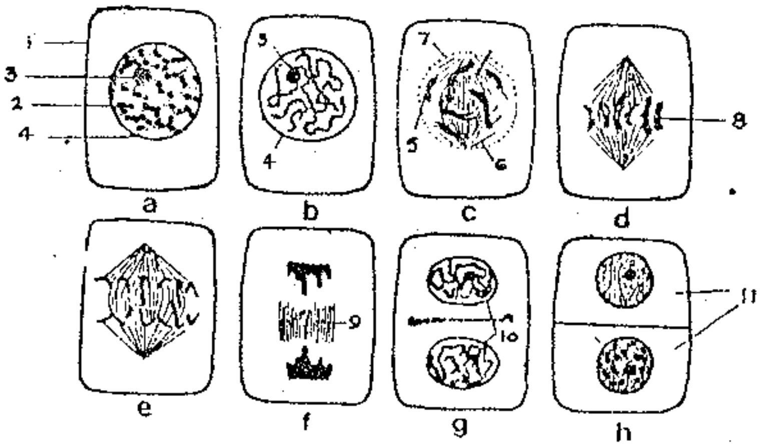

Fig. 11.4 a. Interphase b. Early prophase with six chromosomes c. Late prophase d. Metaphase e. Anaphase f. Late Anaphase g. Late Telophase h. Interphase.

1. Cell Wall 2. Nucleus 3. Nucleolus 4. Nuclear membrane 5. Chromosome 6. Spindle fibre 7. Disappearing nuclear membrane 8. Chromosomes in the equator (centre) 9. Cell plate 10. Daughter nuclei 11. Daughter cells.

The above nuclear divisions (karyokinesis) are followed by the division of cytoplasm (cytokinesis) giving rise to two daughter cells.

Mitosis ensures exact duplication of cells. The chromatin materials, before division is initiated, is doubled and each of the daughter nuclei receives one half set from the doubled chromosomes. Thus the number of chromosomes in each daughter cell remains unchanged even after the division of the parent cell. Mitotic cell divisions are found in the somatic (body) cells and developing embryos. Growth of an organism is totally dependent on mitotic cell divisions, which increase the number of cells as well as achieving an increase in size of the organism.

Meiosis

In 1883, **Edward van Beneden** discovered an entirely new type of cell division known as meiosis. Meiosis typically consists of two successive nuclear division. The individual chromosomes are divided only once (first anaphase). The actual reduction of chromosome occurs during the first division, but the second division is also an integral part of the meiosis. Meiosis, then is the way the genetic material is maintained in a specific quantity for the species.

Check Your Progress

Select from the following stages and put them in correct order of cell division in mitosis.

(a) Telophase (b) Metaphase (c) Prophase (d) Anaphase

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11.6 TISSUES

Nearly all plants and animals are made up of thousands or millions of microscopic cells. Large numbers of similar cells packed together form a tissue. When the development is well advanced the cells of the organism become highly specialized and collect into different tissue types according to their function. Different tissues arranged together form organs in an organism.

Animal tissues

The body of animals consists of several types of tissues. They are *epithelial tissue, connective tissue, muscular tissue, nervous tissue, blood* and *reproductive tissues*.

An *epithelical tissue* is an extensive layer of cells which forms either a covering membrane on the organs or a lining membranes of the cavities found in organ system. The epithelical tissues are of 4 types they. They are - *Squamous, Cuboidal, Columnar* & *Ciliated* epithelical tissues (Fig. 11.5 A-D).

The *connective tissue* is characterized by the presence of non living material called matrix secreted by the cells. There are only a few cells in the connective tissues. The tissue either supports or holds together other tissues of the body. The connective tissue of the body includes *bone, cartilage, tendons, ligaments* and *fibrous* connective tissue (Fig. 11.5).

The movements in animals are effected by the *muscles*. There are three types of muscles: 1. *Skeletal muscles* which are striped or striated and are attached to the bones and are innervated. Their movements are under the control of the will of the organism; and so, they are called the **voluntary muscles**. 2. *Cardiac muscle* is found in the heart. 3. The *Smooth muscle* is found, for example, in the wall of the digestive tract. Both cardiac & smooth muscles are **involuntary muscles**. They cannot be controlled by the will of the organism. They have regular or periodic rhythmicity in their contractions and relaxations (Fig. 11.5).

Blood is a fluid issue. It contains a non-cellular liquid called plasma and the cells. The cells found in blood are of three types : 1. the *erythrocytes*, which in vertebrates contain the pigment haemoglobin; owing to the presence of this pigment the cells are red. They are called the *red blood cells* (R.B.C). The R.B.C. carry oxygen from lungs or gills to the tissues. 2. The *White blood cells* (W.B.C.) are of five different kinds, *lymphocytes, monocytes, neutrophils, eosinophils and basophils* 3. the *Platelets* play an important role in the clotting of blood (Fig. 11.5).

The *nervous tissue* is made up of nerve cells. Each nerve cell contains in it a *cyton*, (cell body) from which the nerve fibres project. The nerve fibres can be classified into two types depending upon the pathway of the nerve impulse. The nerve impulse in *dendrites* transmitted towards the cell body, while in the *axon* it is transmitted away from the cell body (Fig. 11.5).

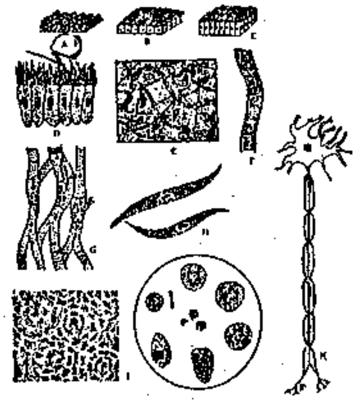

Fig. 11.5 Types of tissue found in animals. A-D Squamous, Cuboidal, Columnar and Ciliated epithelium E. Connective tissue F. Skeletal muscle G. Cardiac muscle H. Smooth muscle I. T.S. of bone J. Blood cells K. Nerve cell

The *reproductive tissue* contains cells which are modified to produce gametes, i.e., the *sperms* and *eggs*. The sperms produced in males are variously shaped in different animals. They contain a head, a middle piece and a tail portion. The eggs, on the other hand, are oval and contain in them yolk material. This yolk material is used as nutrition for the developing embryo.

Check Your Progress

Make a list of tissues found in the body of animals.

Plant Tissues

Unlike animals, plants maintain the regions of growth and differentiation throughout their life. This is accomplished by the action of the *meristematic tissues* present, usually at the tips of shoot and root. New cells are born from this actively dividing tissue. As the plant grows, specialized tissues are formed from the meristematic tissue. The principal tissues of land plants are usually categorized into the following. (1) **Dermal tissue system, (2) Fundamental ground tissue system** and **(3) Vascular tissue system.** (Fig - 11.6)

The dermal tissue system consists of the protective tissues, the **epidermis** and the **periderm.** The epidermis forms a continuous layer on the surface of the primary plant body. The epidermis gives mechanical protection and checks loss of the water. It consists of *epidermal cells, stomata* and *trichomes* (hairs). The epidermis is usually replaced by the *periderm* (cork tissue) on the plant body having secondary growth.

The *fundamental* or *ground tissue system* includes tissues which form the ground substance of the plants. They are *parenchyma, collenchyma* and *sclerenchyma.* Parenchyma cells are characteristically living cells and perform most of the metabolic activities including production and storage of food. Collenchyma is also a living tissue usually lending support in the young organs. On the other hand, sclerenchyma is a dead tissue and mainly provides support and mechanical strength in the plants.

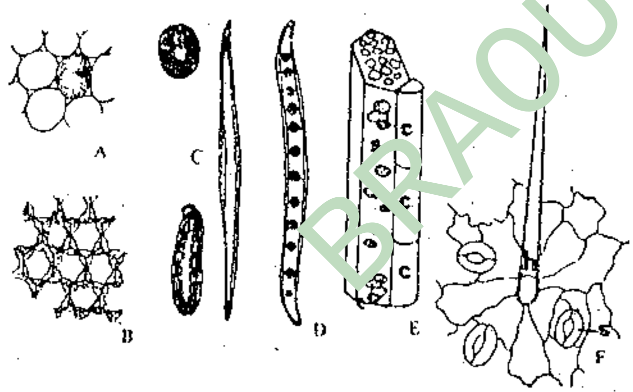

Fig. 11.6 Types of tissues found in plants. A. Parenchyma B. Collenchyma. C. Sclerenchyma D. Xylem (trachied) E. Sieve tube(s) and campanion cells (c) F. Epidermis with stomata (s) and a hair (h).

The *vascular tissue system* consists of two *conducting tissues*, the *xylem* and *phloem.* The xylem is the principal water conducting tissue and the phloem helps in the conduction of food material. These conducting tissues also help in storage and support. They usually possess several kinds of specialized cells.

11.7 SUMMARY

1. The cell theory states that all organisms are composed of cells. New cells arise only by the division of pre-existing cells. There is a fundamental similarity with respect to the chemical composition and metabolic functions of all cells. Based on the structure of nucleus, cells are divided into two categories namely Procaryotes and Eucaryotes. Procaryotes are simpler in their structure and lack nuclear membrane. Eucaryotes have a nucleus enclosed by a nuclear membrane. Among the eucaryotic cells, the plant cells differ from animal cells in having a cell wall, plastids and a big vacuole in the centre of cells.

2. Eucaryotic cells contain in them number of organelles such as mitochondria, endoplasmic reticulum, centrioles and chloroplasts. There is a division of labour among these organelles. Mitochondria for example help in the energy production and centrioles in cell division. Endoplasmic reticulum helps in the distribution of material within the cells. The chloroplasts capture the sun energy for the synthesis of organic matter.

3. Cell division is an important phenomenon. Growth or multiplication of organisms through reproduction involves cell division. There are two kinds of cell division 1. Mitosis 2. Meiosis. Mitotic cell division results in the production of cells which are identical to the parent cells. The meiotic division is reduction division and takes place in gonads. Mitotic division involves only one division and production of two cells. Meiosis division on the other hand involves two divisions and results in the production of four daughter cells.

4. A tissue is a group of similar cells to perform a specific function only. In higher multicellular organisms specialized cells are grouped to form tissues. Such tissue system is seen in plants and animals.

5. Different tissues are produced in the animal body. The *epithelial tissue* is a thin, protective layer of cells of the body and lines the various body cavities and internal organs. The four types of epithelial tissues are squamous, columnar, cuboidal, ciliated epithelial tissues. The *connective tissue* is specialized for connecting or supporting various tissues and organs. It includes bone, cartilage, tendons, ligaments and fibrous connective tissue. The *muscular tissue* form the muscles of the body. They help the body for all its movements. It includes skeletal, smooth and cardiac muscles. The *nervous tissue* makes the nervous system. It is concerned with the responsiveness of animals. The *reproductive tissue* contains cells which are modified to produce gametes, i.e., the sperms and eggs. The blood or fluid tissue consists of the blood and lymph. Red blood corpuscles, White blood corpuscles, Platelets are the cellular parts of the blood.

6. Plants maintain regions of growth and differentiation throughout the life time. Four different kinds of tissue systems are formed in plants. They are *dermal tissue* system consists of the protective tissues, the *epidermis* and the *periderm*. *Fundamental* or *ground tissue system* includes tissue which form the ground substance of the plants. They are *parenchyma, collenchyma* and *sclerenchyma*. *Vascular tissue system* is also called conducting tissue. *Xylem* and *phloem* are two types of conducting tissues.

11.8 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following questions in about 30 lines.

1. Describe the major events that led to the growth of biological sciences.
2. Give a brief account of the cell organelles.
3. Describe the major tissues encountered in animals.
4. Define the terms mitosis and meiosis? Explain the importance of the two types of cell division.

Answer the following questions in about 15 lines.

5. What is cell theory?
6. Write briefly about the type of cell division found in the somatic cells of an organism.
7. Describe briefly about different types of tissue systems that are found in land plants.

11.9 GLOSSARY

Crystae	:	Projection into the central matrix of mitochondrion produced by the repeated invagination of inner mitochondrial membrane.
Cytokinesis	:	Division of cytoplasm during cell division.
Meiosis	:	A process of cellular division which results in each of the daughter cells containing haploid number of chromosomes.
Mitosis	:	The series of changes within a cell nucleus, by which two genetically identical nuclei are formed.
Eukaryotes	:	Organisms whose cells are characterized by true nuclei bounded by a nuclear membrane.
Autotroph	:	An organism which can synthesize its own food from simple organic and inorganic elements by utilizing the energy from sun light.
Chromosome	:	Thread like bodies that occur in the nuclei of living cells. They consists of DNA and proteins.
Intracellular	:	Within a cell.

UNIT-12 EVOLUTION AND HEREDITY

Contents

12.1 AIMS AND OBJECTIVES

Aims

This Unit is to introduce you to the concepts of "evolution" and "human heredity".

The unit discusses the theories of evolution proposed by Darwin and Lemark in brief and explains what industrial melanism is.

The laws of heredity proposed by Mendel and the physical basis of heredity with emphasis on blood groups and sex determination are briefly presented. Some of the sex linked abnormalities in human beings and the reasons for these are also described.

Objectives

After you completed the Unit, you would be able to

1. understand the essential features of Lemark's and Darwin's theories of evolution.
2. appreciate how Mendel successfully explained the principles underlying the human heredity.
3. educate yourself about the ill consequences of certain types of marriages.

12.2 INTRODUCTION

Life is found on earth in different forms. It exists in simple forms like single celled "protozoa" and in complex multi celled forms namely animals, plants and human beings. There is an orderly development of characters from one group to another. Complex forms are evolved from simple forms by a process known as evolution. The concept of evolution had not been accepted till 19th century. Most religions in the world believed in the theory of special creation. They were of the opinion that super natural power designed and created the variety of organisms in Nature. The theory of evolution proposed by Darwin caused a furore among the people.

Darwin could effectively point out that evolution is a process of development. But he could not explain or account for the origin of variations. Darwin could not explain the transmission of heredity characters from one generation to the other. The work of Mendel explained successfully this aspect through the three laws proposed by him. Blood groups, sex determination and sex linked abnormalities are all explained more logically.

12.3 THEORIES OF EVOLUTION

Thoughtful consideration of the nature of change led the ancient Greek philosophers to suggest that change in morphology of organisms was not only possible but probable. These philosophers laid the philosophical foundation for a concept of organic evolution. Thanks to crusaders like **T.H. Huxley**, the theory of evolution has come to be accepted. Although differences exist even today as regards to the details of the mechanism of evolution, biologists all over the world agree that evolution has indeed occurred. There is, however, no dispute over the fact that once life has originated on earth it underwent change and that variety of living forms, which we now observe in nature are the result of an evolutionary process. There is a variety of evidence for this view.

Theory of inheritance of acquired characters

Although Greek philosophers such as **Thales, Anaximander, Empedocles, Epicurus** and **Aristotle** thought about the evolutionary process, serious consideration of the concept of evolution had begun only during the 18th and 19th centuries. **Jean Baptiste de Lamarck** (1744-1829) is said to be the first naturalist who had a logical theory on evolution. His theory of 'Inheritance of acquired characters' published in *Philosophic Zoologique* suggests that an organism develops a new organ system or loses it because of its use or disuse. Some mysterious force in organisms enables them to acquire these characteristics as a way of adapting themselves to changing environmental conditions. Such acquired characters were thought to be transmitted to the offspring. Lamarck's theory on inheritance of acquired characters, however cannot be accepted as a logical theory of evolution, since we know from our own experience that not all characteristics acquired by an organism during its lifetime are transmitted to the offspring. A parent whose leg is amputated cannot transmit this character to his children, not a wrestler who develops muscles after due exercise transmits them to his children. Indians have worn ear rings and nose rings for centuries, but the holes in ears and nose are not transmitted to offspring. With the development of genetics (the science of biological inheritance) we now know that only those characters which are present in the gametes or germ cells; or changes that are brought about therein are inherited.

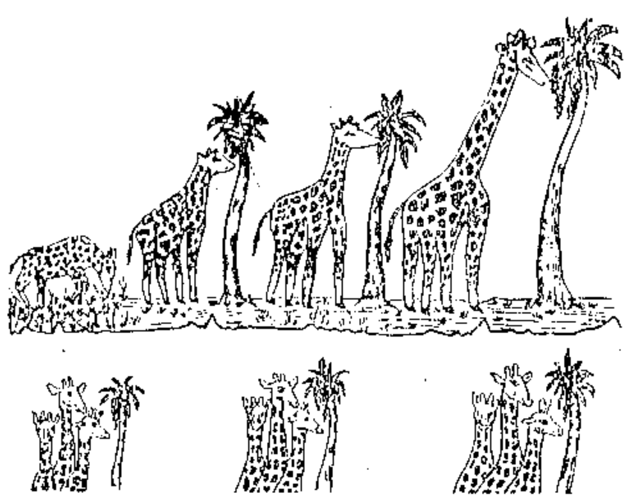

Fig. 12.1 Differences between Lamarckian & Darwinian outlook on evolution

Theory of natural selection

Charles Darwin and **Alfred Wallace** working independently of each other developed a theory of evolution, and it is widely known as the **theory of Natural Selection** or **Darwin's theory of Evolution**. It suggests that Nature (environment) favours the survival and perpetuation of those species which have advantageous variations and not those which lack these advantageous variations. The essentials of the Darwinian theory can be summarized as follows :

1. **Variation** : All organisms show variation. Compare the noses of all your classmates or family members. You would find that no two persons noses are alike. Like wise a shepherd can easily make out the differences marking his sheep. Nature is full of many such examples.

2. **Over Production** : Every species has the capacity to reproduce many offspring. Yet, in nature the number of successive generations remains fairly constant.

3. **Competition** : Since the number of organisms increases due to reproduction there will be competition among them for food and shelter. The competition can be of three types : (1) among the individuals of the same species, **intraspecific** (2) among the individuals of different species, **interspecific** and (3) **environmental** like fire, drought, floods and volcanoes.

4. **Survival of the Fittest** : In their struggle for survival, organisms with advantageous traits which help them to survive under prevailing conditions will survive, while those which do not have the advantageous traits perish in course of time. Darwin called this the **natural selection**.

The major differences between the Lamarckian and Darwinian views on the process of evolution can be illustrated using the giraffe as an example (Fig. 12.1). According to Darwin, there existed giraffes with variations with short and long necks, and that long necked giraffes having the advantage in securing food survived while the shortnecked ones failed to survive since they could not obtain the needed food for survival.

Check Your Progress

Define evolution.

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Theory of inheritance of acquired characters suggest that an organism develops a new organ system or loses it because of its or ______________________

List out the four essentials of the Darwinian theory of natural selection.

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12.4 INDUSTRIAL MELANISM

In order to test the validity of the theory of natural selection an English biologist, **H.B.D. Kettlewell** carried out some experiments with the peppered moth, *Biston betularia* in an industrial area (Birmingham) and a non industrialized area (Dorsetshire). There are two forms, the light and the dark forms of this moth. Soot in the smoke emanating from industries in Birmingham made the tree trunks dark. It was observed that the dark moths had now an advantage as they were not visible to birds which used to eat them. Consequently the white moths started decreasing in number, while the dark ones increased. The reverse was observed in Dorsetshire, where the lichen encrusted tree trunks gave protection to the white moths.

Check Your Progress

Which of the following did Kettelewell conclude from his studies on industrial melanism in moths in an industrial area.

a. A dark moth lays more eggs than a light moth in industrial areas.

b. Dark moths had an advantage to survive in industrialized areas than light moths.

c. Birds prefer the taste of dark moths to the taste of light moths.

d. None of the above.

12.5 MENDEL'S LAWS OF HEREDITY

John Gregor Mendel (1822-1884) was an Austrian monk. He can be called the "Father of Genetics". Three factors helped Mendel in formulating the laws of heredity : (1) Darwin's theory (2) his own background in mathematics and (3) his choice of the pea plant. Mendel did not have much knowledge of biology. His experiments on the pea plant (*Pisum sativum*) and his mathematical calculations on his breeding experiments were very useful in formulating the laws of genetics. Most of Mendel's important experiments were performed between 1856 and 1863. He presented his report in 1865 to the Brun Society for the study of Natural Science which was later published in its transactions. Mendel's methods were simple. He chose one character at a time and luckily for him the seven characters which he had chosen behaved in an identical way and helped him to formulate his three laws (1) the law of dominance (2) the law of segregation and (3) the law of independent assortment.

Law of dominance

When the tall plants are cross-fertilized with the dwarf plants, Mendel found that all those offspring which were produced were tall. Mendel crossed these plants and found that in the second generation the tall and dwarf plants were in the ratio of 3:1. Mendel called the original pure varieties 'parental (or P) generation'. The first generation plants were called the '*first fillial generation* (or F_1 generation)' and the second generation plants produced by self fertilization of F_1 plants were called '*second fillial generation* (or F_2 generation). The results are shown in Fig. 12.2.

Based on these results Mendel formulated the *law of dominance*. The law states that "if individuals with two contrasting characters are crossed, it would result in the appearance of only one of them in the hybrids". The character which appears in the hybrid is called the **dominant** character, while the one which does not appear is called a recessive character.

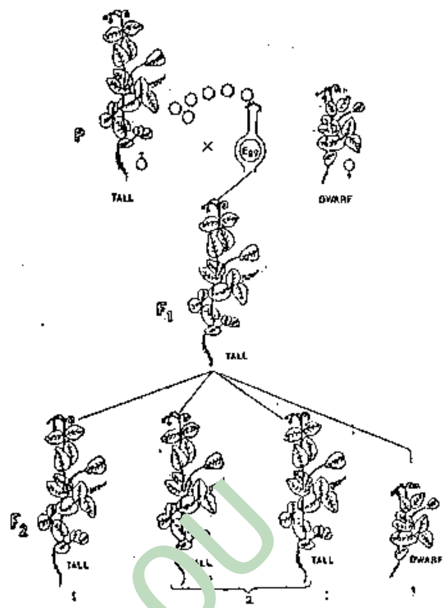

Fig. 12.2 Inheritance pattern of the cross between tall & dwarf plants

Check Your Progress

Define the law of dominance.

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Law of segregation

Mendel speculated on the reappearance in the F_2 generation of recessive characters not seen in the F_1 generation. He developed a hypothesis (gene hypothesis) according to which, of the factors (genes) responsible for each character, only one enters into the gametes. When gametes meet to form a zygote, the two genes coming from different parents meet to form the pair. When the genes are in a hybrid they do not blend or contaminate each other. Instead they separate and segregate as pure and uncontaminated ones to enter into separate gametes formed in the hybrid. This is called the law of segregation or law of purity of gametes.

To explain the inheritance of the characters letter symbols are used. Each gene is assigned a letter of the alphabet. The dominant character is indicated by capital letters, and the recessive character by small letters. The inheritance of the tall and dwarf characters of the pea plant are explained below (Fig 12.3).

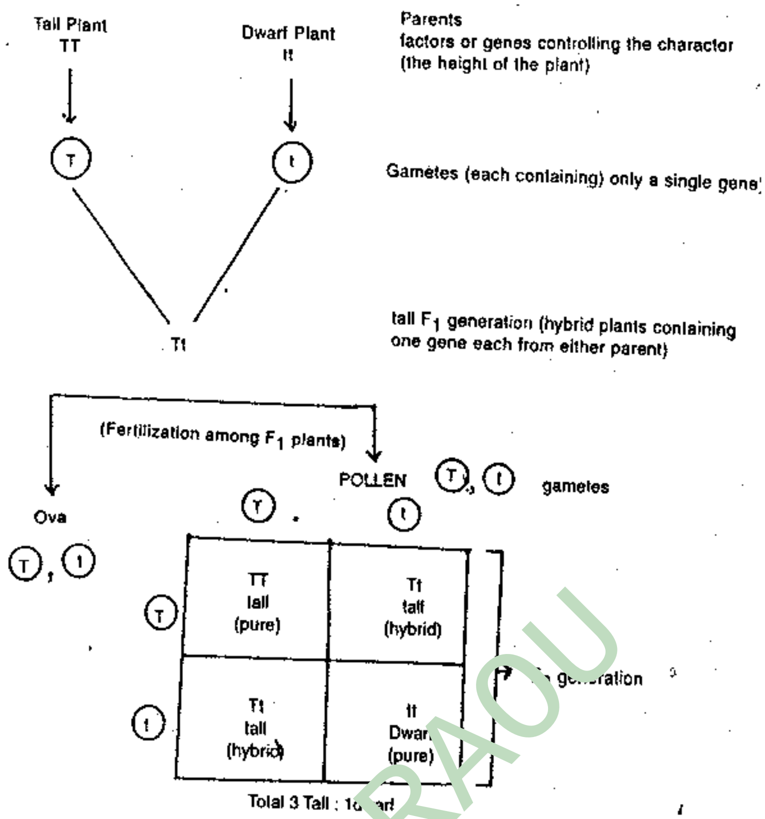

Fig. 12.3 Inheritance pattern of tall and dwarf characters in pea plant

We can thus see that whenever hybrid plants are crossed among each other, one category of plants among the resultant plants will have one gene (T) which is dominant and therefore, appear as tall. On the other hand, another category of plants will have two recessive genes (t) for the dwarf character. These plants will be dwarf in their characters. If we look carefully at the genetic constitution of the tall plants formed from hybrids, we can see that some of these plants will have both 'TT' genes, therefore they are pure, while the others contain one 'T' and on 't' ('Tt') and therefore are hybrids (Fig. 12.3).

Check Your Progress

When the genes are in a hybrid, they do not blend or contaminate each other, instead they separate and segregate as pure and uncontaminated ones to enter into separate gametes formed in the hybrid. This is called the ____________________ or ____________________.

Law of independent assortment

Another important observation made by Mendel is the inheritance of two characters. He has observed that the seeds of the pea plant can be either yellow or green, while the shape can be either round or wrinkled. When these two characters are studied independently the yellow colour is dominant over green, the round character of the seed is dominant over the wrinkled character. When Mendel considered the two characters together, he found that in the F_2 generation a new pattern and new combinations emerged. The experiment and observations are summarized in Fig. 12.4.

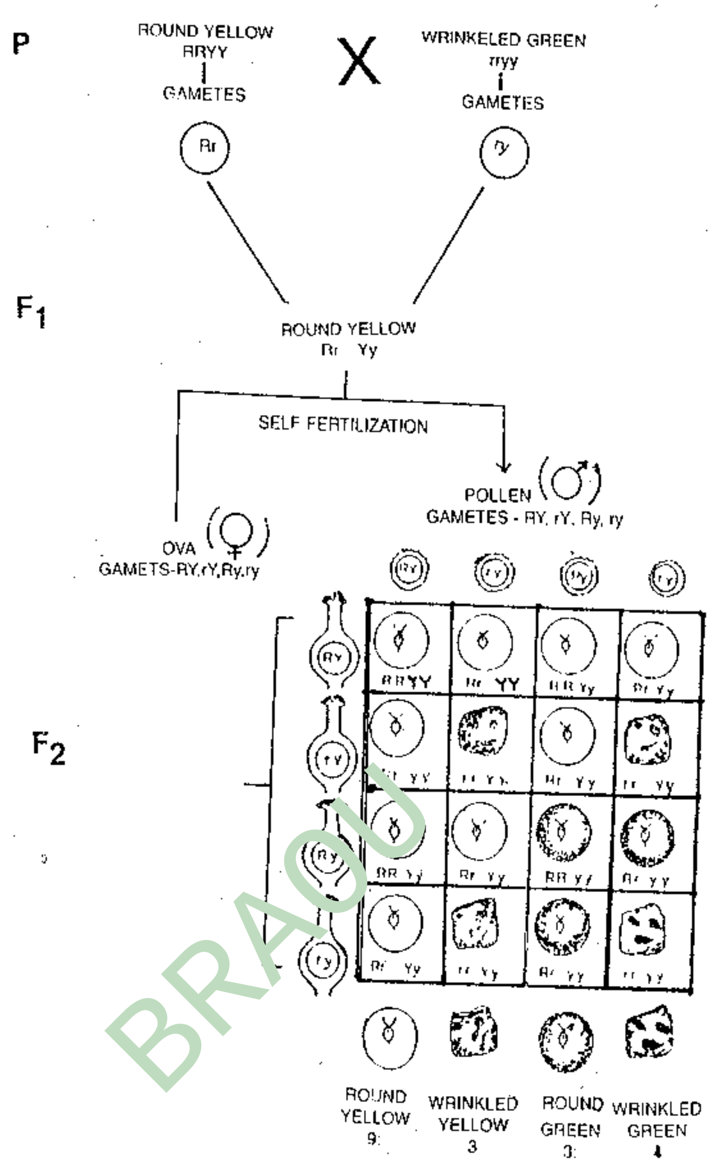

Fig. 12.4 Inheritance pattern of colour and shape of seeds showing the independent assortment. R = round, r = wrinkled, Y = yellow, y = green.

It can be seen from the figure12.4, when round yellow plants are cross-fertilized with wrinkled green plants, that two new combinations like round green seeds and wrinkled yellow seeds appear in the F_2 generation. However, if one observes the figure carefully it may be seen that each character (the round to wrinkled shape or the yellow to green colour) is in the ratio of 3:1 i.e. (9+3) : (3+1) in F_2 generation.

To explain these results, Mendel proposed another hypothesis called the law of *independent assortment.* It states that each character (the shape or the colour) has two genes each and that at the time of formation of gamete only one gene belonging to either character will enter into the gametes independently (the segregation of the genes for colour occurs independent of the shape). It can be seen from figure 12.4 that in all, 16 combinations are possible due to the union of gametes of the F_2 generation; out of these 9 will have at least one 'R' and one 'Y' and are, therefore, round and green; 3 will have both 'r' but at least one 'Y' and are, therefore wrinkled and yellow; and only 1 has both 'r' and 'y' and is, therefore, *wrinkled* and green. The segregation of genes belonging to each character is, therefore, independent of each other. The F_2 generation ratio is 9:3 : 3:1.

Check Your Progress

The law of independent assortment states one of the following.

a) In the inheritance of two characters the segregation of genes belonging to each character is independent of each other.

b) In the inheritance of two characters the segregation of genes belonging to each character is dependent of each other.

c) None of the above.

12.6 PHYSICAL BASIS OF HEREDITY

Mendel's work was ignored for nearly 35 years. In 1900 three scientists, **de Vries** in Holland, **Correns** in Germany and **Tshermark** in Austria, discovered independently of one another the importance of Mendel's principles. In the initial stages there was a debate for and against these principles. Ironically, the biometricians opposed the theory. It was **William Bateson** (1861-1926) who successfully argued in favour of Mendelian principles. It was there that the search started for the material basis of heredity. It was **Walter Sutton** (1877-1916), a student of Columbia University and **Theoder Boveri** (1862-1915), a German cytologist, who independently of each other came to the conclusion that genes are carried in the chromosomes. Sutton, indeed suggested that there is a close similarity between the separation of homologous chromosomes in cell division and Mendel's hypothesis of segregation. Later work confirmed that the chromosomes are the transmitters of the genetic information. We know from Unit - 11 that during cell division in Meiosis (gametogenesis) the diploid number of chromosomes become half (e.g. out of 46 chromosomes in man only 23 appear in the gametes) and that when the gametes fuse to form the zygote the original diploid number is restored. We also know that chromosomes exist as homologous pairs. It is now established that the allelic genes exist in different homologous sets.

Check Your Progress

In the search for the material basis of heredity it was ______________________ and ______________________ who independent of each other came to the conclusion that genes are carried in the chromosome.

Human Heredity

Mendel's laws of heredity and the fundamental concepts of genetics are universally accepted. Although human heredity is also governed by the same principles, there are certain difficulties involved in the study of human heredity. For example, human being cannot be treated as an experimental animal and he cannot be made to mate at will. The offspring produced by human beings is relatively small which makes it difficult for statistical accounts to be made. All evidence on heredity in human beings comes from indirect studies of variations among larger population. The study of human genetics, therefore, involves (1) the detection of the genetically determined traits and (2) the detection of the pattern of inheritance by collecting the family history over generations i.e. pedigree charts.

Genetically determined traits can be detected by the study of the bio-chemical differences in the population. Biochemical studies involved the study of proteins and enzymes. Enzyme determination in blood and urine, has become important part of clinical biochemistry. These studies help in the diagnosis of certain diseases like polio, tetanus, etc. Certain traits like the colour of the eye, tongue rolling ability and attached ear lobe can be easily detected. We can also determine the possible genotypes by determining the dominant and recessive factors. For example, brown eye is dominant character as compared to blue eyes. Therefore, a blue-eyed man will be homozygous where as brown-eyed man can be either homo or heterozygous.

Blood groups

Blood groups are the important hereditary characters of human beings. There are four major types of blood groups. A, B, O and AB. These groups are result of 3 genes I_a, I_b, I_o. I_a and I_b are dominant and I_o is recessive to both A & B. Persons having 'O' group shall have both recessive 'O' genes. Those having 'AB' group contain both the dominant genes. 'A' group persons have dominant 'A' gene, 'B' group persons shall have dominant 'B' gene. It is common knowledge that a blood transfusion is given whenever a patient needs blood. In this process the blood from a healthy person (the donor), is first tried for his/her blood group and is fed into the one of the patient's veins. As we already know there are four types of blood groups - 'A', 'B', 'O' and 'AB'. The 'O' group person (universal donor) can donate blood to any of the four categories. An 'A' group person can donate blood only to 'A' and a 'B' group person only to 'B'. However, an 'AB' cannot donate blood to anyone but can receive blood from all the four categories (universal acceptor). **Karl Landsteiner** discovered these blood groups in human population. The differences in the blood groups are due to certain chemical substances present in the red blood cells and also in the plasma of the human beings. The red blood cells contain the antigens, whereas plasma contain antibodies.

For a transfusion to be successful the blood group of the donor has to match the blood group of the patient. If the blood groups of the donor and patient do not match, the antibodies in the patient's blood will act on the donor's red cells and clump them together in the patient's blood vessels which will cause serious harm to the patient. The antigens and antibodies present in different blood groups are as follows (Table -12.1).

Table : 12.1 Antigens and antibodies in different blood groups

Blood group	Antigen in the red cells	Antibodies in the plasma
A	A	Anti - B
B	B	Anti - A
AB	A & B	None
O	None	Anti - A & Anti - B

It can be seen from the table that a person having 'A' blood group will contain antigen A in his red cells and anti-B (antibody) in his plasma. Therefore, he cannot receive the blood from 'B' or AB who contain antigen B in their red blood cells. An 'O' group person has neither Anti - A nor Anti - B antigens in his red cells, therefore, he can donate blood either to 'A', 'B' or 'AB'. Persons with 'AB' blood group, on the other hand, contain - A, - B antigens, but as there are no antibodies in their plasma they can accept blood from anybody. The 'O' group persons are called **universal donors**. 'AB' group persons are called **universal acceptors**.

Another important antigen carried by the human blood cells is called the Rh (so named after rhesus monkeys) factor. When the blood of a human being contains this antigen he/she is called Rh+ (Rh positive); when this antigen is absent he/she is called Rh- (Rh negative). When an Rh- woman marries an Rh+ man, if the child is Rh+, it causes the production of antibodies in the mother even while in the mother's womb. Normally the first conception passes without incident and the first child is normal. But in subsequent pregnancies, the antibodies against Rh+ in the mother's body cause the agglutination of the red cells in the growing baby. This causes the death of the baby either before or after the birth. This phenomenon is called **erythroblastosis faetalis.**

Check Your Progress

From the A, B, O, AB blood groups point out the two blood groups, one of which is commonly known as 'universal donor' and the other 'universal acceptor'.

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Sex Determination — Non-disjunction of sex chromosomes

Morgan's work on the fruitfly, *Drosophila melanogaster,* revealed that there are two types of chromosomes in cells, the **autosomes** and the **sex chromosomes**. It was demonstrated that in Drosophila two 'X' chromosomes shall make the individual a female, while one 'X' and one 'Y' chromosome shall make a male. In this species the sex determining factors are located in 'X' chromosomes and it was shown that the presence of two 'X' chromosomes and one 'Y' chromosome also characterise a female and in the absence of 'Y' chromosome the presence of 'X' chromosome shall make an individual a male. It was earlier thought that a similar type of relationship between the chromosomes and sex determination exists in all animals. However, it is now established that the sex determination in various animals can differ from this pattern.

Table 12.2 Relationship between the sex chromosomes and the phenotypic appearance in human beings.

Types of Sex Chromosomes	Phenotype	Characteristics
XY	Male	Normal male
XX	Female	Normal female
XO	Female	Turner's syndrome (they have no functional ovaries, female features do not develop properly, they are subnormal in their intelligence).
XXY	Male	Klinefelter's syndrome (they have male genitalia, which are not functional. They develop breasts. They are mentally retarded)
XXX	Female	Triple 'X' syndrome. They are normal and fertile.

In human beings, the 'Y' chromosome contain sex determining factors. If an individual has 'Y' chromosome he shall be a male even when he has one, two or three 'X' chromosomes. The relationship between the type of sex chromosomes and the phenotypic appearance of sex is given in Table 12.2.

It can be seen from the table that while two 'X' chromosomes make a female, an 'X' and 'Y' shall make a male. The Turner and Klinefelter's syndromes and other abnormalities are produced because of the non-disjunction of chromosomes during gametes formation. An egg produced by a female shall normally contain only one 'X' chromosome and a male sperm shall contain either one 'X' or 'Y'. In normal pregnancies, the union between the eggs and sperms each with an 'X' shall produce a female, whereas a union with the sperm containing a 'Y' chromosome shall become a male. But under some abnormal conditions the two 'X' chromosomes in female go into a single egg due to non-disjunction and a union with the normal sperm results in the formation of either Triple-X female or male with Klinefelter's syndrome. Like wise, when a sperm with 'X' chromosome fertilizes the egg in which 'X' chromosome is lacking, it produces a female with Turner's syndrome. The inheritance pattern is explained in Fig. 12.5.

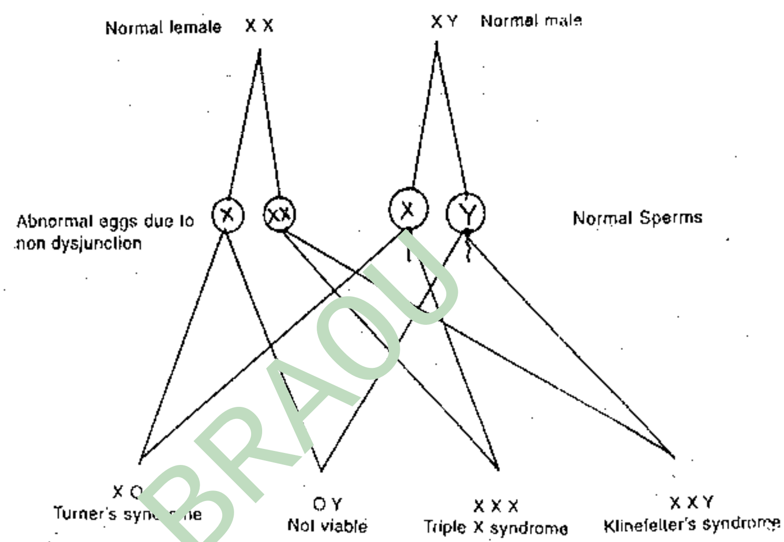

Fig. 12.5 Abnormalities due to non-disjunction of sex chromosomes in female.

Check Your Progress

The Turner's and Klinefelter's syndromes are produced because of the following.

(a) non-disjunction of sex chromosomes in female

(b) non-disjunction of autosomes in female

(c) non-disjunction of both sex chromosomes and autosomes in female

12.7 SEX LINKED ABNORMALITIES IN HUMAN BEINGS

Certain characteristics are associated with the sex chromosomes. Genes for two important diseases - **haemophilia** and **colour blindness** have been found to be located on the X-chromosome. Haemophilia is characterized by the lack of clotting mechanism in the blood. A patient who has this disease cannot survive for long as even a simple cut or injury results in the constant loss of blood which does not clot. The gene for the disease has been identified as recessive and it is localized in the X chromosome and it normally appears in males. When a heterozygous female marries and bears children, half of her male children shall have this disease. The inheritance pattern is shown in Fig.12.6.

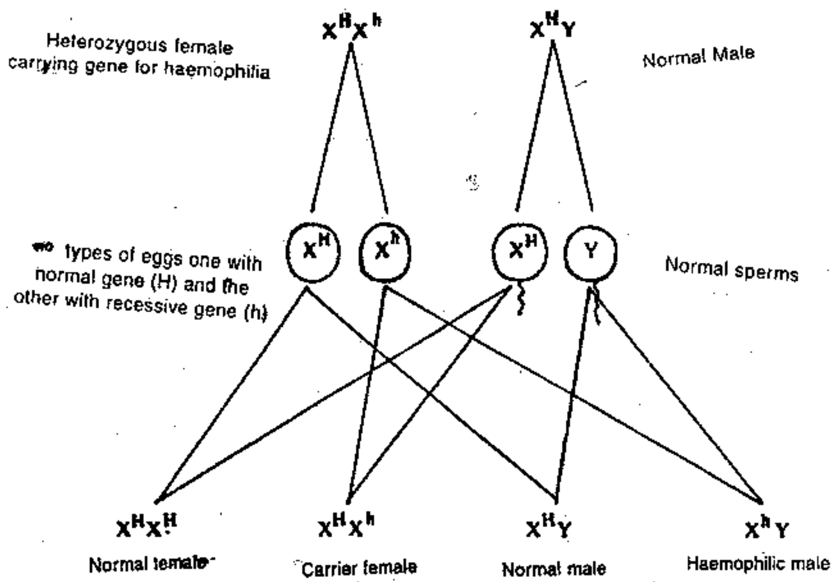

Fig. 12.6 Inheritance pattern of haemophilia

It can be seen that the X chromosome present in the sons come from mothers. Since the mother is a carrier of the recessive gene for haemophilia half of her sons who receive the X chromosome with the haemophiliac gene shall be haemophiliacs because there is no corresponding gene on 'Y' chromosome in the males. Hence, it is clear that a single dose is required for the expression of this character in males. This is the reason why this disease is more common in males. The gene for the colour blindness is also found to be recessive and localized in the X chromosome. Numerous other conditions like albinism, G-6-P.D. (Glucose-6-Phsophate dehydrogenase) defects are also found to be located on the X-chromosome. Certain characters, like hair on the ear and also the genes responsible *for* determining male characters are located on the Y-chromosome.

Check Your Progress

Suppose a heterozygous female carrying gene for haemophilia married a normal male; then of what type will their children be?

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Consanguineous Marriages - Genetic Disadvantages

As the number of recessive alleles in a population is small, the probability of two heterozygotes marrying each other is slender when the marriages are between the unrelated members of a population. It has been worked out that heterozygotes for albinism in a population are 1 in 140. It has been calculated that in random marriages only one out of 78,000 people shall exhibit this defective trait. In consanguineous (closely related) marriages on the other hand, one out of every sixty four persons shall inherit this defective trait.

12.8 SUMMARY

1. Evolution is a gradual and orderly change from one form to the other.
2. The wide variety of living organisms that are existing on earth to-day are the result of an evolutionary change. There are many evidences to support this statement. The evidences can be had from the morphology and anatomy of various organ systems.
3. The presence of embryonic stages of lower vertebrates in the development stages of higher vertebrates show the gradual change in the evolution of horse.
4. Lamarck was the first to put forward a logical theory in support of evolution.
5. His theory, "The theory of inheritance of acquired characters" suggests that the organs are formed or lost depending on the use or misuse of organ systems.
6. This theory was later rejected.
7. The theory of "Natural Selection" proposed by Charles Darwin was considered more logical and accepted.
8. Alfred Wallace working independently came to similar conclusions.
9. H.B.D. Kettlewell working on "moths" in England confirmed the validity of theory of "Natural Selection".
10. Heredity is the means by which living organisms reproduce their kind.
11. Mendel was the first to explain this transmission of characters through his laws of heredity.
12. His laws are known as Law of dominance, Law of segregation and law of independent assortment.
13. Two factors (genes) control each character in an individual.
14. These two do not blend or contaminate each other. They segregate or separate out into independent gametes of the hybrid.
15. Human heredity follows the same principles.
16. The important human heriditary character is blood group. There are four major blood groups A, B, O and AB.
17. 'O' group persons are universal donors and 'AB' group persons are universal acceptors.

12.9 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines each.

1. What is evolution? Explain with examples the true meaning of evolution.
2. Describe the different theories putforth to explain the process of evolution.
3. How are characters transmitted to the offspring? Explain the laws of heredity proposed by Mendel.
4. Describe the sex determination pattern in human beings.
5. What are the different types of blood groups that are found in human beings. Discuss the importance and significance of these blood groups.

Answer the following in 15 lines each.

1. What is meant by the theory of acquired characters? Why it is not accepted?
2. Describe the theory of natural selection.
3. What is non-disjunction of chromosomes? What are the abnormalities caused by it?
4. Explain the law of independent assortment.
5. Discuss about the inheritance pattern of haemophilia.

12.10 GLOSSARY

Competition : Struggle between the organisms for the necessities of life.

Inheritance : The acquisition of characteristics by transmission of germ plasm from ancestor to descendant.

Mantle : Extended body wall lining the shell of invertebrates.

Paugenesis : Darwin's theory that every cell of the body contributes gemmules to the germ cells and so shares the transmission of inherited characters.

Pedigree : A record of ancestors.

Phenotype : Physical appearance of an individual.

Preformation : The idea that an already formed, miniature individual exists within the egg and merely increases during embryological development.

Segregation : The separation during gemetogenesis of paired factors (alleles) influencing a single trait.

Allele : Genes that carry contrasting inheritance factors (T and t; R and r; Y and y).

Anaemia : A state of deficiency of either circulating red blood cells or the amount of haemoglobin in red blood cells.

Autosome : Any chromosome that is not a sex chromosome.

Dominant : In genetics, the term is used to refer to a gene that always express itself over its recessive allele in the heterozygous condition.

Epigenesis : A theory which states that the development of an embryo consists of the gradual production and organisation of parts.

Gamete : Male or female reproductive cell.

Genotype : Genetic make up of an organism. What alleles it actually contains and can pass on to its offspring.

Heterozygote : Individuals in which the pairs of genes are different (Tt, Rr, Yy).

Homozygote : Individuals in which the pairs of genes are identical (TT, tt).

Hybrid : Plant or animal resulting from cross between the unrelated species.

Non-disjunction : Failure of two homologous chromosomes of a pair to separate to opposite poles at the time of meiosis. This results in one daughter cell having both the chromosomes, while the other having either of them.

UNIT-13 HUMAN BODY REGULATORY SYSTEMS

Contents

13.1 AIMS AND OBJECTIVES

Aims

This Unit will help you to understand how physiological functions are regulated in the body.

Objectives

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

1. describe the three types of regulatory systems in the body - the nervous, *hormonal* and metabolic.
2. explain the phenomenon of homeostasis.

13.2 INTRODUCTION

Regulation refers to the adjustment of the rate of a reaction in cells. The process concerning the coordination of body functions which makes the effective functioning of the whole organism easy is called *integration.*

There are three important regulatory systems that regulate the functions of the body. (1) nervous regulation, (2) hormonal regulation, and (3) metabolic regulation. Before we study about these systems, we shall first define certain common terms.

Stimulus : Any change in the environment of an organism that can made out by the organisms is called a 'stimulus'.

Response : The voluntary or involuntary change in the behaviour of the organism due to a stimulus is called 'response'.

Sensors : The specialized cells or tissues that detect the changes in the environment are called 'sensors' (receptors). The eye, ear, the taste buds on the tongue, heat and cold receptors in the skin are examples of 'sensors'.

Effectors : The cells or the organs that respond to the effectors. They include cells like chromatophores, gland cells, muscles etc.

Now, let us know about the regulatory systems of the body.

13.3 NERVOUS REGULATION

In a multicellular organisms, nerves constitute an important network. They integrate various components of the body. The nervous system has attained its highest complexity in vertebrates. It consists of the brain and the spinal cord which together constitute the central nervous system. Other nerves connect this central nervous system to the peripheral parts of the body. The neurons (nerve cells) in the body can be divided into three categories.

a) The sensory neurons which carry impulses from sensors to the central nervous system.

b) The interneurons or the connecting neurons and

c) The motor neurons which generate impulses in response to stimuli in the central nervous system.

In a simple reflex arc the stimuli are received by the sensors which then pass them over to the spinal cord. This in turn, passes it over to the motor neurons which generate impulses for transfer to the effectors. A simple reflex arc can be seen in Fig. 13.1.

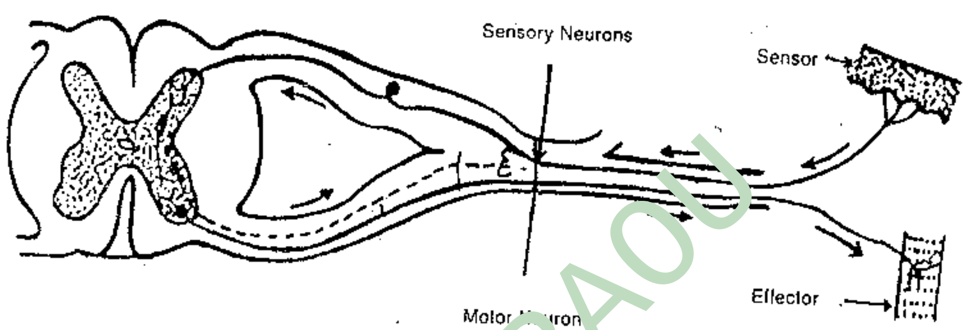

Fig. 13.1 Simple reflex arc

A typical nerve cell is shown in figure 13.2. It consists of the cell body and process projecting from the cell body. There are two kinds of processes, the **'dendrites'** (which are short) and the **'axons'** (which are long). The dendrites carry impulse towards the cell body and the axons carry it away from the cell body. The axon of one nerve cell has synoptic contact with other nerve cell or effector cell (eg. muscle fibre). Thus the nerve impulse is transmitted from one nerve cell to other cell. The nerve impulses are transmitted as electrical impulses. These electrical impulses are generated due to the movement of sodium and potassium ions across the nerve cell membrane, whenever the nerve is stimulated. That means a membrane potential is maintained across the cell membrane. These membrane potentials can be measured by using instruments like cathode ray oscilloscope.

Check Your Progress

Into how many categories the neurons in the body can be divided? Name them.

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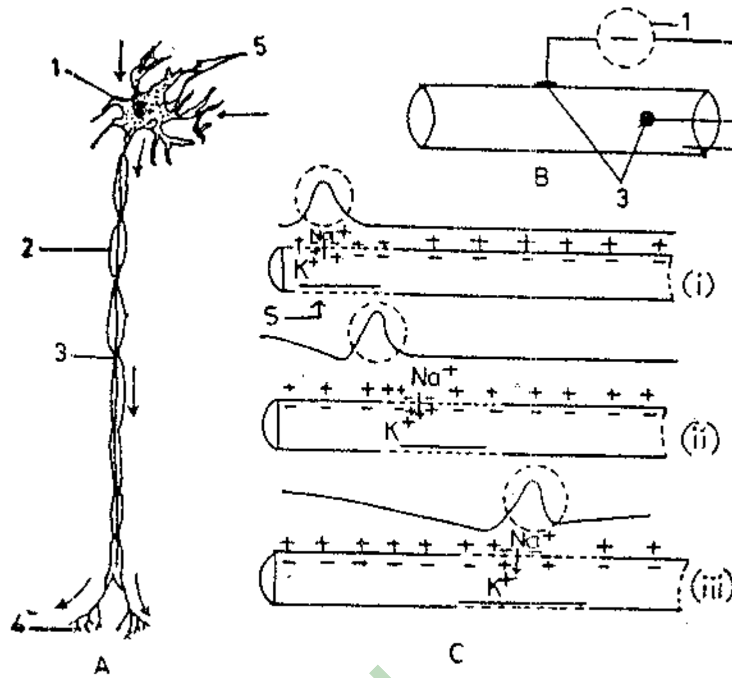


Fig. 13.2 A. Structure of a neuron (1. Cell body 2. Myelin sheath 3. Node of Ranvier 4. Dendritic ends 5. Dendrites (Arrows indicate the path of nerve impulse transmission). B. Recording of nerve impulse by placing microelectrodes in and on the nerve cell. 1. Cathode-ray-oscilloscope 2. Axon 3. Electrodes C. Nerve impulse transmission across the axon. S = stimulus

13.4 HORMONAL REGULATION

Hormones are chemical substances that are secreted by specialized organs called *'endocrine glands'*. The endocrine glands are ductless. They secrete the hormones directly into the blood. The endocrine glands found in the human body are shown in Fig 13.3 and also given in Table 13.1.

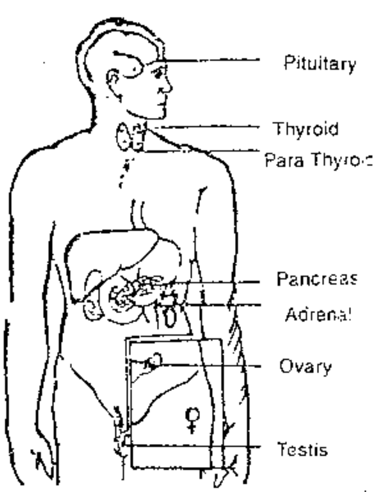


Fig. 13.3 Endocrine glands in human body

Table 13.1 Endocrine glands, their secretion and their hormonal functions

Gland(s)	Hormone(s)	Function(s)
Pituitary	Growth hormone	Growth of bone & body parts
	Thyrotropic hormone	Stimulates the thyroid gland.
	Adreno corticotropic hormone	Stimulates the adrenal cortex.
	Follicle stimulating hormone	Stimulates growth of (a) ovary & maturation of follicles (b) seminiferous tubules in the testes, etc.
	Luteinizing hormone	Luteinization of ovarian follicle and release of estrogen and progesterone and testosterone by testis.
	Prolactin	Promotes mammary gland development and milk production.
	Melanocyte stimulating hormone	Promotes the dispersal of pigment in chromatophores.
	Oxytocin	Stimulates the contraction of smooth muscles of uterus and milk ejection from mammary glands.
	Vasopressin	Prevents excessive urine formation and secretion.
Thyroid	Thyroxine	Increases basic metabolic rate in cells. Morphogenesis.
	Tri-iodo-thyronine	Brain development.
	Calcitonin	Opposite to that of parathormone.
Parathyroid	Parathormone	Regulation of the calcium and phosphate levels in blood and of mineralization of bone.
Pancreas (Islets of Langerhans)	Insulin	Reduces the blood sugar level by increasing the permeability in cells. Converts liver glycogen to blood sugar.
Adrenal medulla	Adrenaline	Reinforces the action of sympathetic nervous system, glycogenolysis (Production of glucose from glycogen).
Adrenal cortex	Cortisol etc.	Stimulates the conversion of proteins to carbohydrates; anti-inflammatory.
	Aldosterone	Regulates the metabolism of sodium and potassium.
Testis	Testosterone	Stimulates development of male sex characters.
Ovary	Estrogen	Stimulates the development of female sex characters.
	Progesterone	Regulates the estrus & menstrual cycles in females.

Apart from the important glands, the mucous membrane of alimentary canal also secretes some hormones like gastrin, pancreozymin and cholecystokinin. These are called *gastro-intestinal* hormones. They play a regulatory role in the secretion of digestive enzymes. The hypothalamus region of the brain also is a very important organ which secretes several important peptide hormones that regulate the function of the pituitary.

Hormonal regulation differs from that of nervous regulation in two important ways : Unlike the nervous system, the action of hormones is slower and some glands become functional only during the later stages of development of the organism. In nerves, the transmission of impulses takes place in milliseconds. A specific nerve innervates a specific effector, but in case of hormones they reach the effector (target organ) through blood. Even so, target organs are specific to various hormones.

The hormonal regulation of body functions is best studied in the human reproductive system. In human beings, the gonads remain dormant for 10-14 years. At that stage the pituitary gland starts secreting the gonadotropic hormones. Then in the female ovary, follicles grow and mature releasing estrogen. After the egg is released the ruptured follicle develops as the corpus luteum and it secretes progesterone. If fertilization of egg occurs and pregnancy results, the corpus luteum is maintained and the progesterone secretion is promoted. No further, maturation of follicles occurs. If pregnancy does not occur, the corpus luteum degenerates, the thickened wall of the uterus is cast off and menstruation occurs. Gonadotropin is again secreted afresh as the follicle matures and the cycle is repeated. In males the gonadotropins promote the production of sperms and of the hormone testosterone which promotes and maintains male sex characteristics.

Check Your Progress

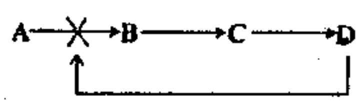
Mention the gland(s) which secrete the hormones given below.

a) Insulin b) Vasopressin c) Leutinizing hormone d) Prolactin e) Thyroxine f) Parathormone.

13.5 METOBOLIC REGULATION

Metabolic regulation is achieved by controlling the activity of enzymes. The control of enzyme activity can occur by a feed-back inhibition or by regulating the synthesis of the enzyme at the genetic level.

In feed-back inhibition the accumulation of the end product inhibits the reaction. For example in a reaction in which A is coverted to D through B and C, the accumulation of D may inhibit the reaction.



There are many such examples in metabolism. For example, when glucose in oxidized to carbon dioxide through glycolysis & Kreb's cycle, it yields energy in the form of ATP Accumulation of ATP causes inhibition of glycolysis. The inhibition is relieved when the available ATP diminishes.

The other type of regulation which controls the synthesis of enzymes is called the genetic regulation. There are certain genes called the 'regulator genes' in the chromosomes. They control the production of specific enzymes.

Check Your Progress

Oxidation of glucose to carbon dioxide through glycolysis & Kreb's cycle is an example of metabolic regulation by ______________________________ .

13.6 HOMEOSTASIS

'Homeostasis' is a term used to describe the regulation of internal environment of living organisms. **Claude Bernard** was the first to recognize that all organisms have the capacity to regulate their internal environment at fixed state. The ability of an organism to restore its internal environment to its original state is called 'homeostasis'. The maintenance of constant body temperature and the regulation of body fluids are two examples which explain us the phenomenon of homeostasis.

It is common experience that in winter our body shivers due to cold. But the shivering lasts only for a short period till the body attains the required temperature and is restored to normalcy. In summer, on the other hand, we sweat and the evaporation of sweat has a cooling effect on the body.

13.7 SUMMARY

1. Regulation refers to the adjustment of the rate of function or reaction of cells. Coordination of various functions in the body come under integration. There are 3 systems which regulate the body functions (1) nervous system (2) hormonal system and (3) metabolic system. Nervous system contains i) Central nervous system and ii) Peripheral neurons.

2. Neurons present in the body are of three types :

   i) Sensory neurons : These take impulses from sense organs to central nervous system.

   ii) Interneurons : These are present in the central nervous system.

   iii) Motor neurons : These are impulses from central nervous system to the effectors.

3. In a simple reflex arc, sensor gets impulses from the environment and passes them over to the sensory neurons. These in turn take the impulses to the spinal cord. Motor neurons receive impulses from the spinal cord and pass them to the effectors to counteract the forces of stimulus.

4. The impulse transmission in nerve cells is due to the movement of sodium and potassium ions across the nerve cell membrane. The distributions of these ions inside and outside cells causes polarity in nerve cells. Neurotransmitters are secreted into the nerve cell junctions when the impulse is travelling along with nerve fibre. They help in propagating impulse from one cell to the other.

5. Hormones are chemical messengers secreted into the blood by endocrine glands. Various endocrine glands are found in human body. Hormonal regulation is a slow process. Important functions like growth, pregnancy and its regulation are under the control of endocrine glands.

6. Metabolic regulation refers to the regulation of chemical reactions. This is achieved by controlling the enzyme activities. Enzyme activity is controlled either by feedback inhibition or by the control of synthesis of enzymes at genetic level.

7. Homeostasis is the term used to describe the regulation of internal environment of living organisms. This is achieved by complex interactions of nervous, hormonal and metabolic regulations.

13.8 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines.

1. Briefly describe the nervous system in the body. Add a note on nerve impulse transmission.
2. Explain the role of hormones with suitable examples.
3. Describe briefly the nervous and hormonal regulation in the body.

Answer the following in about 15 lines.

1. Describe the structure of a neuron.
2. What is a nerve impulse? How it is transmitted?
3. Describe the hormonal regulation of human reproductive system.
4. Write a brief note on metabolic regulation in the body.
5. What is homeostasis? Explain the mechanism of temperature regulation in the body.
6. What are the main hormones that are secreted by Pituitary glands? Mention their important functions.

13.9 GLOSSARY

Response	:	A change in behaviour on the part of an organism (or tissue) as a result of some chemical or physical change in the environment.
Nerve	:	A bundle of nerve fibres or processes held together by connective tissue.
Gonads	:	A primary sex gland; an ovary or a testis.

UNIT-14 CLINICAL BIOCHEMISTRY

Contents

14.1 AIMS AND OBJECTIVES

Aims

This Unit aims at developing your awareness of hereditary disorders and clinical biochemistry which is helpful in the detection and treatment and prevention of diseases. This Unit introduces you to the great developments in organ transplantation and biomedical engineering devices.

Objectives

When you have finished this Unit, you will be able to :

1. list the common inherited disorders, their causes and effects.
2. explain the importance of clinical biochemistry.
3. explain the practice of organ transplantation and the most common organs which are presently being used for the purpose.
4. describe the common biomedical engineering devices used in the field of medicine.

14.2 INTRODUCTION

We have discussed about the infectious diseases and their control in the 21 Unit. There we talked about how the study of microorganisms like bacteria, viruses and fungus led to the major advances in the treatment of many diseases of human beings. Now we shift to the inherited disorders and biochemical basis of those disorders in this Unit. Biochemistry is concerned with the nature of chemical constituents of living organisms. It deals with qualitative and quantitative studies of the reactions taking place in living cells. The origin of biochemistry can be traced to the second half of the nineteenth century. In the early years, the teaching of this discipline was promoted by botanists and medical men. It is only during the past five decades that a separate department has come to be established for biochemistry which reveals changes in body constituents as a great aid in the detection and therefore, treatment of diseases. Developments in organ transplantation and products of biomedical engineering are discussed as they promise greater health and longevity to man.

14.3 CLINICAL BIOCHEMISTRY IN MEDICINE

Clinical biochemistry is the application of chemical and biochemical techniques to the study of diseases in man. This is helpful in the detection, diagnosis, treatment and prevention of diseases. Disease in man is often associated with changes in the biochemical reaction within the cells. The detection of such changes is thus an invaluable aid in the diagnosis and treatment of the disease.

Biological fluids such as blood, urine and cerebrospinal fluid are routinely used for biochemical analysis. Proper collection and preservation of such samples is of utmost importance. Sometimes tissue biopsies are also used in diagnosis of certain diseases. Analysis of gastric juice and pancreatic juice is of use in digestive disorders. The biochemist employs a variety of chemical tests in routine investigations. The appearance of increased amounts of glucose in urine is an indication of diabetes. The determination of proteins, glucose and lipids in blood is important in the diagnosis of some common disorders. The separation of different proteins present in blood is useful in diagnosis of chronic infections, heart diseases and arthritis. Lipid analysis of blood is useful in diagnosing heart diseases.

Urine analysis reveals the state of kidneys, nutritional states of an individual and several pathological states. The presence of abnormal urinary constituents such as proteins, amino acids or sugars are indicative of congenital defects and some malignant tumours.

Enzyme determination in blood and urine has become an important part of clinical biochemistry. Enzymes are proteins. They are the biocatalysts and play an important role in cellular function. Certain enzymes which are normally found within the cells, leak into the circulation or other extracellular fluids of the body when the cells are damaged. The determination of the concentration of these enzymes in serum or urine is thus of diagnostic value. Heart and muscle tissues contain the enzyme, *aldolase*. Its levels in serum are high in diseases such as polio, tetanus and muscular dystrophy.

Check Your Progress

______________, ______________ and ______________ are the biological fluids, which are routinely used for biochemical analysis.

14.4 INHERITED DISORDERS - DIAGNOSIS AND TREATMENT

A number of diseases of man are acquired at birth. Such diseases are passed on from one generation to another in some members (congenital defects). **Sir Archibald Garrod** was bold enough to say that such inherited disorders are due to defective metabolism. However we now know that not all inherited disorders are due to defective metabolism.

At present more than 250 inherited disorders are known. The inherited disorders are of two types. Those arising out of a chromosomal defect. There could be abnormal chromosome number instead of normal 23 pairs. Genetic disorders could also arise as a result of mutations in the genes. This results in the synthesis of functionally defective protein or an enzyme. The majority of genetic diseases identified belong to this category. *Haemophilia* (defective blood clotting) and *sickle cell anaemia* are due to the synthesis of functionally defective proteins.

Table 14.1 Some inherited diseases, their causes and effects

Disease	Cause	Effect
Down's syndrome	Abnormal chromosome number	Mental retardation
Haemophilia	Defective blood clotting mechanism	Bleeding
Sickle cell anaemia	Change in the shape of RBC i.e. to sickle shape	Anaemia
Thalassemia	Abnormal haemoglobin	Anaemia
Phenylketonuria (PKU)	Defective conversion of phenylalanine to tyrosine	Mental retardation

Albinism	Conversion of tyrosine to Dopa is defective	Milk white skin, grey eyes light sensitive
Gout	Abnormal production of uric acid	Arthritis
Gaucher's disease	Cerebrosides accumulation	Enlarged spleen, enlarged liver, neurological manifestations
Galactosemia	Impaired metabolism of galactose	Cataracts, mental retardation, enlarged liver
Glycogen storage	Defect in glycogen breakdown	Heart diseases, muscle weakness, mental retardation

A number of inherited disorders are identified as due to abnormal chromosomes which differ either in their structure or number. These are referred to as chromosomal aberrations. The causes of chromosomal aberrations are not known. However factors such as hazardous radiations leading to chromosome damage are important. Down's syndrome or Mongolism is a typical chromosomal defect.

Since inherited disorders cannot be cured, early diagnosis is crucial in management and care of the affected individuals. Diagnosis of genetic disorders is aimed at two levels.

1. Early diagnosis and detection even during the neonatal period i.e., diagnosis immediately after birth.
2. It is more important to identify individuals who are not affected by the disease but who are carriers of that particular trait i.e., heterozygotes.

Dietary manipulation is presently effective in the management of certain inherited disorders such as galactosemia. Galactosemic children are unable to metabolize galactose. Hence a galactose free diet (milk-free) is needed. A number of genetic disorders are also due to missing enzymes. Therefore, therapy with the missing enzymes offers great promise in the case of number of disorders. This is known as *enzyme therapy.*

Check Your Progress

Inherited diseases could arise as a result of

a) Chromosomal defect

b) Mutations in the genes

c) Either one of the above reasons

d) None of the above reasons

14.5 ORGAN TRANSPLANTATION

Organ transplantation often involves the removal of a defective organ of one individual and its replacement by grafting a healthy organ from another individual. It is only since 1950 that significant progress has been made in this field. Today it is very common practice to replace the damaged cornea of the eye or a malfunctioning kidney with a healthy one from a donor. Organ transplantation of the heart, liver, lungs are also increasingly popular. Blood transfusion is of course the commonest form of tissue replacement which every one has heard of.

The success of organ transplantation would depend mainly on overcoming the recipient's immunologic reaction against it. At the same time the individual's own defensive mechanisms should not be seriously impaired. The donor organ should have as close a genetic similarity as possible to the recipient identified. Therefore tissue matching is performed prior to organ transplantation. Invariably organ transplantation is followed by treatment with drugs to suppress the immunological reaction.

Check Your Progress

Define organ transplantation.

14.6 BIOMEDICAL ENGINEERING

The application of engineering techniques and thinking in the study of biology and working of the human body may be defined as bioengineering. Biomedical engineering may be described as the application of bioengineering techniques to medicine. With the advent of modern electronics, biomedical engineering devices have become important and essential in medical practice. Some of the common measuring devices are electrocardiogram recording unit and the electroencephalogram recording device. The most important biomedical engineering devices are the so called prosthetic devices. These serve as substitutes for missing or damaged parts of the body. In fact the common hearing aid may be considered as a typical prosthetic device.

One of the best known prosthetic devices and the greatest life saving one is the artificial cardiac pacemaker. The natural pacemaker that regulates the rate of a healthy heart is a small piece of a specialized heart tissue in the left auricle of the heart. It supplies the blood in the right quantity and at the right pressure to various parts of the body as needed. The impulses of the natural pacemaker spread throughout the auricles stimulating the muscles and bringing about contraction in the correct sequence leading to an efficient pumping action. The artificial cardiac pacemaker supplies stimulus directly to the ventricles and maintains adequate blood circulation. Thus patients with several forms of diseased heart condition are able to lead more or less a normal life with the aid of an artificial pacemaker.

For certain surgical operations it is required temporarily to stop or disconnect the heart from the circulation. Such operations therefore require the heart-lung machine.

Great progress has also been made in the field of limb prosthetic devices. A large number of biomedical engineering devices are available now. The foregoing brief description of some such devices is meant only to emphasize the importance of the bioengineering technology in medical practice.

Check Your Progress

Define biomedical engineering. Name few common biomedical engineering devices used in the present day medical practice.

14.7 SUMMARY

1. The application of chemical and biochemical techniques to study of the diseases in man is called clinical biochemistry. This helps in the detection, diagnosis, treatment, prevention of diseases.

2. Blood, urine, cerebrospinal fluid and certain tissues are used for biochemical analysis. The appearance of glucose in urine indicates diabetes. Lipid analysis of blood and separation of proteins in blood are useful in the diagnosis of certain heart diseases and arthritis. Urine analysis reveals the state of kidneys. The determination of enzyme concentration in urine is important in clinical biochemistry. High concentration of the enzyme aldolase occurs in persons affected with polio, tetanus and muscular dystrophy.

3. The diseases which are passed on from one generation to another are called inherited diseases. There are about 250 inherited disorders. These are two types.

   1. The diseases occurring due to the defect in chromosome number.

   2. The diseases occurring due to mutations in chromosomes.

4. The example of the inherited diseases are Down's syndrome, Haemophilia, Sickle cell anaemia, Thalassemia, Phenylketonuria, Albinism, Gout, Galactosemia etc. The chromosomal aberrations are due to hazardous radiation and chemicals.

5. Inherited disorders cannot be cured. So they must be diagnosed immediately after birth to take much care of the affected individuals. It is also important to identify the persons who are the carriers.

6. Dietary manipulation is important in the management of certain inherited disorders. For example, the galactosemic children cannot synthesize galactose. So they should be given diet with out galactose (i.e., without milk). Most of these diseases are due to the absence of enzymes in their body. So these patients can be treated with the missing enzymes. This is known as enzyme therapy.

7. The replacement of a defective organ of one individual with a healthy organ of another individual is called organ transplantation. The transplantation of the cornea of the eye, the kidney, the heart, the liver and the lungs are of common practice. The donor and the recipient must have a close genetic similarity for a successful transplantation.

8. The application of engineering techniques to the study of biology and human body is called bioengineering and to the study of medicine is biomedical engineering. Some biomedical engineering devices which are popularly used now are the electrocardiogram recorder, the electroencephalogram recorder, the common hearing aids, the artificial heart pacemaker, the heart-lung machine, the limb prosthetic device etc.

14.8 TERMINAL EXAMINATION MODEL QUESTIONS

Answer the following in about 30 lines.

1. Describe briefly the role of clinical biochemistry and biomedical engineering in medicine.

2. What are inherited disorders? Describe their diagnosis and treatment.

Answer the following in about 15 lines.

1. Give a brief account on clinical biochemistry and its role in medicine.
2. Mention five important inherited diseases along with their effects.
3. What is organ transplantation? Under what conditions will it be most successful?
4. Describe briefly about biomedical engineering and its significance.

14.9 GLOSSARY

1. Pacemaker : An electric device implanted in the chest wall to regulate heart rythms by means of electrical impulses.
2. Prosthetic Device : The supplying of an artificial part of the body to replace one which is deficient or absent.

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U.G. Foundation Course I Year

Science & Technology

ASSIGNMENT NUMBER - 1

N.B:

1. Do not copy the answer directly from any of the books.
2. As far as possibly try to answer the questions independently in your own words.
3. If it is necessary to quote from any source give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment normally should not take more than an hour's time.

Section - A

Answer any one question out of the two questions given in this section.

Answer should be in about 30 lines.

Q.1. Describe the structure of Living cell.

Q.2. What are the important achievements of Palaeolithic men that led to the development of Science and Technology?

Section - B

Answer any **2** questions out of the **4** questions given in this section.

Answers should be in about 10 lines.

Q.1. What is modern scientific revolution?

Q.2. Write a brief note on industrial carbon compounds.

Q.3. What is biochemistry and briefly explain its significance?

Q.4. What are molecules of life? Explain.

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Science & Technology

ASSIGNMENT NUMBER - 2

N.B:

1. Do not copy the answer directly from any of the books.
2. As far as possibly try to answer the questions independently in your own words.
3. If it is necessary to quote from any source give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment normally should not take more than an hour's time.

Section - A

Answer any one question out of the two questions given in this section.

Answer should be in about 30 lines.

Q.1. What are the major biomolecules and briefly mention their salient features?

Q.2. Write briefly about evolution and heredity.

Section - B

Answer any **2** questions out of the **4** questions given in this section.

Answers should be in about 10 lines.

Q.1. Write a brief note on internal structure of living animal cell.

Q.2. What are the important contributions of chinese to biology and medicine.

Q.3. Write briefly about the atoms and molecules.

Q.4. Illustrate different properties of light.

SCIENCE AND TECHNOLOGY - A FOUNDATION COURSE : SYLLABUS

Unit-1	Science - A Human Endeavour
Unit-2	Science and Technology in Ancient Times
Unit-3	Science and Technology in Medieval Times-1
Unit-4	Science and Technology in Medieval Times-2
Unit-5	Modern Scientific Revolution
Unit-6	Electricity, Light, Magnetism, Electromagnetism
Unit-7	Semi Conductors and Electronics
Unit-8	Atoms, Molecules and Compounds
Unit-9	Industrial Carbon Compounds
Unit-10	Molecules of Life
Unit-11	Living cells and Tissues
Unit-12	Evolution and Heredity
Unit-13	Human Body and Regulatory Systems
Unit-14	Clinical Biochemistry
Unit-15	Our Universe
Unit-16	Land, Water, Air
Unit-17	Ecosystems and Biodiversity
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Unit-19	Agriculture and Population
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Unit-21	Health and Disease
Unit-22	Food Production and Preservation
Unit-23	Natural Resources and Energy
Unit-24	Space and Satellite Technology
Unit-25	Biotechnology
Unit-26	Science, Technology, Quality of Life and Options of Choice

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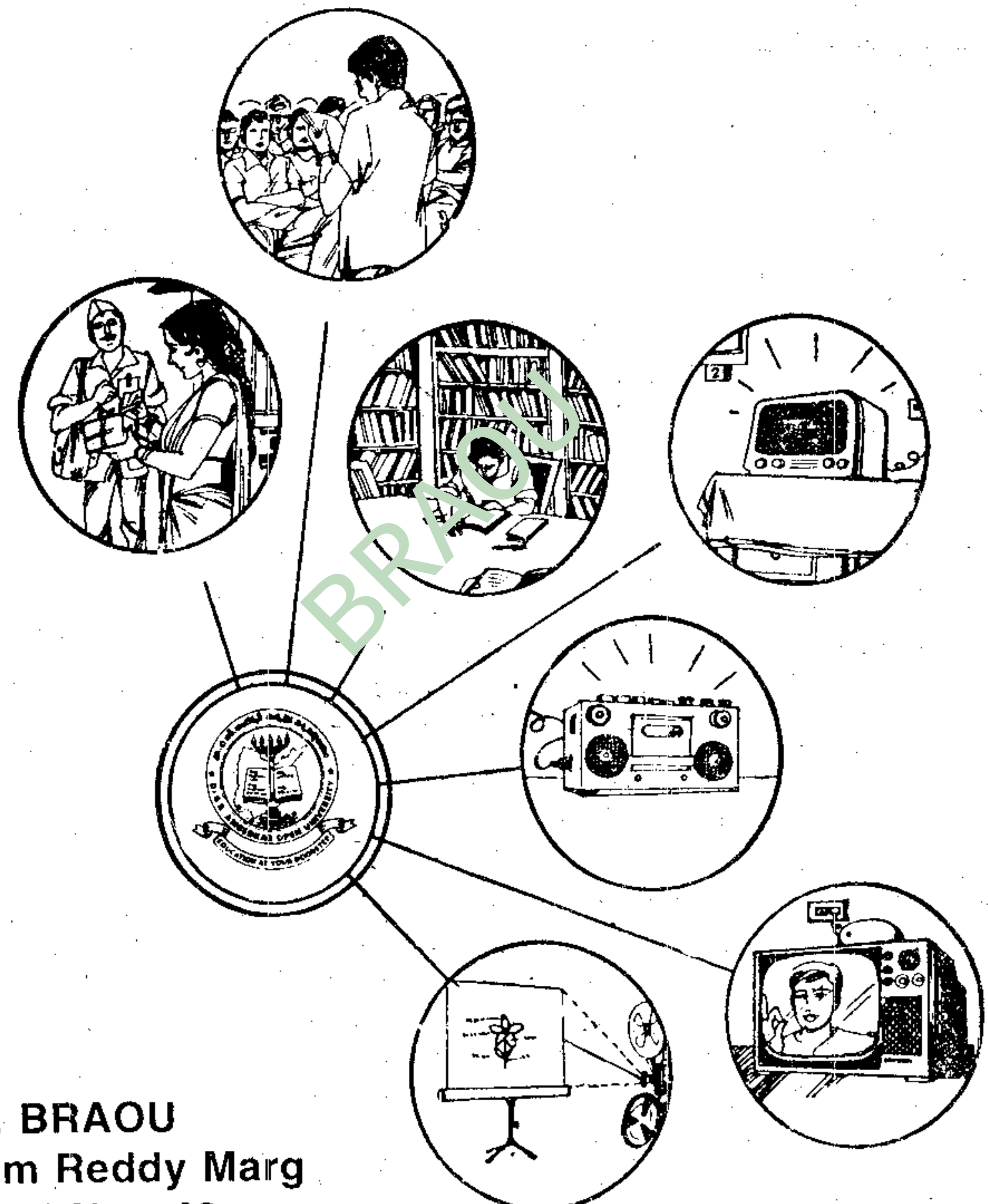

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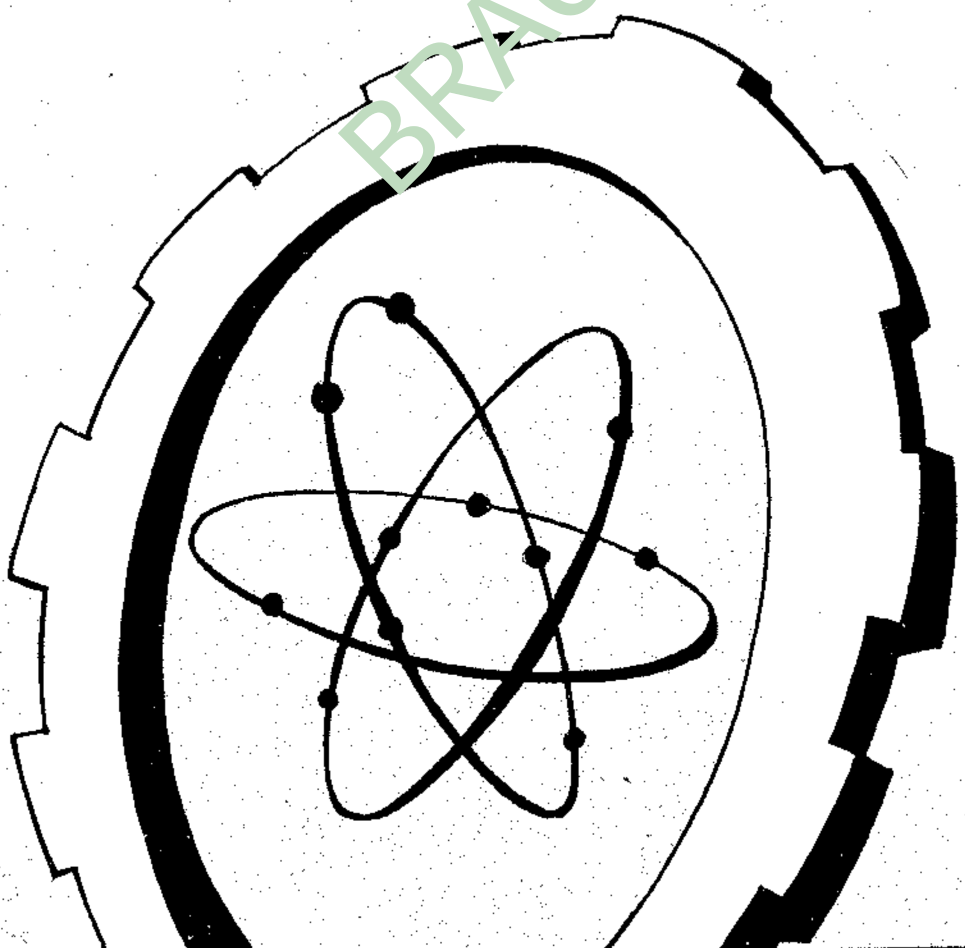

SCIENCE AND TECHNOLOGY
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BLOCKS IV — VI

Block IV Environment and Ecology
Block V Food and Nutrition
Block VI Future of Humanity

Dr. B.R. AMBEDKAR OPEN UNIVERSITY
HYDERABAD
2003

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PREFACE

What is Science? In the earlier years, science was regarded as natural philosophy. Science is characterised by the experimental method and by the use for the purpose of and distinguishing truth from error. The progress of science since the 18th century has been phenomenal. While pure scientific inquiry provides basic fundamental knowledge, it is often applied to technical practice. Such applications go under the label 'technology'. Science and Technology have come to exercise, with the passage of time, an increasing influence which has had the effect of refining the quality of human existence. It is, therefore, necessary for one living in modern world to cultivate a scientific attitude of mind and appreciate the innumerable benefits that science and technology could confer on mankind. It is for this reason a Foundation Course on Science and Technology is included in the Undergraduate Programmes of this University. The aim of the Foundation Course on "Science and Technology" is to acquaint the student with the concepts of science and major scientific developments in order that he may become aware of the extent of scientific development.

The first Block of this course provides a profile of the growth of science and technology during prehistoric times, the discoveries made in science and technology by major ancient civilizations and finally the developments during the scientific revolution which took place between the 16th and 19th centuries. The other five blocks acquaint the student with basic developments in different branches of science, the many useful discoveries made for the benefit of man, and also questions relating to medicine, food, the environment and the 'Future of Man' are discussed. A brief account of India's scientific progress made in major basic and applied fields of science are mentioned at appropriate places.

The six blocks of this course are divided into 26 units. Each Unit starts with a statement of its **aims** and **objectives**. At the end of each Unit the examination model questions and a glossary of unfamiliar words or terms are given.

It is hoped that the student who takes this course will gain an understanding of the scientific and technological enterprise of man, the benefits that science and technology conferred on man and also the great progress made therein by our own country.

CONTENTS

BLOCK-IV ENVIRONMENT AND ECOLOGY

You study in this block about the historical aspects of **universe,** the **solar system** and our galaxy, the **milky path, earth's atmosphere** and **environment.**

You will realise after you completed this block that a clean environment will ensure a healthy life and that an healthy life gives you a wealthy living. You all learnt even in your early days from your parents that "Health is Wealth" and that 'Cleanliness is next to Godliness.

You also learn in this block about our natural resources and how these resources are either over exploited or misused by human community. You must discipline yourself and plan an environment friendly life to avoid the ill-effects caused by environmental degradation and pollution. The block is subdivided into 4 units as follows.

Unit 15 Our Universe
Unit 16 Land, Water, Air
Unit 17 Ecosystems and Biodiversity
Unit 18 Pollution and Health Hazards.

After you completed the block you must be able to

1. understand clearly our universe, our planetary system and our earth and earth's environment.
2. know that all forms of life including man are dependent on their environment which is composed of living and non-living things.
3. identify the sources, causes and ill effects of different types of pollution.
4. list out the natural resources, their importance and how these are undesirably exploited.

We are sure that if you carefully read the unit and understand the importance of a clean environment for an healthy living, you will not only keep your environment clean but force your neighbours also to do the same. "Clean and green" is essential for healthy and wealthy life.

UNIT 15 OUR UNIVERSE

Contents

15.1 AIMS AND OBJECTIVES

Aims

This unit aims at giving you a brief account of our universe in respect of

1. the historical perspectives about the universe
2. the views and the laws governing the arrangement and movements of the planets
3. some important features of the sun, the earth, the stars, the constellations, and the galaxies, the atmosphere and the other related spheres of the earth.

Objectives

After you completed this unit you must be able to

1. understand the perspectives the primitive man had about the universe and its composition.
2. explain the laws of motion of the planets around the sun.
3. know the important features of the stars, the constellations and the galaxies.
4. understand clearly the Milky Way and our Solar system etc.,
5. have an insight into the structural aspects of the sun, the earth, and the atmosphere.

15.2 INTRODUCTION

Life in a very real sense is a part of the universe and is closely related to it. Life is the most complex but yet an ordered state of organisation that matter has achieved in our universe. To answer the questions relating to the origin of life on the earth, we must

SCIENCE AND TECHNOLOGY
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UNIT 15 OUR UNIVERSE

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15.1 AIMS AND OBJECTIVES

Aims

This unit aims at giving you a brief account of our universe in respect of

1. the historical perspectives about the universe
2. the views and the laws governing the arrangement and movements of the planets
3. some important features of the sun, the earth, the stars, the constellations, and the galaxies, the atmosphere and the other related spheres of the earth.

Objectives

After you completed this unit you must be able to

1. understand the perspectives the primitive man had about the universe and its composition.
2. explain the laws of motion of the planets around the sun.
3. know the important features of the stars, the constellations and the galaxies.
4. understand clearly the Milky Way and our Solar system etc.,
5. have an insight into the structural aspects of the sun, the earth, and the atmosphere.

15.2 INTRODUCTION

Life in a very real sense is a part of the universe and is closely related to it. Life is the most complex but yet an ordered state of organisation that matter has achieved in our universe. To answer the questions relating to the origin of life on the earth, we must first of all know about the origin of the planet earth itself and the changes it had undergone in the course of millions of years. We expect that after studying this unit you must be able to understand that the universe is a system with its own characteristic structure and the constituents. You would realise after you completed the unit that the earth is unique amongst the planets known to us. The earth possessed an environment which is most congenial for the life to exist on earth. The life on the earth is surviving due to the existence of the various spheres namely the atmosphere, the hydrosphere and the lithosphere surrounding the earth. Probably, but for these spheres and the different **material cycling processes,** that are taking place, in these spheres, life on this planet would not have survived and developed to the present day level.

The scientific method has helped us unravel many mysteries of nature. The origin and evolution of universe is one of them. In the last hundreds of decades many discoveries were made about the universe. But significant and unexpected discoveries have been made only in the recent times. Probably discoveries made in the twentieth century are note worthy. In this respect modern science has revealed to us a vast and ancient universe.

In this unit you will know how our views and understanding of the universe had progressed in a systematic fashion through the ages. You also understand what the current perceptions about the universe as a system are. A brief description about the physical universe, namely the objects that constitute the universe is also presented in this unit. Our present understanding of the universe is a result of the scientific investigations carried out by us by modern sophisticated scientific instruments together with the space explorations conducted using the various probes.

15.3 HISTORICAL PERSPECTIVES OF THE UNIVERSE

The primitive human beings depended mainly on **food gathering** and **hunting** for their survival. Therefore they were searching for suitable seasons for performing these tasks of food gathering and hunting. They realised in this context that the seasons depended on movement of the sun and the stars. Thus they understood that the sun and the stars controlled the seasons, food and warmth, the essential things for the survival of man. They also understood that the moon's motion controlled the formulation and course of tides in the ocean and eventually the life cycles of many animals. Therefore primitive man was interested in knowing about the **rising** and the **setting** of **the sun,** and the **waxing** and **wanning** of the **moon.** This definitely tells us that even the primitive man knew about the positions and the movements of the sun, the moon and the stars. From this they could reliably and accurately fix the seasons and the timings for hunting the animals and gathering the food from them. Their survival actually depended on their ability to know these 'calenders'. Bone engravings estimated to be about 30,000 years old depicting the phases of the moon were found in many caves. With the passage of time "human thought grew" and improved. Between 600 and 400 BC a great revolution began in human thought. Philosophers in many societies tried to understand the universe as a physical system without invoking the intervention of gods. They observed the world around them and tried to seek answers to questions such as

1. Why did the sun rise ?
2. Why did the moon change its shape ?
3. Why only few stars move amongst all others?

They could give their own answers to these questions based on the results of the experiments conducted by them with the primative tools and experimental techniques available with them. But their theories could not for a long time progress beyond "**an earth centred planetary system.**"

Geocentric system or Ptolemic System

The earliest ideas of Egyptians and Sumarians about the universe are strange. Earth was considered by them as a flat solid. This idea of flat earth was discovered by the Greeks. It was only 600 BC the philosopher **Thales** considered the earth to be round. **Pythogoras** and his disciples also proposed that the earth was spherical. This conclusion was reached by them on the basis of the fact that a circular shadow was cast by it on the moon during the eclipse. Greek astronomers could map the star constellations and even estimated the brightness of the stars. The model given by the Greeks to the universe contained a stationary earth at it centre. This is known as the **Ptolemic system.** The models constructed by the Greeks to explain the movements of planets consisted of perfect concentric spheres or circles.

'Planet' means in Greek a "wanderer". They proposed that each planet was attached to an invisible circle that rotated round the earth at a speed which is different from the speeds of the rest of the spheres. For example Eidoxus model contained 27 spheres. Ptolemy gathered all the astronomical ideas of many earlier Greeks and published them in his **almagest.** This combined picture of the universe in known as **Ptolemic system.**

Figure 15.1 Ptolemic system

Aristarchus of Samos however argued that the earth was one of the several planets and that this orbits round the sun, which was at the centre of the universe. He also pointed out that the sun was much bigger than the earth and the stars were enormously far away. But it was not clear how he got these ideas and later these ideas were found correct. The Ptolemic model of the **geocentric universe** stayed there for over 1000 years. But the 15th century scientists especially the european astronomers built observatories and improved the Ptolemy's instruments and devised the new ones also. The observations made with these instruments clashed with the Ptolemy's theory and Ptolemy's theory suffered a set back.

European astronomers started examining the ancient Greek knowledge of the universe. A polish astronomer **Nicholas Copernicus** reexamined the long neglected sun-centred theories of the universe. In 1543 he proposed the new model to explain the apparent motion of the planets. The most striking feature of the model was that the sun, not the earth, was at the centre of the universe.

The Copernican model

This copernican model consisted of the sun at the centre with the six planets, **Mercury, Venus, Earth** with Moon, **Mars, Jupiter,** and **Saturn** revolving round the sun in circular orbits. Copernicus also believed that all the planets are of the same size. This model was not accepted generally for a long time. But Galileo's and Kepler's works at a later date gave support to this **helio-centric model.**

Figure 15.2 Copernican model

Check your Progress

1. The model which assumed that earth is at the centre of the planetary system is?

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2. The model which considered the sun at the centre is known as -

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3. The scientist who said that the sun is at the centre of the planetary system is?

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4. For how many years Ptolemic model was in existence?

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15.4 KEPLER'S LAWS OF PLANETARY MOTION

The helio centric model of Copernicus received further support from the laws proposed by **Johannes Kepler** at around the same time as Galileo's observations. Kepler was a German astronomer. He was trying to propose a theoretical model which can explain all the observations of planetary motion. At that time **Tycho Brahe** *could* make the most accurate observations of the apparent planetary positions. So Brahe invited Kepler to work with him. Brahe found the motion of mars to be anomalous. Kepler also found that the speeds of the planets changed with their distance from the sun. Therefore it was a big task for Kepler to propose the laws of planetary motion which can explain the above facts.

Kepler's laws of planetary model are based on the observations of the movements of planets around the sun . These laws state that

1. The planets move in eliptical orbits (not circular orbits) around the sun and the sun is at one of the two foci.

2. A planet sweeps out equal areas in equal times.

3. The square of the period of revolution T^2 of a planet round the sun is proportional to the cube of its mean distance R^3 from the sun. $T^2 \alpha R^3$ These laws helped to reject the Pythagorean and Ptolemic views of the heavenly bodies showing perfect circular motion.

By the end of the seventeenth century, the helio-centric model of the universe was accepted generally.

15.5 STARS AND CONSTELLATIONS

Stars

For a long time stars were considered as point sources of light coming from the solar system. **Herschel** in 1785 for the first time showed that the stars were not the back drop to the solar system but were individual objects that extended to infinity. Further among the Galileo's many discoveries with the telescope, his observation that the nebulous band in the sky namely **"Milky Way"** was made up of many stars was an important one. Herschel proposed for the first time a map of the **Milky Way galaxy** and showed that it was a flat disc of countless stars. In his model the solar system was situated within the Milky Way Galaxy.

Constellations

The night sky is very interesting. The stars appear in specific patterns. The sky is divided into these patterns of stars or star groups. These star groups or star patterns are known as **constellations.** A constellation is an orbitrary grouping of stars. It defines a specific area of the sky. All cosmic objects in a given area of the sky form a constellation. Eighty eight constellations each having a definite boundary were identified. Modern astronomers use the ancient names of these constellations and not the imaginary figures of long ago. You can see in the figure 15.3 the star charts of bright stars and constellations visible in the northern and southern hemispheres.

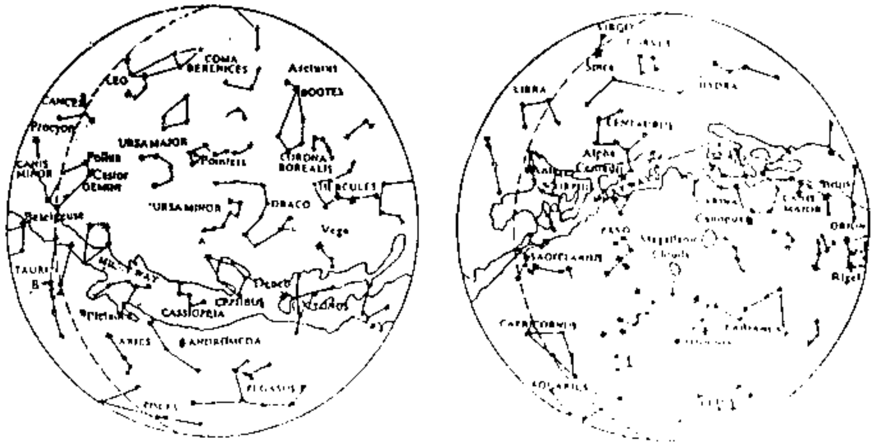

Figure 15.3 Star charts of hemispheres
(a) South (b) North

The stars and the constellations help navigators. In ancient times the sailors could determine the latitude of the ship by watching the position of the constellations with respect to horizon. Of all the stars, **pole star** is the most important ("**Druva**"). It is a bright star situated in the north almost on the earth's axis of rotation. Its position gives the geographical north. As earth revolves round the sun, constellations appear, disappear and reappear at different times of the year. Different constellations appear prominant in different seasons.

15.6 GALAXIES, THE MILKY WAY

Galaxies

An enormous collection of gas, dust and billions of stars is known as **galaxy.** There are millions of galaxies in the sky. On the clear nights we see a glorious white band stretched across the sky . This is known as **Milky Way.** It is a big galaxy. The solar system and all the stars that we see in the sky belong to the Milky Way galaxy.

The Milky Way

The white band stretched across the night sky is a partial view of the Milky Way galaxy. Because our star system is in this galaxy. We can see the galaxy only in parts. We can not see the whole of it. Of course we can see other galaxies in a different way. Form the telescopic observations made on the Milky Way from different positions scientists have been able to form a picture of what our galaxy must look like from out side. The observations made about the stars in our galaxy, in respect of the distances and motion also helped the scientists to visualise the shape of the galaxy. The pictures of the galaxy constructed by the astronomers in this way are shown in the Figure 15.4

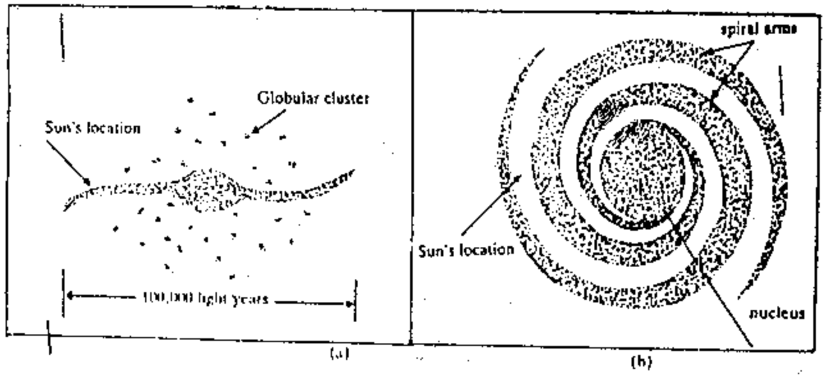

Figure 15.4 The Milky Way galaxy
(a) Edge-onview (b) Face-onview

It looks like a disc with a swollen centre. This galaxy contained about 100 million stars. The stars are not uniformly distributed. If the galaxy is observed from the top, we get the face-onview (15.4b). If we look at it from the edge, we get the "edge-onview" (15.4a) In the edge on-view there are two parts. The disc and the halo. The disc consists of stars, clouds of gas and dust called nebulae. Its diameter is 100,000 light years and its thickness in 5000 light years (one light year is the distance travelled by light and is 300,000 x 60 x 60 x 24 x 365 km. The speed of light is 300,000 km/second).

Astronomers have identified about 1000 galactic clusters in the disc. Each cluster contains 10 to 1000 stars. The disc of the galaxy contains spiral arms which are 2,500 light years wide. The spiral arms are seen clearly because the brightest stars and the gas clouds are found here. The sun lies between the two spiral arms. The halo is spherical and has its centre at the nucleus of the galaxy. The central region consists of large number of stars. The halo does not rotate along with the disc. The sun is not at the centre of the Milky Way galaxy.

Check your progress

1. What is Milky Way ?

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2. How many light years are apart the spiral arms of the Milky Way ?

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3. What is the halo of the Milky Way ?

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4. What is the value of one light year ?

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5. What is the shape of the Milky-Way ?

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6. How many million stars are there in the galaxy ?

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15.7 OTHER GALAXIES

If we venture into space beyond, moving away from the earth, we find a large number of faint, wispy tendrils of light. These are all galaxies. These galaxies are too made up of billions of stars and clouds of gas and dust. Thus the universe is full of galaxies only. Most of them move in clusters. The galaxies are usually found in three shapes. These are **spiral** galaxies, **elliptical** galaxies and **irregular shaped** galaxies (Fig 15.5)

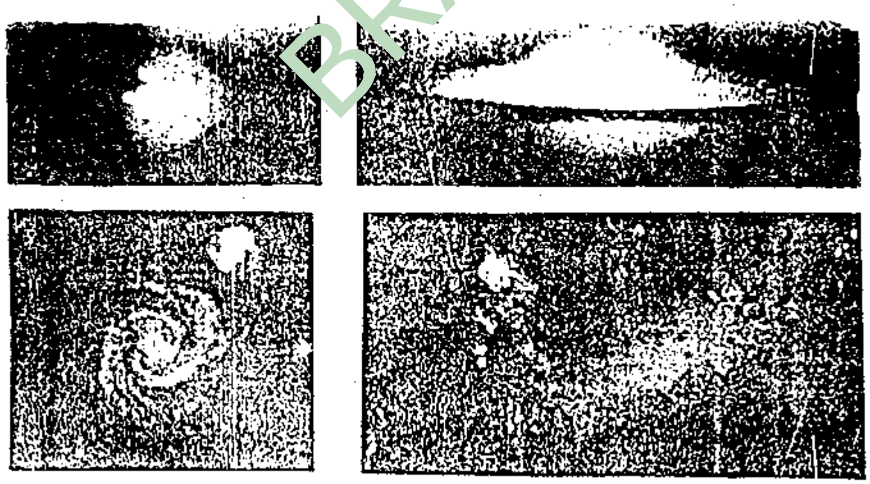

Fig 15.5 Shapes of some galaxies

Elliptical and spiral galaxies are found to occur in almost equal numbers. Irregular shaped ones are only 10% of all the galaxies. The galaxy **Andromeda** lies nearly two million light years away and can be seen with naked eye. It is a spiral galaxy, three times bigger and lighter than the Milky Way. There are many clusters of galaxies. There are some hundreds of millions of galaxies in the universe. There are rich clusters and poor clusters. Rich clusters contain ten thousand galaxies, poor clusters contain only a few galaxies. Our galaxy, Milky Way is a member of the poor clusters. Virgo is the nearest richest cluster. It is at a distance of 10 million light years. It is irregular in shape. There are also super clusters or super galaxies. They may contain 100 clusters. The clusters

Local Group and **Virgo** are members of the same super cluster. The universe is not static. It is changing. New stars and new galaxies are being born. Stars, galaxies and clusters move. They may collide to give new galaxies. Thus this universe is unimaginably big and dynamic.

Check your Progress

1. What are the other types of galaxies present in the universe besides the Milky Way ?

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2. What are clusters and super clusters ?

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15.8 THE SOLAR SYSTEM

Our knowledge of the universe and stellar evolution is rather imperfect. However one tiny part of the vast universe which we know much better is the Solar System. Our planet earth is a part of the Solar System. In this section we will try to know about this Solar family and the characteristics of its members and also about the formation of the Solar System. With in the Solar System we know more about the earth and its satellite, more than its other members.

At night we see many stars in the sky. But during the day, only one star is visible. This is the Sun. It is the star close to us. The **Solar System** consists of nine planets including the earth, their satellites, asteriods and comets. According to the increasing distance from the Sun, the planets which go around the sun can be listed as Mercury (Buddha), Venus (Sukra), Earth (Prithvi), Mars (Mangal), Jupiter (Brihaspati), Saturn (Shani), Uranus (Arun), Neptune (Varun) and Pluto (Yama).The arrangement of these planets around the sun in their respective orbits is known as the Solar System. This is shown in the figure 15.6

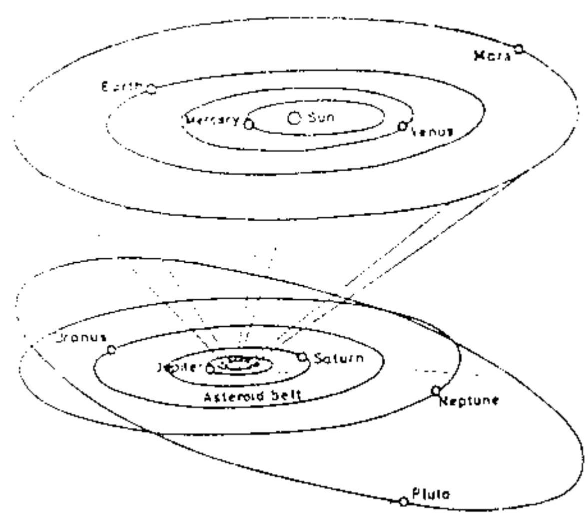

Figure 15.6 The planetary system - Solar system

All the planets and asteroids and some comets revolve round the sun in eliptical orbits. Of the nine planets. Jupiter, and Saturn are the most massive accounting for 92% of the mass of all planets. Planets do not generate their own light, like the sun does. The planets are not self luminous bodies. But the sun light falls on these planets and hence the planets shine. Mercury reflects less light. Moon appears very bright because it is very near to the earth.

All planets except venus and uranus rotate on their own axes in the anticlockwise direction. Therefore on these planets the sun rises in the east and sets in the west like on the earth. But on venus and uranus the sun rises in the west and sets in the east because these planets rotate on their axes in the clock-wise direction. Mercury, Venus, Earth and Mars are known as the inner or terrestrial (earth-like) planets. Jupiter, Saturn, Uranus, Neptune and Pluto are the outer or Jovian (Jupiter-like) planets. The inner planets consist mostly of metals and rocks. Their density is 4-5 g/cm^3. Inner planets are mostly gaseous with an average density of 1-2 g/cm^3.

Check your Progress

1. What is the position of the earth in the Solar System ?

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2. Why the moon appears very bright ?

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3. On venus the sun rises in the............ and sets in the........................

15.9 THE SUN

The sun is the most important star as far as the earth is concerned and all of us are concerned. It is the only star close enough to be studied in great detail. The sun is very big. Its diameter is 110 times that of the earth. The mass of the Sun is about 2 x 10^{33} g. Thus sun is 30,000 times heavier than the earth. The average density is 145/cm^3. The sun rotates about its axis once every 25 days. Dark patches appear on the surface of the sun. These dark patches are called **sunspots.** A sunspot consists of gases about 1000^{o}C cooler than those surrounding the area. The number of sunspots increases and decreases in a cycle every 11 years.

Structure

The sun's body is made up of several layers. The visible surface layer of the sun is called **photosphere.** It is an important surface because it demarcates the body of the sun and its atmosphere. The temperature of photosphere is about 6000°C. The innermost layer of the sun is called the **core.** The energy of the sun is produced in this layer only through nuclear reactions. There are many other layers between the core and the photosphere. Solar atmosphere too has sever layers. The outermost layer of the sun's atmosphere is called the **corona.** The photosphere is very bright and brilliant. Hence in the brilliance of photosphere, corona can not be seen. But during a total solar eclipse,it can be seen in its full brilliance. The corona extends all the way upto the earth's orbit and beyond.

Solar Wind

The rapidly moving stream of charged particles is called the **Solar Wind.** About one million tons of material is removed every second from the sun in the form of solar wind. These charged particles react with the atoms of the earth's atmosphere to produce northern lights called **aurora borealis** at North Pole and the southern lights **aurora australis** at the South Pole.

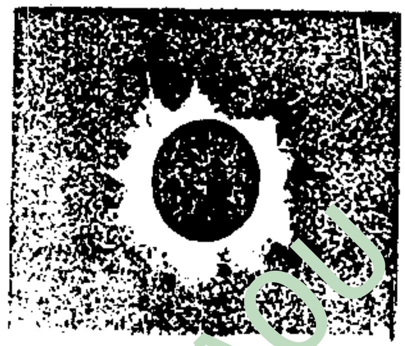

Figure 15.7 Sun's Corona

Check your Progress

1. What is solar wind ?

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2. What is corona of the sun ?

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3. What is photosphere ?

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4. What is the maximum temperature of the sun ?

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15.10 THE EARTH

The earth is our planet on which we all live. Seen from space, it appears as a bluish - white sphere. The earth is a very beautiful planet with lot of plant and animal life. Many snow covered mountains, blue oceans and white clouds make the planet appear very beautiful. Earth has been explored extensively. A thin shell of rock and water extending to a few kilometers below the surface and the atmosphere above the surface also extending to a few kilometers have been investigated in detail by direct methods. Scientists were also able to picture the earth's interior without ever seeing it by indirect methods. Earth's atmosphere has been studied as indicated earlier thoroughly. These results are presented in 15.10

Structure of the Earth

The structure of the earth which consists of rocks and minerals was one of the great challenges the modern scientific investigators have been facing. Man, even though he was able to land on the moon, he was unable to probe the body of the earth beyond a depth of a few kilometers. However **seismology,** a branch of geology which deals with earthquakes provided some useful information about the density, rigidity and compressibility of the rocks. This information helped scientists in knowing the interior of the earth. During the earthquakes, the vibrations are given out in the form of waves. These are known as seismic waves. These waves are of two types (1) the body waves and (2) the surface waves.

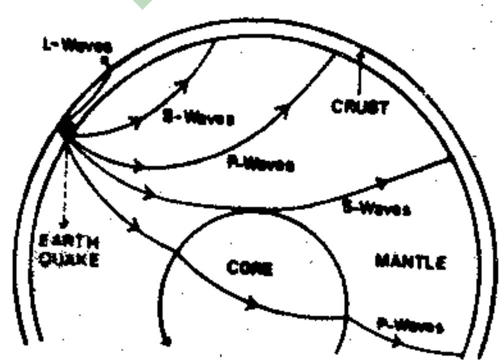

Figure 15.8 Earth-quake waves

Body waves originate below the earth surface. These are further classified into two types (i) primary waves or 'P' waves and (ii) secondary waves or 'S' waves. Primary waves can travel through solids, liquids and gases. Secondary waves can travel only through solid media.

The surface waves originate at the surface. The surface waves consist of long waves or 'L' waves. These can travel on the surface only. Based on the study of the nature of these waves, earth has been divided into three layers. These are (a) **crust** (b) **mantle** and (c) **core** as shown in the figure 15.9.

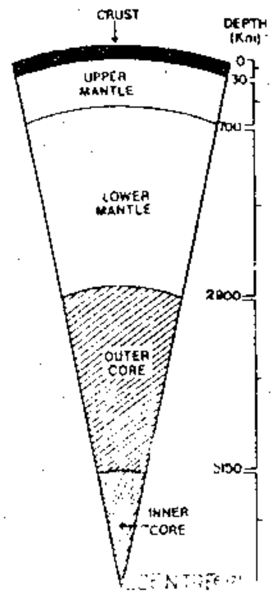

Figure 15.9 Layers of the Earth (Internal Structure)

The **crust** is the uppermost layer of the earth. This extends down to a depth of 35 kms beneath the continents and to 10 km beneath the sea level in oceanic regions. At the end of the crust P & S waves showed an abrupt increase in velocity. This is because they entered a denser layer known as **mantle**. This **crust - mantle** boundary was first discovered by an Yugoslov Scientist, **Mohorovicic.** Therefore this discontinuity was named as **Moho** or **Mohorovicic** discontinuity.

The **mantle** or the middle layer is composed of ultrabasic rocks. These rocks essentially consisted of ferromagnetic materials or minerals (minerals contaning Fe and Mg)

These rocks extended down to the boundary of the core or to a depth of about 2,900 kms. This layer records the presence of P and S Waves. This suggested that the mantle is solild. The **mantle - core boundary** was discovered by the geophysicist, **Guttenberg.** This discontinuity is therefore called **Guttenberg discontinuity.**

The **core** extended from 2,900 kms to 6,371 kms (upto the centre of the earth). The core consisted of two layers. These are **outer core** and **inner core.** The outer core extends from 2,900-5,750 kms. It may be a liquid because of the absence of propogation of 'S' waves. There was also a sudden increase in the velocity of 'P' waves at 5,150 kms. This gave an evidence that the inner core is a solid. The inner core extended from 5,150 - 6371 kms. The composition of the core is commonly known as Nickel - Iron (Ni - Fe)

Check your Progress

1. Give the different parts of the earth.

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2. How is the structure of the earth determined ?

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3. What are S, P, waves ?

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4. What in seismology ?

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15.11 THE ATMOSPHERE AND THE OTHER SPHERES

During its long history earth had acquired a layered structure in and around itself consisting of **atmosphere, hydrosphere** and **lithosphere.** We shall discuss briefly about these spheres, their composition and their usefulness to the life on the earth.

The Atmosphere

Atmosphere is the cover of air consisting a mixture of gases around the earth. It is present roughly upto 1000 kms above the earth's surface where it merges into space. It is a mixture of gases of which nitrogen is 78.08%, oxygen is 20.9%, argon and carbondioxide are just less than 1%. The rest of the gases are present in traces. A considerable amount of water vapour evaporating from oceans lakes and rivers is also present in the atmosphere. The density and the temperature of the atmosphere change with increase in the height of the atmosphere. The physical nature of the atmosphere is different at different heights. The atmosphere is thus layered as shown in the figure 15.10.

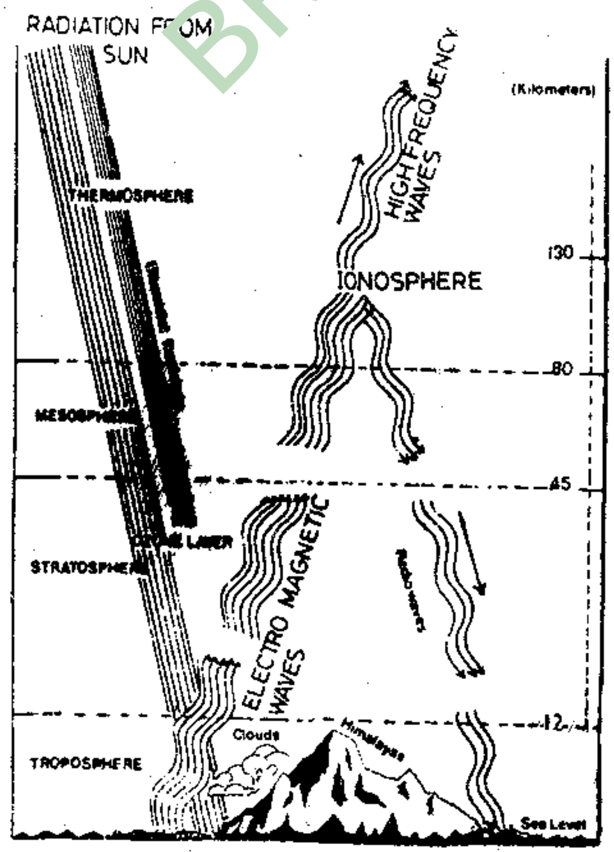

Figure 15.10 The atmospheric layers

At about 4000 metres it is difficult for man and many other animals to survive without supplly of additional oxygen.

The lowest layer from the earth's surface is the **troposphere.** This extends to a height of about 12 km, This troposphere is the layer responsible for the weather on the earth. The source of heat for this layer is mainly sun's rays. The layer next to troposphere is **stratosphere.** This begins at a height of 12 km and extends upto about 45 kms. This layer at the top is also warmed up. But this warming is due to the ozone layer at the top. Ozone is a chemical substance like oxygen, but unlike oxygen its formula is O_3, formula of oxygen is O_2. This ozone layer at the height of 35 kms at the top of the stratosphere is a kind of great security blanket. It absorbs harmful ultraviolet rays from the sun and protects life on the earth. Above this stratosphere is the **mesosphere.** This extends from 45 - 80 kms and the temperature drops heavily in this layer. This layer can not transmit sound. From 80 kms onwards the **thermosphere** starts and it extends upto 400 kms.

This layer in many ways different from the other atmosphere layers. Ozone, carbondioxide and water are virtually absent. Here the atmospheric gases, particularly oxygen and nitric oxide split into atoms and also undergo ionization after absorbing solar radiation. This layer is therefore known as **ionosphere.** It reflects back the radio waves on to the earth. However the ionosphere does not reflect the short waves that are used to transmit television signals. The outer most layer of the atmosphere is known as **exosphere.** This extends from about 400kms into space.

The temperature of the atmosphere, varies from -[illegible]° c to a maximum of +1200° c. Some physical features of the major regions of the atmosphere are presented in the table 15.1

Table 15.1 Major regions of the atmosphere

Region	Altitude (kms)	Temperature 0° C	Important chemical species
Troposphere	0 - 12	15 to - 56	N_2, O_2, CO_2, H_2O
Stratosphere	12-45	-56 to -2	O_3
Mesosphere	45-80	-2 to -92	O_2^+, NO^+
Thermosphere	80-400	-92 to 1200	O_2^+ O^+, NO^+

Check your Progress

1. Give the different layers of the atmosphere.

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2. What are the temperature ranges of these layers ?

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Hydrosphere

Hydrosphere is defined as the water of earth's surface. This includes all types of water resources namely **oceans, seas, rivers, lakes, streams, reservoirs, glaciers, polar ice caps** and **ground water.** (water below the earth's surface)

Water is the most abundant substance in and on the earth. About 97% of the earth's water supply is in the oceans. About 2% is locked in the polar ice caps and glaciers, only 1% is available as fresh water for human use. There are rivers, lakes, streams and ground water sources. Water is also being recycled in nature (water-cycle) through its movements from oceans, lakes and rivers into the atmosphere and back to the ocean again due to rains. (see unit 16)

Lithosphere

Lithosphere is the solid portion of the earth which is present both on the earth surface and also at the bottom of the oceans. The earth is made up of rocks and minerals. The rocks are considered as combination of minerals, the naturally occurring chemical compounds of the metals. A mineral is an inorganic compound of known composition. More than 1500 different minerals have been identified so far. But about ten of these minerals occupy 99% of the area.

A rock is a naturally occurring mass, which is an aggregate of minerals usually two or more. The science of study of rocks is known as **Petrology.** Three major rock types are identified. These are (i) **Igneous** (ii) **sedimentary** and (iii) **metamorphic** rocks. The formations and the interrelations between these three types can be illustrated by a cycle known as Rock Cycle (Figure 15.11)

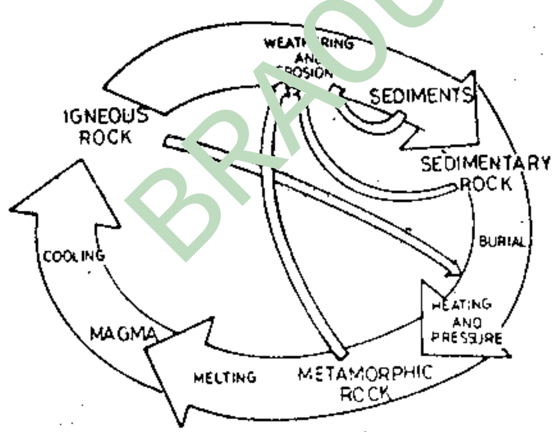

Figure 15.11 Rock Cycle

Igneous rocks : These are most abundant constituents of the earth's crust. These are the direct products of magma. Magma is molten rocky material available beneath the surface of the earth. These are classfied into **volcanic, hypabasal,** and **plutonic** rocks depending on the depth, temperature and pressure conditions encountered during their formations. The most common examples are Basalt, Dolerite and Granite.

Sedimentary rocks : The sediments formed in the erosion and the destruction of igneous or metamorphic rocks convert themselves into a new group of rocks. This group of rocks is known as **sedimentary** rocks.

Metamorphic rocks : The altered forms of pre-existing rocks are known as **metamorphic rocks.** The pre-existing igneous or sedimentary rocks when subjected to intense pressures and high temperatures are converted into new forms of rocks called metamorphic rocks. These rocks on deep burial give rise to magma (mother rock material). Thus a cycle is completed between the different types of rocks as shown in the figure 15.11.

Check your Progress

1. What are rocks?

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2. How many types are these rocks?

....

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3. How are these rocks interconverted ?

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4. What is lithosphere ?

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5. What is hydrosphere ?

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15.12 SUMMARY

In this unit we tried to present a picture of the universe as a system consisting of different planets, stars, constellations and galaxies. The earth is the most important planet of the universe on which life exists. Let us now summarise, what we have studied in this unit.

1. Prehistoric and the Bronze Age ancestors considered that the earth was at the centre of the universe or planetary system. This is known as geocentric system (Ptolemic model).
2. The Greak philosphers tried to understand the universe on the basis of observations, logic and reasoning. They gave many models which got absorbed into the Ptolemic model of the universe.
3. Galileo's observations and Kepler's laws of planetary motion based on the observations made by Tyco Brahe established the revolutionary heliocentric model (sun at the centre).
4. The sun was one of the millions of stars in the Milky Way and was located at a large distance from the centre of the galaxy.
5. The planets, stars, galaxies, clusters, and super clusters form a dynamic universe. This is always changing.
6. A galaxy contains, a group of millions of stars, and vast clouds of gas and dust called Nebulae.

7. The average galaxy is about 30000 light years in diameter.

8. The earth, our planet exists in the Milky Way whose diameter is 100,000 light years.

9. The galaxies have different shapes. These are spiral, ring and discs.

10. The recognisable patterns of collections of stars are called constellations.

11. The sun with its nine planets is called the solar system.

12. The planets of the solar system are
    Mercury (Buddha)
    Venus (Shukra)
    Earth (Prithvi)
    Mars (Mangal)
    Jupiter (Brihaspathi)
    Saturn (Shani)
    Uranus (Arun)
    Neptune (Varun)
    Pluto (Yama)

13. The cover of the air around the earth is called atmosphere. The atmosphere consists of five layers. They are troposphere, stratosphere, mesosphere, thermosphere and the exosphere. The atmosphere extends to 1000 kms and then merges into the space.

14. Between 80 to 500 km the air is highly ionized, and hence this is called ionosphere.

15. The ozone layer present in the stratosphere is protecting the life on the earth from ultraviolet radiations.

16. Besides the atmosphere, there are hydrosphere and the lithosphere.

17. Minerals and rocks are present in the lithosphere

18. The earth consists of three main concentric layers. These are crust, mantle and core.

19. Rocks are classfied as igneous rocks, sedimentary rocks and metamorphic rocks.

20. These are inter converted into each other under the suitable conditions. This is called rock cycle.

15.13 TERMINAL EXAMINATION MODEL QUESTIONS

I. **Answer the following in about 30 lines each**

1. Describe in detail the composition of the universe
2. Give an account of the solar system and the Kepler's laws of planetary motion.
3. Discuss the structures of the atmosphere and the earth
4. Explain the terms, stars, constellations, galaxies, and the Milky Way.
5. How many types of rocks are there ? How are they related to each other ?

II. **Answer the following in 15 lines each.**

1. Describe the sun
2. Give an account of the Milky Way
3. Describe the structure of the atmosphere
4. Discuss the structure of the earth
5. State Kepler's laws

15.14 GLOSSARY

Aurora	:	The display of lights in nature in the polar regions 'aurora borealis' and 'aurora australis'.
Constellation	:	A definite region of the sky defined by a group of stars.
Core	:	The central part of a planet of a heavenly body.
Crust	:	The outer layer of the earth.
Galaxy	:	A collection of millions or hundreds of billions of stars, clouds of gas and dust.
Light year	:	The distance travelled by light in one year.
Mantle	:	The middle layer of ultrabasic rocks or of the earth.
Milky Way	:	The galaxy in which our solar system is present.
Nebulae	:	A cloud of dust in space
Photosphere	:	Visible part of the sun which is hot and gaseous.

UNIT-16 LAND, WATER, AIR

Contents

16.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about

1. What is meant by environment?
2. What are the components of the environment?
3. How the main components of the environment namely forests, oceans and the atmosphere are being adversely effected at present times.
4. The changes that are occurring in the environment as a result of human and non-human activities.

Objectives

After you completed this unit, you must be able to

1. describe how all forms of life are dependent directly or indirectly on their environment as well as on one another.
2. understand and explain the role of forests, oceans, and atmosphere on the ecological balance existing in the nature.
3. understand clearly the changes that are occurring and are likely to occur as a result of industrialization and technological developments that are taking place all over the world.

16.2 INTRODUCTION

Our earth is the only planet where life exists. Ofcourse scientists are constantly searching for signs of life on other planets. Several hundred million years ago life came into existence on this planet. The living conditions on the earth were quite different from what they are to-day. Earth has got the right temperature and pressure for life to exist on this planet and also to evolve and diversify. The air, water, land, the other living and non-living organisms are together collectively known as man's **environment.** There is a very delicate balance that is existing between earth's environment and the living organisms. Life is likely to be effected adversely if the balance is disturbed by natural or man made activities. You learn in this unit some of these aspects with special reference to the important components, namely forests, oceans. and the atmosphere.

16.3 ENVIRONMENT AND COMPONENTS

In the last unit-15, you studied that the four main segments of earth's environment are - atmosphere, hydrosphere, lithosphere and biosphere. Living beings together with their environment constitute an **ecosystem.** The three major components of earth's environment namely oceans, forests and atmosphere play a significant role in maintaining the ecological balance in the earth's environment.

We shall therefore study in this unit about these components and their role in creating the environmental conditions most suitable for a comfortable and healthy living.

16.4 THE FORESTS

The forests represent a well organised and highly evolved community of living organisms on this planet. Nearly one third of the total land area of the world is coverd by forests.

Forests contain 90% of the total global biomass. Forests harvest the solar energy much more than any other segment of the environment. Forests are present in all regions except in the polar regions. Forests are mainly dominated by trees. But these contain in them small plants, mosses, ferns, fungi, microorganisms, insects, reptiles, birds, mammals, and animals. Each of these is a part of forest ecosystem and each interacts with all others. The energy required for the survival of all these organisms is supplied by the sun and trapped in the foliage. Man is also considered a member of the forest community and is probably the most distructive of all. Men are therefore considered as **intruders.**

Forests occur in different parts of the world and in varying climatic conditions. These are

(i) **Forests in regions where the temperature falls to - 40°C;** These have little diversity of life

(ii) **Forests in regions having long winters :** Here water is not available as it freezes. This is similar to drought. In such forests we find heaps of fallen leaves in autumn season. Animals hibernate for long periods.

(iii) **Forests in regions where the rain occurs in plenty and temperatures are very high :** These are the richest forests. Large numbers of species are present in such forests. Therefore we find flowers of diffirent kinds all the year round. Much of the animal life lives high above the ground.

(iv) **Forests in regions where the temperature is very high in summers :** The plants in these forests will have a waxy, water-tight surfaced leaves with few pores only. These characters compensate for the loss of water in these forests by evaporation.

Forests are considered as environmental buffers. Forests provide suitable habitat for the wild life. Extensive forests cause extensive rains. They also intercept heavy rain fall and release the water steadily and slowly to the soil. Forests are sources of wood. Forests yield a variety of products of commercial value such as lac, resin and essential oils. Forests are store houses of medicinal plants.

16.5 THE OCEANS

The oceans are the largest amongst the ecosystems of the earth. The Atlantic, the Pacific, the Indian, the Arctic and the Antarctic are the major oceans of the world. These are inter connected and have many common features. Oceans cover 70% of the earth's surface. The depth of oceans varies from coasts to the middle. Oceans are shallow at coasts and deep in the middle. There are also trenches, valleys and hills under the ocean waters. Pacific ocean has the deepest part in the middle and this depth is greater than the height or Mount Everest. (Highest peak in the world). Ocean waters are never still. Water level of sea rises and falls twice a day. The gravitational pulls of the sun and the moon are responsible for the tides. High tides occur when the sun and the moon are on the same side of the earth and low tides occur when these are on the opposite sides. Ocean water is salty. Its salt content is 35parts per 1000parts of water. Common salt or sodium chloride is the main salt. Salts of magnesium, calcium and potassium are also present. The temperature of the waters is minimum at poles (< 0° C) and maximum in tropics (28° C). The pressure at the surface is one atmosphere and increases with depth. At a depth of 3000 meters, the pressure is 300 atmospheres.

Ocean as an ecosystem

The oceans are the largest and the thickest ecosystems. Tiny plants and animals exist in them in largest numbers. A cubic meter of sea water contains 200,000 organisms. In oceans the intensity of light decreases rapidly with depth. At a depth of 200 meters, there will be almost no light at all. Plants are therefore available only in zones where light is available. Sun light has red, green, and blue as principal colours. Red light is absorbed by water of surface layers and hence green plants grow here (green is complementary to red). Green light is absorbed by middle layers and brown algae grow at this depth (brown complementary to green). Blue light is absorbed by deep waters and hence red algae prevail at this depths (red complementary to blue).

Animals are also distributed like plants zone-wise. Small animals (zooplankton) co-exist with phytoplankton and derive energy from them in the upper layers. At middle layers, the energy for animal life is obtained from dead bodies and wastes even though temperature is low, the pressure is high and the sunlight is absent. 2000 species of fish occur at a depth of 600meters. In the totally dark zones, the organisms themselves produce light. This phenomenon is **bio-luminescence.** Certain sponges, jelly fish, snails, worms and prawns are some examples. Animal species living at greater depths contain bones made from silica instead of calcium salts. This is to make them withstand high pressures obtaining at these depths.

Phytoplankton in the upper layers are producers. Therefore they take the nutrients present in these layers. The nutrients are then passed on to herbivores and carnivores. These later organisms when they die, they are eaten up by other animals or they get decayed by decomposers. The decomposed matter sunks to the ocean floor. Thus the nutrients from the upper layers are constantly drained to the bottom layers of sea water. The nutrients are supplied to the upper layers by the river waters that join the seas. The nutrients drained to bottom layers are also driven up.. This is called 'upwelling'.. Thus the ecological balance is mantained in the sea and hence sea is the best known eco system of nature.

The clear, blue waters are generally poor in nutrients and hence there is less concentration of plankton in these waters. Nutrient rich waters that support a large plankton communities are greenish and murky.

16.6 THE ATMOSPHERE

Atmosphere is an envelope of the most useful gases that cover the planet earth. If the earth did not have an atmosphere, we would not have oxygen to breathe and the plants would not have carbondioxide to make food from. The rays from the sun would have scorched all the living organisms on the earth during day time if the atmosphere is not there above the earth's surface and temperatures would have far below the freezing point at night.

Atmosphere contains 78% nitrogen, 21% oxygen by volume. There is 0.03% CO_2. A thin layer of ozone is present and this protects life from ultraviolet radiations. A considerable amount of water vapour is also present. The atmosphere also sustains life. Various types of insects, mites, birds, bats and other organisms are present besides the large variety of life forms that we can only see with the help of a microscope. Spores of plants such as fungi, mosses, ferns, pollen grains of various types, bacteria, viruses are all found floating in the air. There are also tiny seeds of many plants. Some of the spores or seeds or pollen grains are taken to great heights by the air currents. So life forms are available even at great heights in the atmosphere.

But unfortunately the natural atmosphere which the man has inherited from the past with healthy and fresh air has been deteriorating both under the impact of population rise and extensive industrialization. Atmospheric or air pollution is thus intruding into this natural system badly.

Check your Progress

1. .... are the largest and the thickest ecosystems of the earth.
2. The factors that govern the type of life in oceans are .... and ....
3. Oceanic waters that have high nutrients and support large varieties of planktons appear ....
4. .... is the blanket around the earth and protects the life on earth.
5. The life in the atmosphere includes ....
6. At height above 4000 metres, man can not survive without ....
7. Forests occur in all regions except at ....
8. .... are the major processors of solar energy.
9. .... are the dominant life form of forests.

16.7 CHANGING ENVIRONMENT

Early human was a nomad and he spent a lot of time in search of food. He was environment friendly. His existence depended directly on plants and animals. The man then changed from hunting and food gathering to farming. Modern man has constructed dams on rivers, cut down forests, ploughed land and grown crops. He also built towns, cities, roads and canals. All these developments have made man's life easy and comfortable. But in this process man has changed the environment and even damaged it. There is clear evidence for man induced harm in many regions of the earth, such as the dangerous levels of pollution in water, air and soil.

As a reslult of all these happenings, the ecological balance of the biosphere is disturbed. Destruction and depletion of irreplaceable natural resources has occurred and has been occurring.

All these unwanted and unwarranted changes taking place in the environment are collectively referred to as **environmental degradation** or **changing environment.** There is therefore, need to identify the areas and causes for the degradation of environment that has occurred over the years.

You learn about this in the next units.

16.8 SUMMARY

1. The four main segments of the earth's environment are atmosphere, hydrosphere, lithosphere and biosphere.
2. All living organisms together with its environment can be called ecosystem.
3. The three main components of earth's environment are forests, oceans and the atmosphere.
4. These play significant role in maintaining the ecological balance in the earth's environment.
5. Forests represent a well organised and highly evolved community of living organism on this planet.
6. One third of the total land area of the would is covered by forests.
7. Forests contain 90% of the total global bio-mass.
8. Forests harvest the solar energy much more than any other segment of the environment.
9. Forests are present in all the regions except in the polar regions.
10. Forests contain trees, small plants, mosses, ferns, fungi, microorganisms, insects, reptiles, birds, mammals and animals.
11. Forest are there 1) in the regions where the temperature is - 40° C, 2) in the regions with long winters, 3) in the regions with plenty of rains and with high temperatures and 4) in the regions with high summer temperature.
12. Forests are considered as environmental buffers.
13. Extensive forests cause extensive rains.
14. Forests yield variety of products of commercial value.

15. Forests are store houses of medicinal plants.

16. Oceans are the oldest and the largest eco-systems of the earth.

17. The major oceans are the Atlantic, Pacific, Indian, Arctic, and Antarctic. These are all inter-connected and have common features.

18. Oceans cover 70% the earth's surface.

19. The depth of oceans change from shores to middle portions.

20. The depth of Pacific ocean is the maximum and this is greater than the height of Mount Everest.

21. Ocean waters are not still. Water level rises and falls twice a day.

22. The gravitational pulls of the sun and the moon are responsible for the tides.
    - High tides occur when the sun and the moon are on the same side of the earth.
    - Low tides occur when these are on opposite sides.

23. Ocean waters are salty. The salt content is 35 parts per 1000parts. The major salt is common salt, the other salts are potassium, calcium and magnesium salts.

24. The temperature is minimum at poles (0°C) and maximum in tropics (28°C). The pressure at the surface is one atmosphere and 300 atmospheres at 3000 metres depth.

25. Oceans are the largest and the thickest ecosystem.

26. Tiny plants, animals & minerals exist in it. A cubic meter of sea water contains 200,000 organisms.

27. The intensity of light decreases as we go down the ocean. At a depth of 200 metres there will be no light all.

28. Green plants grow at surface, brown algae at the middle, and red algae at deep depths.

29. Small animals at the upper layer, at middle layer bigger animals and at large depths no animals are present.

30. In deep oceans, there will be no natural light and hence animals themselves exhibit light. This is called bio-luminescence.

31. Ecological balance is maintained in oceans.

32. Atmosphere is an envelope of gases surrounding the earth's surface.

33. It protects life from unwanted radiations.
    - ozone is present as ozone layer. This protects life on earth from ultraviolet radiations.

34. But for the atmosphere, the day temperature would have been very high and the night temperature would have been very low.

35. Atmosphere also sustains various form of life, namely insects, mites, birds, bats, and other organism. Life forms are available at great heights due to transport of spores by air currents to these heights.

36. Unfortunately all these three segments are adversely affected by man's activities.

37. Hence the environment is changing adversely. There is an urgent need therefore to set right this situation.

16.9 TERMINAL EXAMINATION MODEL QUESTIONS

I. **Answer the following in 30 lines each.**

1. What are the three main components of earth's environment ? How are these functioning as ecosystems. Explain.
2. Giva a detailed account of oceans, their structure and how they funtion as eco-system
3. Explain clearly the forest structure and describe how it serves as an ecosystem
4. What is atmosphere ? Describe its components and how it functions as an eco system.
5. What are the adverse effects caused by human activities on these three main segments. Illustrate your answer.

II. **Answer the following in 15 lines each**

1. Give a description of ocean and its structure
2. How are forests functioning as ecosystems ?
3. Describe how atmosphere is functioning as an ecosystem.
4. What is meant by changing environment ?

16.10 GLOSSARY

1.	Algae	:	simple plants found in nature where abundant moisture is available. These grow on wet walls, moist soils, and in seas.
2.	Bioluminiscence	:	the emission of visible light by living organisms
3.	Biomass	:	the total weight of all or selected group of living beings in any area
4.	Fungi	:	yeast, mushrooms, molds etc.
5.	Habitat	:	land, water, or vegetation, which is a natural home of many living being
6.	Hibernation	:	A condition of partial or complete condition into which some animals relax during winter

7. Moss : green plants occurring in all damp places except oceans.

8. Pastures : green lands for cattle.

9. Pollen grains : male reproductive unit of plant. It unites with egg to form a seed.

10. Reptiles : animals with dry scale skin. eg : snakes, lizards, turtles, crocodiles

11. Silica : a hard, white substance occurring in nature. Main component of sand.

12. Spore : reproductive cell that can grow into an individual.

13. Tide : the periodic rising and falling of oceanic waters resulting from solar forces.

14. Zooplankton : the many animal life near the surface layers of a body of water.

UNIT-17 ECOSYSTEMS AND BIODIVERSITY

Contents

17.1 AIMS AND OBJECTIVES

Aims

The unit aims at describing

1. the interactions that are existing between the different living organisms on the earth
2. the delicate balance existing between the living and the non-living components of the earth.

Objectives

After you completed the reading of this unit, you must be able to

1. describe how different forms of life are dependent directly or indirectly on their environment
2. understand the inter-dependence of these organisms
3. know how essential needs for the existence of life such as energy, food and water are continuously made available by natural cyclic processes
4. describe the ecosystems and their structure
5. understand the prey and predator relationships.

17.2 INTRODUCTION

Our earth, you know is the only planet. where life exists. Ofcourse scientists are constantly searching for signs of existence of life on other planets. Several hundred million years ago, living conditions on the earth were quite different from what they are to-day. The present living conditions on the earth as well as the present variety of animals and plants are not only quite different from those existed million years ago but are also at very higher levels in the process of evolution. There exists a very delicate balance in nature between earth's environment and the living organism on it. If this balace is disturbed there is every chance of the present life being affected adversely. This imbalance may lead to on set of floods soil erosion and many such natural calamities. Therefore we must understand how living and non-living things exist in harmony with nature and what processes are responsible for maintaining this balance. In this unit you learn about these balances and also about the factors that are posing a threat to these balances.

17.3 ECOLOGY AND ENVIRONMENT

Ecology and environment are the two terms which are often used by people of different walks of life. But many a time these terms are understood differently by different people. But in these days of rapid developments in science and technology, these terms possess great significance and hence there is a need to establish some common understanding of these terms.

Ecology is a branch of biological sciences which deals with the relationships between the living organisms and their "environment". Everything that influences from outside the life of living organism can be collectively known as its **Environment.** These influencing agencies are called **factors.**

The living things that effect an organism are called **biotic factors.** Those that are not alive but are influencing the organism are known as **abiotic factors.** Let us try to understand these terms with the help of some familiar examples. Let us examine an aquarium or a fresh water pond in which fishes are grown. We know that for the growth of fish, food is needed. Fish depends upon organisms like small insects, insect larve, daphnia and on plants such as algae for their food. In a natural pond all these organism are available. But in an artificially maintained aquaruim we have to supply these food materials. How do these food organisms grow and develop? Living organisms utilize raw materials from the environment. Green plants synthesise food from raw materials from the environment by utilizing the energy derived from the sun. For example aquatic planktons (algae) synthesise their food materials by using the sun's energy and the minerals that are available in the pond. These are eaten by other organisms. After death and decay the organism releases the nutrients to replenish the environment. Thus as long as these natural events are allowed to occur, the nutrients are only recycled within the aquarium and the only external source is the supply of energy from sunlight. But when we grow fish in an aquarium and when we take out the crop, we are taking away a part of the living material produced in it and consequently the available nutrients slowly get depleted. So we have to supply food from outside in the form of cake, haydust, cowdung etc.

Thus for a fish in an aquarium we can identify many environmental factors, that are important for its life. The temperature of the water is one such non-living or abiotic factor. The kind and number of organisms that serve as food for fish are the important living or biotic factors. The type of materials added to the aquarium water and the amount of oxygen dissolved in water are also two other abiotic factors. So in brief we can say that the environment of an organism is complex and different factors (biotic and abiotic) are interrelated.

Check your Progress

1. .... is the study of the interaction of organism with their environment.

2. The word .... means as anything that affects an organism during its life time.

3. The environment consists of .... and .... factors. (ecology, environment, biotic and abiotic)

4. Give an example to illustrate the principle of ecology.

5. Name two abiotic factors that influence an organism during its life time.

6. Name one biotic factor that influences fishes life in aquarium.

17.4 ECOSYSTEMS AND STRUCTURAL ASPECTS

From the above, discussion it is clear that a natural pond is a self sustaining unit and the only external source needed is the energy of sunlight. Such self sustaining natural systems are called **ecosystems.**

A fish in a stream is yet another example of an ecosystem. So if we want to understand the living things and their place in nature properly, we must not consider the living things alone, but we must consider the living things as well as the non - living things that are interacting with each other in the system.

Thus the interacting system as a whole is called ecosystem. Hence "stream" in the above examples is one ecosystem, Aquarium is yet another ecosystem.

A lake, a pond, a grassland, or a forest are all examples of some ecosystems.

The living things (biotic factors) include various types of plants, frogs, birds, fish, turtles, insects and numerous kinds of micro organisms. The water, the dissolved oxygen, the nutrients, the soil, the stones and other impurities if any constitute non-living things (abiotic factors)

These various components of pond interact with each other. In this pond living things are born. they live, breathe, eat, move, grow, reproduce and act as food for each other. They finally die within the pond Itself. This pond has a dynamic existence. But it is not the same today as it was yesterday.

Structural aspects of ecosystem

Any ecosystem consists of two factors as mentioned earlier. These are **biotic factors** (living factors) and **abiotic factors** (non-living factors). The organisms in an ecosystem can be classified into three categories namely **producers, consumers** and **decomposers.**

1. The non-living factors (abiotic factors) : carbondioxide, nitrogen, water and other inorganic materials. climatic factors such as temperature, light, humidity, altitude salinity and pressure are also considered as abiotic factors. Life activity is limited to 0-45°C only. Rare forms exist at extreme temperatures. Life activity needs humidity also. Only few organisms tolerate saline water. Many need fresh water.

2. The living factors (biotic factors) : These are of three kinds namely **producers, consumers** and **decomposers.**

Sun is the ultimate source of energy for nearly all life on the earth. This energy enters life mainly through green plants, some kinds of bacteria and algae. Therefore these are called producers.

Producers : These utilize sunlight and synthesise food from carbondioxide and water. These simple low energy substances are converted into more complex substances called **carbohydrates** which we may call food. The process is called **photosynthesis.** Oxygen is obtained as a by-product in the process. For this photosynthesis not only carbondioxide, water, green plants and solar energy, but also some minerals such as calcium, potassium, magnesium are also needed.

Photosynthesis

$$\text{carbondioxide} + \text{water} + \text{solar energy} + \text{minerals} \xrightarrow[\text{green plants}]{\text{sunlight}} \text{food} + \text{oxygen}$$

In an organism the food is used up with the release of its stored energy by process of respiration. Oxygen is used up in respiration and again carbondioxide and water, the starting materials of photosynthesis, are obtained back.

Respiration

$$\text{Food} + \text{oxygen} \longrightarrow \text{carbondioxide} + \text{water} + \text{energy}$$

Thus green plants act as producers.

Consumers : These depend on other living organisms for their food. For example animals depend on plants for their food. They can not make their own food. Consumers include **herbivores,** the animals that eat plants, **carnivores,** the animals that eat other animals, **omnivores,** the animals that eat both plants and animals.

Deer, duck, goat, and cow are examples of herbivores. Human beings who are vegetarians by choice are also classified under herbivores.

Rats and most human beings are examples of omnivores.

Herbivores are also called as **primary consumers.**

Carnivores are called **secondary consumers.**

Those which live by eating **secondary** and **tertiary consumers** are known as **tertiary** and **quaternary consumers.**

Decomposers : These act on dead plants and animals for their existence. They decompose the substances which form these dead bodies. Examples are bacteria, fungi and worms. These convert the materials of plants and animals back to their elementary form.

Check your Progress

1. The biotic factors are subdivided as ....
2. Herbivores are .... consumers.
3. Carnivores are those which eat ....
4. Name any two abiotic factors ....
   (producers, consumers, decomposers, animals, carbondioxide, water)

5. Give examples of decomposers ....

6. What are decomposers ?
(bacteria, fungi, worm)

....

....

17.5 FOOD CHAINS AND FOOD WEBS

From 'biotic factors' discussed in 17.4, we easily understand that one of the ways in which different organisms are related to each other is through food. One organism becomes food for the other and soon therefore a sequence of organisms that feed on one another constitutes a food chain (Figure 17.1)

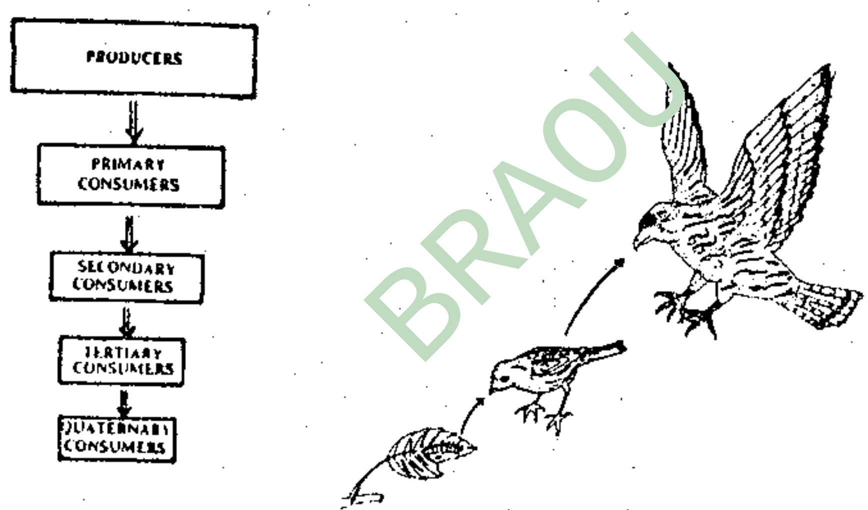


Figure 17.1 Food Chain

The nutrients and the energy go from the producer to the last organism of the chain as shown by the direction of the arrows. The number of links or steps in a food chain are generally limited to only four or five. The link or step in the food chain is called **trophic level.** This level indicates how far it is away from plants (the first level) in the food chain. Green plants or producers make up the first trophic level. The **second** level is usually the plant eating **animals** (herbivores), higher trophic levels are made up of carnivores. One organism can occupy more than one trophic level. For example man, an omnivore belong to second/or the third trophic levels. If we analyse the food chain we understand that there should be a large number of producers to sustain the preliminary consumers, which in turn shall be more in number than the secondary consumers. The tertiary and quaternary consumers will be fewer than the secondary consumers. Therefore when living matter is flowing through the food chain its quantity gradually decreases along it. This is shown in the figure (17.2) This is known as **ecological pyramid.**

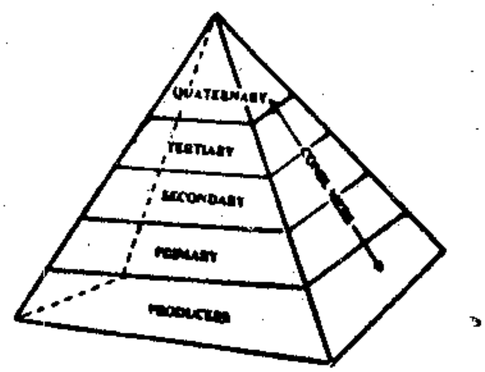


Figure 17.2 Ecological Pyramid

If we examine nature even casually we observe this trend. Plants are always larger in number than the animals eating these plants. Plant eating animals, (herbivores) are more in number than animal eating animals (carnivores) viz lions, tigers, etc. It is also a common experience that when we eat food only part of it is digested, while the rest is thrown out as undigested matter. Part of the digested matter is broken down to give energy while the remaining is converted into tissue matter. Therefore the amount of living matter present in the primary consumer is far less than the amount of food consumed. Like wise when primary consumers are eaten by the secondary consumers, only part of this remains as living matter (biomass). The rest is either removed as undigested waste. (ejection) or broken down (respiration) to yield energy. (Figure 17.3)

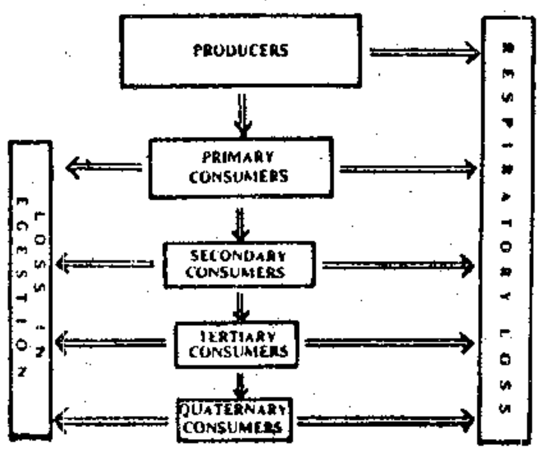


Figure 17.3 Flow of biomass in a food chain

Within an ecosystem, there are many different food chains. Some organisms may be involved simultaneously in many food chains. (Figure 17.4) so a number of food chains become interwoven into a single entity which may be very complex. This entity is called **Food web.** This term is often used to describe more accurately the feeding relationships that exist within a given ecosystem.

A typical illustrative food web is shown in the figure 17.4.

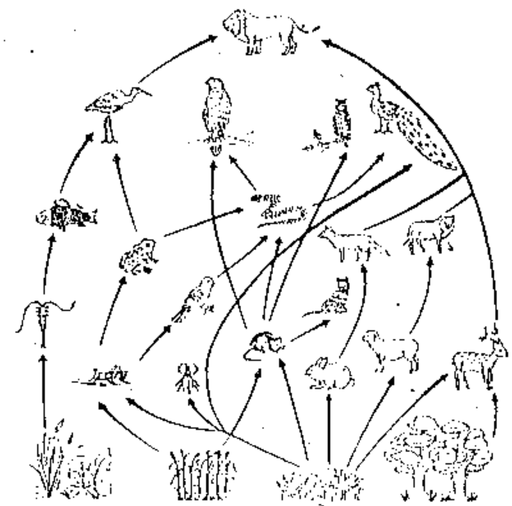


Figure 17.4 Food web

Interlocking food chains provide stability to the ecosystem. A food web thus makes it possible for the living beings to survive minor or major set backs and the changes that take place in their surroundings. Suppose a predator, a wild animal like tiger could not get its usual food animal, say deer due to some unexpected changes that took place in the surroundings, the tiger can feed itself on other animals such as fox, till the usual pray animal (deer) is available.

Check your Progress

1. Find the missing links in the food chain given below

   1) Plant ——> - - - - - - ——> Fish ——> Man

   2) Grass ——> Grass hopper ——> — - - ————> Eagle (insect, rate, snake)

2. Construct a food web using plant, rabbit, deer, wolf, snake, insect, spider, sparrow and hawk.

17.6 ENERGY FLOWS IN ECOSYSTEMS

The principal energy source for any ecosystem is sunlight. The solar energy is converted by plants into food materials and is stored in the body of the plant. Similarly other food materials we or plants consume are manufactured directly or indirectly by plants. Egg is obtained from hen, which eat plant products for its survival. We get milk from cow and cow eats grass, a plant material. So we can say that the energy we are getting from plants is actually the solar energy trapped by plants in the photosynthesis. Thus we depend on stored resources of solar energy. Even the nonvegetarian food such as meat is also obtained from animals like goat which also live on plant foods for several years. The energy stored in fire wood is also the energy accumulated and stored by plants for over a century or more. Similarly we can say that petrol and coal contain solar energy stored in them by plant life for millions of years ago.

We can graphically represent the energy flow in an ecosystem as shown in the figure 17.5.

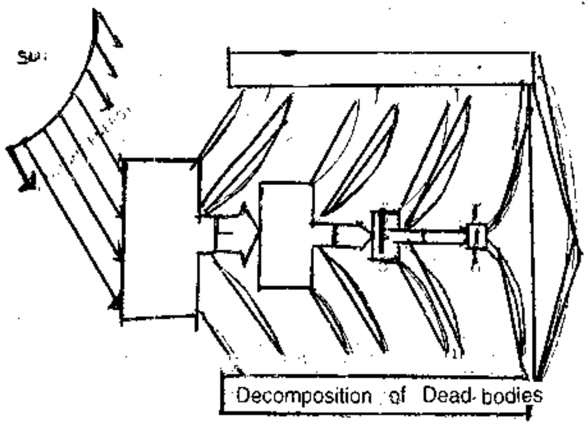


Figure 17.5 Energy flow in ecosystem

But the energy decreases considerably from producer to the last level. The energy content at each trophic level is indicated by the size of the rectangle. Some energy is lost as heat and this is shown by the arrows pointing outwards. The arrows pointing down wards in the lower half indicate the loss of energy in the form of water and deadbodies, which decomposers use as source of food and derive energy from them.

This energy captured by producers passes to various consumers via a food. Only very little energy is left for the last trophic level since some energy is always lost from one level to the next. The number of trophic levels in the ecosystem therefore depends on the magnitude of this loss. The levels for this reason are not more than four or five in an ecosystem.

Check your Progress

1. What is the main source of energy in any ecosystem (solar energy)

....

....

2. How does the energy quantum change as we go from producer to carnivore ? (The energy is lost at every trophic level as heat as well as through waste)

....

....

3. How many trophic levels are generally found in an ecosystem? (Four or Five)

....

....

17.7 CYCLING OF MATERIALS IN ECOSYSTEMS

Living organisms require carbon, hydrogen, nitrogen and oxygen as nutrients in large quantities. Besides these four elements the living organisms require phosphorus and sulphur too. All these elements are present in nature but in fixed quantity. Hence these must be recycled in order to sustain life. These elements therefore must move efficiently from living components to non-living components and vice-versa.

For example plants take carbon from atmosphere in the form of carbondioxide and convert it into carbohydrate (food). The herbivores eat the plants and consume these carbohydrates. Thus herbivores get the carbon in the form of food. Carnivores eat these herbivores and get into them the carbon. From carnivores, the carbon goes back into the atmosphere through the decomposition processes of excreta of carnivores by bacteria.

Carbon is eventually returned to the non-living pool in the ecosystem. Thus the carbon from the atmosphere goes via producers consumers and decomposers back to the atmosphere and the cycle is completed. Through such cyclic processes the nutrients are used over and over again by the living organisms. This aspect of the ecosystem functioning is called the **cycling of materials.**

We have seen in the earlier section (17.6) that the energy flow is a one way process.

The important cyclic processes operating in nature are 1) nitrogen cycle 2) carbon cycle 3) water cycle. Let us look into these cyclic processes in a detailed fashion.

The nitrogen cycle

Nitrogen is an important element of essential carbon compounds namely proteins and nucleic acids (RNA & DNA) of living organism. Further nitrogen is a major component (79%) of the atmosphere. Thus atmosphere is the chief reservoir of nitrogen. It is present as a gas in the atmosphere. Plants & animals therefore are not able to use this element (gas) directly from the atmosphere. Plants obtain nitrogen from the soils in the form of nitrates and ammonium salts and prepare proteins. Animals use these proteins. Let us examine the cycling process of nitrogen in greater detail.

The different important steps of nitrogen cycling process can be summarised briefly as follows.

1. During thunder storms, oxygen and nitrogen of the atmosphere combine at high temperatures of lightning to give oxides of nitrogen. These oxides dissolve in rain water, reach the soils and get converted into nitrates. These nitrates are taken up by plants.

2. Certain bacteria utilise atmospheric nitrogen and convert it into nitrates. Such bacteria are called nitrogen fixing bacteria. These bacteria are present in the soils freely or live in small nodules on the roots of some plants (leguminous), such as beans, peas, peanuts, alfa alfa etc. It is for this reason farmers use these plants to increase the nitrates in the soil.

3. Plants absorb these nitrates from the soil and convert them into aminoacids and proteins.

4. Thus nitrogen enters the food web in the form of proteins through plants and passes on to animals, which feed on these plants.

5. Nitrogen then returns back to the soil 1) as nitrogenous waste in the form of ammonium compounds during excretion by animals and 2) as dead plants followed by bacterial decomposition.

6. In the soil, the nitrogen - containing matter is acted upon by bacteria and is converted to ammonium compounds and finally to nitrates.

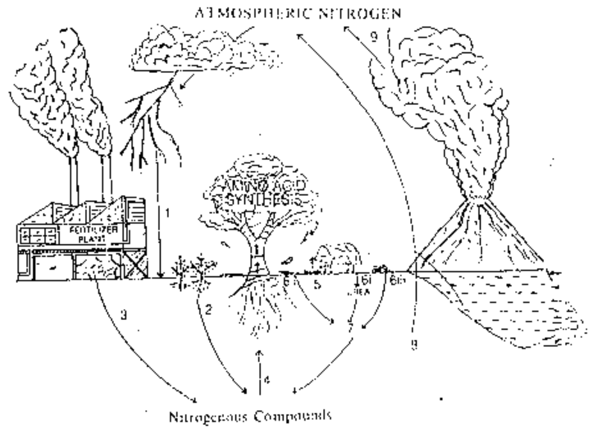


Figure 17.6 Nitrogen Cycle

Acid rains and addition of synthetic nitrogen fertilizers are to some extent intruding into the nitrogen cycle and disturbing it.

The carbon cycle

Carbon is present in the atmosphere as carbondioxide. It forms 0.03 to 0.04% of the atmosphere. Oceans also have carbondioxide dissolved in their waters. Let us now examine the different important steps involved in the cycling process of carbon in nature. These can be summarised as follows.

1. Carbondioxide enters food webs through plants by the process of photosynthesis.
2. The organic compounds formed in the photosynthesis are party converted back into carbondioxide during respiration.
3. A portion of these organic compounds in the plants is later passed on to the herbivores.
4. The living beings release carbondioxide into atmosphere through breathing process.
5. Decay of dead bodies and wastes of animals and plants by bacterial as well as by combustion processes release carbondioxide into the atmosphere.
6. Air is direct contact with the sea. Therefore carbondioxide in air dissolves in sea water and forms carbonates.
7. Sea water plants use these carbonates in the photosynthesis, since they do not get atmospheric carbondioxide.
8. Foods produced by water plants passes through aquatic food chain. Fish live on these sea plants and get carbon from them. These fish are eaten by other organisms and these organisms therefore get the carbon.
9. Some of the marine organisms like snails, oysters extract dissolved carbondioxide in sea water and combine it with calcium to form calcium carbonate. This calcium carbonate appears in the form of shells. When these shelled animals die, the shells are collected in under sea deposits and are finally converted into limestone deposits.

But carbondioxide input into the atmosphere is increasing considerably these days on account of increased growth of industries, vehicular traffic and accidental fires etc. This is intruding into the carboncycle and affecting it adversely. This consequently led to the green-house effect and to the increase of surface temperature of the earth.

The cycling of carbon in the atmosphere is represented in the figure 17.7

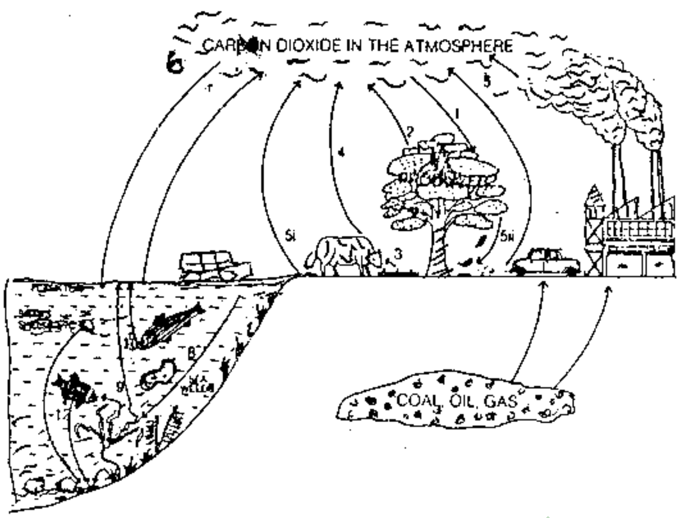


Figure 17.7 Carbon Cycle

The water-cycle

Water is essential for all living organisms to sustain life. It is the most abundant substance in the environment. Oceans are the major reservoirs of water. Water covers about 75 percent of earth's surface. But water in oceans is salty while water in rivers is fresh water. The water cycle is driven by the sun's heat energy. Water evaporates on account of this heat energy and gravity draws this water back to the earth after vapour condenses into rain unlike in the carbon and nitrogen cycles. The forces that are responsible for water cycling do not involve organisms. These forces are mostly the physical processes.The water cycle can be divided into 4 basic steps. These are,

1. The fresh water used for personal and industrial purposes is obtained from ocean water through evaporation and precipitation (rain)
2. The rain water falls partly directly on the ground and partly into oceans. The water that falls on the ground, seeps through the soil and is collected as ground water. This underground water is used by human beings for domestic, agricultural and industrial purposes.
3. Some of the ground water is collected into lakes & ponds and some of it goes into rivers.
4. A part of rain water evaporates back into the atmosphere. Plants send out water vapour through leaves into the atmosphere (transpiration). Water in the lakes, rivers, streams and oceans also evaporates and goes back into the atmosphere.
5. The water vapour forms clouds and condenses back to water in the form of rain. But many human activities are intruding into the water cycle and disrupting it. These are 1) over concentrations of populations in industrial areas, 2) lack of proper, sanitary facilities, waste disposal methods and 3) deforestation processes.

A schematic representation of water cycling is shown in the figure 17.8

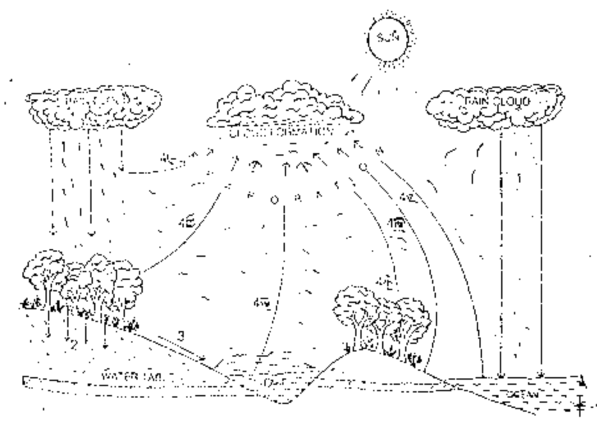


Figure 17.8 The Water Cycle

Check your Progress

1. Plants take up nitrogen in the form of ....
2. Nitrogen gas is fixed into useful compounds by ....
3. Nitrogen fixing bacteria are found in the root nodules of .... plants.
4. Nitrogen in the soil is converted into ....
5. Carbon from the atmosphere is converted into carbon compounds useful as food in the process of ....
6. Carbon returns to the atmosphere in the form of .... in the processes of ....
7. Water covers .... percent of earth's surface.
8. Water from oceans reach the atmosphere in the form of ....
9. Water vapour comes back as water in the form of ....

17.8 BIODIVERSITY

There are about 30 million living species on earth. But only about 1.5 million are on record. Of these species about 75,000 are insects, about 41,000 are vertebrates & about 25000 are plants. The rest are invertebrates, fungi, and micro organisms. Most of the species are found near the equator. Species diversity is at its peak in tropical forests and coral reefs.

It is expected that 25% of the earth's species is likely to extinct in the next three or four decades. This is mostly due to deforestation. Tropical forests contain more than 50% of world's species and it is expected that 20% of this may be eliminated by 2020.

It is very essential to preserve the numerous varieties of plants and animals that belong to a species. Each variety will contain unique genes. The diversity of genes within a species increases its capacity to adapt to pollution, disease and also other changes of the environment. If varieties of plants or animals are destroyed, the genetic diversity within the species is reduced. Rural people exploit many different species for their food & fuel.

Industrial countries use biodiversity indirectly. This use is in the form of exporting the genes from wild plants and animals to develop medicines and chemicals. Forests where the temperature drops to - 40°C have little diversity of life. Depending on the plants present in an area, diversity of animal life also varies. Thick forests occur in areas that receive plenty of rain and have high temperatures throughout the year. Such thick forests will have the richest and the most varied types of plants and animals found anywhere on the earth. Forests have been over-exploited and are shrinking through out the world. India is losing forests at an extremely rapid rate. Andhra Pradesh lost nearly 2 million hectors of forest during 1972 and 1982. If one plant species becomes extinct it takes with it many dependent organisms, sometimes as many as 30. Hence protection of forests and launching of afforestation programmes must be the immediate and only remedy for protecting and improving the Biodiversity of the environment.

Check your Progress

1. What is biodiversity ?

   ....

   ....

2. How many species are expected to be present in the world ?

   ....

   ....

3. What is the main source for biodiversity ?

   ....

   ....

4. What are the reasons for the rapid vanishing of biodiversity ?

   ....

   ....

5. How to preserve biodiversity ?

   ....

   ....

17.9 ECOLOGICAL CRISIS

The rapid changes that are taking place all over the world in the fields of scientific, technological and consequently industrial developments are directly or indirectly responsible for the rapid deterioration of the human environment. Unwarranted population growth may be the major reason for such an environmental degradation. As a result of all these happenings, air is polluted, oceans, rivers and lakes are polluted, soil is polluted, and deforestations are taking place. All these adverse happenings are disturbing the natural cycling processes as well as the ecological balances. This is referred to as **Ecological Crisis.** This crisis may be in oceans, in air and in forests.

Crisis in oceans

Coastal and marine areas all over the world including those in India are under stress. Two thirds of the world's population live near the coasts and 60% of the marine food is harvested from the zone near the coasts. Most of the sewage, garbage and industrial wastes find their way into the sea. In earlier times it was thought that the sea is so big that we can throw anything into it without effecting it. But every one knows now that it is not correct. Even in Indian coasts, dead fish were found floating in the Arabian sea on the western coast. The rivers which join the seas, bring sand from the hills and plains and thus lot of silt gathers near the coast. Seas are precious ecosystem for marine life and they provide food and medicinal plants for many people. Hence it should be everybody's concern to preserve and protect the oceans.

Crisis in air

The natural atmosphere inherited from the past contained healthy and fresh air. Ozone is protecting the man from harmful radiations. But unfortunately factories, automobiles and fuel burning are pumping lots of dust and smoke into the air and polluting it. CFCs entering the atmosphere are puncturing the ozone layer and are contributing to radiation pollution too. The air pollution has therefore become a matter of great concern. The natural water, nitrogen and carbon dioxide cycles are highly effected. This can therefore be called as crisis in air.

Crisis in forests

Forest have been over exploited. They are shrinking through out the world. Destruction of forests are due to.

1) shifting cultivation 2) conversion of forests to pastures for cattle, 3) over grazing 4) commercial exploitation for wood and other forest products. 5) developmental projects such as irrigation, road, building projects. As a result of these deforestation activities, 1) soil erosion, 2) silting of lakes and rivers, 3) on set of devastating floods and 4) loss of flora and fauna are taking place very rapidly. This can be called **crisis in forests.**

Check your Progress

1. What is ecological crisis?

....

....

2. Give reasons for ecological crisis in oceans.

....

....

3. How is ecological crisis in air taking place ?

....

....

4. What are the reasons for ecological crisis in forests ?

....

....

5. Suggest remedial measures for averting these ecological crisis.

....

....

17.10 SUMMARY

1. Atmosphere, oceans and forests are the significant components of earth's environment
2. Ecology and environment are the two important concepts of vital importance to man
3. Ecology deals with the relationship between the living organisms and their environment
4. Environment influences the life of living organisms and the living organisms in turn effect the environment.
5. Two main factors namely biotic and abiotic factors of the environment influence the life of living organisms.
6. Any self contained system in which there is an ecological balance between the organisms and the environment is called ecosystem.
7. An aquarium is a simple example of an ecosystem : There will be exchange of materials and energy between the organisms and the environment in any ecosystem.
8. Forest is another good example of an ecosystem in nature.
9. The living factors (biotic factors) are classified as producers, consumers and decomposers.
10. One organism becomes food for the other. The sequence of such organisms that feed on one another constitutes a food chain. Every stage of food chain is called trophic level. There will be generally four or five levels only.
11. The food quantity gradually decreases from the first level to the last level. Hence this sequence assumes pyramidal shape.
12. There may be different food chains and some organisms may be common in these food chains. Therefore these food chains get interwoven and a web is formed. This is called food web.
13. The energy flows from producer level to the last trophic level in a food chain and it decreases in magnitude from the first to the last level.
14. Matter is cycled through natural cycles in ecosystem. Living organisms require essentialy C, H, N, O and H_2O. These are all cycled in nature to maintain the quantities of these at optimum levels.

15. These are called carbon cycle, nitrogen cycle, water cycle etc.

16. These cycles are now being adversely effected due to pollution effects.

17. There are about 30 million living species on earth. But only 1.5 million are on record. Of these about 75,000 are insects, 41000 are vertebrates, & 2,500 are plants. This diversity is called bio diversity. Forests are the main sources of these diverse species.

18. Deforestation activities are contributing to the depletion of these biospecies in the environment.

19. Environmental pollutions, deforestation activities and extinction of biological species including their diversity are creating environmental crises.

20. These environmental crises are known as ecological crises also.

17.11 TERMINAL MODEL EXAMINATION QUESTIONS

I. **Answer the following in 30 lines each**

1. What is an ecosystem ? Explain any two ecosystems in detail.
2. Write briefly about biotic and abiotic factors that control the ecological balance.
3. Explain the terms with examples, food chain, food web, ecological pyramid.
4. Discuss about energy flows in ecosystems
5. Describe in detail the nitrogen cycle in nature.
6. Describe in detail the carbon cycle in nature.
7. Give a descriptive account of the water cycle in nature.
8. What is bio-diversity ? How is it being effected ? And what are the remedial measures to be followed to protect this diversity ?
9. Explain the term 'ecological crisis' with necessary explanations.

II. **Answer the following in 15 lines each**

1. What is an ecosystem ? Give one example.
2. Discuss the biotic factors operating in an ecosystem.
3. What are the abiotic factors that control ecological balance.
4. What is food chain ? Illustrate the same
5. Write a few lines about the energy flows in the ecosystem
6. Describe the nitrogen cycle
7. Describe the carbon cycle
8. Describe the water cycle
9. Explain the term with example "biodiversity"
10. What is ecological crisis.

17.12 GLOSSARY

Abiotic factors	:	non-living parts of an organism, environment
Biotic factors	:	living components of an organism, environment
Carnivores	:	the animals that eat other animals
Decomposers	:	organisms that use dead organic matter as a source of energy
Ecology	:	branch of biology that studies relation between organisms & their environment.
Ecosystem	:	an interacting collection of organisms and the abiotic factors that effect them.
Food chain	:	a sequence of organisms that feed on one another resulting in the flow of nutrients and energy from producer to consumer.
Food web	:	a system of interlocking food chains
Herbivores	:	the animals that feed directly on plants
Omnivores	:	the animals that are carnivores at times and herbivores at others.
Producers	:	organisms that produce new organic material from inorganic material with the aid of sunlight
Trophic level	:	level in the food chain at which an organism functions.

UNIT-18 POLLUTION AND HEALTH HAZARDS

Contents

18.1 AIMS & OBJECTIVES

Aims

In this unit you learn about

1. What is pollution?
2. How is pollution caused and classified ?
3. What are the sources? and
4. What are the harmful effects of different pollutions?

Objectives

After studying this unit you must be able to

1. define pollution
2. classify pollution into different types
3. list the pollutants relating to each type of pollution
4. know the ill-effects caused by the different types of pollution
5. understand the sources and the factors that cause these pollutions.
6. be aware of national laws promulgated to prevent spread of pollution and protect the environment

18.2 INTRODUCTION

If we compare the life of early man with that of to-day, we find great difference. Now a days technology is playing a significant role in improving the quality of life of man. Today most people are better off with regard to food and other basic needs of life. Man has constructed dams on rivers, cutdown forests, brought more land into cultivation and improved tremendously the transport systems. Revolutionary changes were also brought into the methods of cultivation and in the methods of protecting crops and also in increasing the agricultural yield. These were also possible because of the use of large variety of agrochemicals in agriculture. Hence man in his anxiety to improve his comforts, food production and also health standards knowingly or unknowingly altered his own environment adversely. It is also not improper to say that he even damaged the environment to a great extent. Now every region of the earth is polluted to even dangerous levels. The ecological balance is disturbed and natural resources are being depleted enormously. Therefore there is a great need to identify the different types of pollution damages and the causes for such damages. This will enable man in future atleast to take steps to preserve the environment and to adopt methods which help the man live in harmony with the environment.

In the last unit, you studied about ecology, environment, ecosystem, energy flows in the ecosystems, cycling of materials, biodiversity and ecological crisis. In this unit you learn about pollution, types of pollution, causes for pollution, ill effects caused by pollution and also about the remedial measures if any to prevent further pollution.

18.3 POLLUTION

Everyday we read in the news papers, hear in the radios and see in the television programmes about 'pollution'. What does then 'pollution mean?

Pollution can be understood or even defined in different ways. Whatever may be the real scientific definition of pollution, we can say, it is a present day happening which is posing a great threat to all types of life on this earth. It can be described as an endangering degradation of environment on account of human or non-human activities. Pollution can be caused by chemical substances, by biological species or by dangerous radiations including sound and heat.

Hence pollution is defined broadly as the addition to the environment (air, water, land) of harmful chemical substances or energy (heat, sound, radioactive emanations) at a rate and in quantities that are harmful to life.

Pollution therefore can be described as disturbance of ecological balance caused in so many ways that can be disastrous for mankind as well as other living and non-living partners of man on earth.

18.4 TYPES OF POLLUTION

Depending on which sphere of the earth is polluted, or depending on which source is polluting these spheres, pollution is broadly classified as

1. Air pollution (air or atmosphere is polluted)
2. Water pollution (water or hydrosphere is polluted)
3. Land pollution (land or soil or lithosphere is polluted)
4. Chemical pollution (pollution caused by chemicals)
5. Biological pollution(pollution caused by biological species)
6. Sound pollution (pollution caused by high sounds)
7. Heat pollution (pollution caused by high temperatures)
8. Radiation pollution (pollution caused by harmful radiations - radioactive, uv etc)

Air Pollution

This is the major type of pollution mostly created by man. It is estimated that about 100 million tons of chemicals in the form of wastes are introduced into our atmosphere every year over the globe. These wastes which go into air are generally gaseous or particulate in nature.

Smokes coming from industries, powerplants, automobiles, homes and waste disposal methods cause mainly air pollution.

Even air crafts also release large amounts of burnt or unburnt fuel into the air.

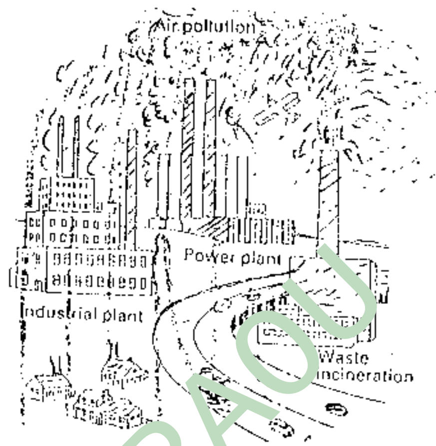


Figure 18.1 causes for air pollution

The primary air pollutants are listed as

1. Carbon monoxide (CO)
2. Hydrocarbons (CH)
3. Oxides of nitrogen (NOx)
4. Oxides of sulphur (SOx)
5. Particulates (C, metals, dust, etc)

These primary pollutants may interact with one another and produce secondary pollutants. The secondary pollutants are more dangerous than primary pollutants some times. We shall discuss in this unit mainly the primary pollutants.

1. Carbon monoxide (CO) : This is generally produced when organic substances containing C, H and other elements if any are burnt incompletely in air.

$$(CH) + (O) \rightarrow CO. \ [(CH = \text{hydrocarbons})]$$

Such materials in use in our daily life are wood, coal, charcoal, cooking gas, biogas, petrol, diesel, kerosine and even organic trash.

Therefore our gas stoves, openair or forest fires, factories, power plants, automobiles, all of these are giving off carbon monoxide in large amounts virtually everyday. Even the cigarette smoke contains carbon monoxide. Carbon monoxide is a very dangerous pollutant. It combines, when inhaled with hemoglobin of blood and reduces oxygen carrying capacity of hemoglobin. This if CO is inhaled in large doses for long times, it may cause even death due to suffocation. CO causes blurred vision, headache and unconsciousness. Fortunately for us CO is absorbed by some microorganisms present in the soils and this saves man to a large extent from CO pollution.

2. Hydrocarbons (CH) : These are organic compounds containing carbon and hydrogen These go into the atmosphere either through leakages from sources of hydrocarbon fuels such as cooking gas, diesel,petrol, kerosine, etc. or through incomplete burning of these fuels.

Hydrocarbons in air are generally washed down by rain water into surface waters. Then they form oily films on water surfaces. These do not cause as such much harm but are responsible for highly harmful secondary pollutants (photochemical smog)

3. Oxides of nitrogen (NOx) : The oxides, NO, and NO_2 are together represented as NOx. These are major primary pollutants. Due to combination of nitrogen and oxygen under suitable conditions these oxides are formed in nature. Under normal atmosphere conditions nitrogen and oxygen do not combine but when storms are there, these gases in the atmosphere may combine to give different oxides of nitrogen. Automobile engines, nitrogen fertilizer factories, explosive factories, sulphuric acid plants (lead chamber method) contribute largely to the atmospheric oxides of nitrogen.

Acid Rain

These oxides (NOx_1) cause what is called "acid rain". The oxides under suitable conditions dissolve in rain water and increases its acidity (pH 4-5). The pH of the usual rain water decreases by nearly 2 units. Acid rain causes direct damage to the plant leaves. Forests around the industrial places are dying due to acid rain. It leaches out the nutrients (Ca, Mg) from the soil. Acid rain effects marine life. Fish die due to accumulation of metals such as aluminium on their gills. The concentration of aluminium increases in river waters affected by acid rain. Acid rains effect badly big constructions, statues, monuments etc made from stones, marble, slate, lime etc, Acid rain to some extent can be prevented by treating the industrial effluent gases chemically for the removal of the oxides of nitrogen and sulphur, before they are led into the atmosphere.

Photo Chemical Smog

This is referred to as a secondary pollutant. The word 'smog' is generally considered as a combination of smoke and fog. It is brown in colour and very dangerous. Many people seem to die every year in england and some other industrial countries due to this smog. It is formed by the reaction of oxides of nitrogen, hydrocarbons, ozone (O_3) under the influence of sunlight. It is therefore called photochemical smog. The main substance responsible for this photochemical smog is PAN (Peroxy Acetyl Nitrate) formed between NOx, CH and O_3, in the photochemical reactions. It appears as a brown haze. This causes respiratory disorders and nervous disorders. It effects eye membranes and stimulates tears. It causes headache. Plants exposed to PAN exhibit leaf *mottling* and reduced growth.

4. Oxides of Sulphur (SOx) : Oxides of sulphur mainly sulphurdioxide and sulphur trioxide are collectively represented as SOx. Those are gaseous compounds of sulphur and oxygen. These are thrown into the air by sulphur bearing industries such as fertilizer plants, thermal power plants, besides by burning of fossil fuels containing sulphur as impurity. It is not an exaggeration if we say that no big city or town is free from this pollution in India or in any other country in the world to-day.

The oxides of sulphur also constitute to the cause of acid rain.

Sulphurdioxide irritates the respiratory systems. These cause lung diseases. These also affect the plants adversely and reduces their growth.

5. **Particulates** : These are mostly fine carbon particles formed during the combustion of fossil fuels (coal, charcoal etc) These remain suspended in air. These also absorb metals such as lead, zinc, cadmium and also other substances, nitrogen oxides etc. Besides these, even dust particles, cement particles, asbestos particles and other materials contribute to this particulate pollution of human beings. These particles enter the lungs of human beings during breathing and cause many lung diseases including lung cancer. **Asbestosis** a cancerous disease is caused by asbestos particulates entering into the atmosphere during asbestos mining operations and also during the manufacture, use and disposal of asbestos containing materials such as insulation devices, asbestos roofs etc. Several miners working in Singhbhum, Bihar are known to have died due to asbestos pollution. This disease is now recognised under the Factories Act as "killer disease". Silica particulate matter is entering the atmosphere mainly at places where cement and glass industries are large in numbers. The silica that entered into the air, gets deposited in the lungs of the workers working in cement, glass, pottery and stone cutting & finishing industries. The cancerous disease caused by silica particulates matter is known as **silicosis.**

Green house effect : This is another dangerous effect caused by the accumulation of mainly carbondioxide in the atmosphere. Carbondioxide is not a toxic chemical. But because of green house effect, the surface temperature of the land and the water of the globe each seems to be rising by a few degrees. This causes the sea-level to increase by a few meters. It is feared that many island countries are likely to be submerged in seas. It is feared that cities like Tokyo, Osaka, Montreal, Stockholm, London. Glasgow Florida, Calcutta and Madras may lose much of their territory due to this effect.

When sun's rays fall on the atmosphere containing large amounts of carbondioxide, some of the heat is only reflected towards the sky but much of it passes down to the earth. Thus only a part of the heat from the earth enters the atmosphere and most of the heat is blocked by carbondioxide and again reflected back to the earth. This leads to the heating of surface of the earth. A green house is a glass house used in cold weather to grow plants which normally grow in warmer climates. The glass walls of the green house thus also prevents the heat inside the house from being lost to the atmosphere. Hence the effect caused by carbondioxide in the atmosphere in view of similarity is called **green house effect.** The accumulation of carbondioxide in the atmosphere has risen by 6 percent and is expected to increase further in the next decades. The other gases likely to be causing green house effect are methane, chlorofluorocarbons and oxides of nitrogen.

Depletion of ozone layer : Ozone (O_3) is a gas resembling oxygen (O_2) and is present in the upper atmosphere. It is acting as a protective layer and saving the life on the earth from the dreadful effects of ultra-violet radiation coming from the outer atmosphere. But unfortunately this ozone layer is being depleted by the action of certain gases such as chlorofluorocarbons (or freons) led into the atmosphere by man. These gases are used generally as refrigerants, propellants in aircrafts and in making plastic foams. These gases are very stable, accumulate in the atmosphere. and react slowly with ozone. The reactions of ozone with chlorofluorocarbons are complex and lead to depletion of ozone in the atmosphere. This depletion of ozone is generally referred to as **"holes in ozone layer".** It is also found that nitrogen oxides introduced into the upper atmosphere by jet planes flying there are also responsible for ozone depletion. These holes in ozone layer allow ultraviolet radiations reach the earth. and cause skin cancer.

Check your progress

a) Pollution is defined as..

b) Pollution is classified as ...., ..., ... mainly

c) Primary pollutants are ....

b) Acid rain is caused by mainly the oxides of .... and ....

e) The main adverse effects caused by acid rain, CO, NOx, SOx, and particulates are

.... by acid

.... by CO

.... by NOx

.... by SOx

.... by particulates

f) Green house effect is caused by gases..

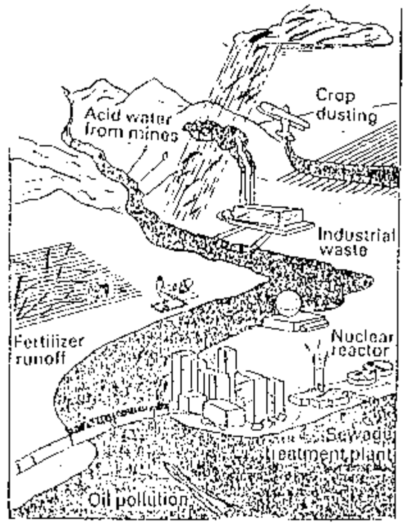
g) The adverse effects caused by green house effect are .... and ....

h) The ozone holes are caused by gases .... and ....

i) The adverse effect of ozone depletion is ....

Water Pollution

After air pollution, probably, the pollution of fresh water is one of the most serious one. In our country, most of the rivers and lakes are polluted and the waters of these sources are not only unfit for drinking but are acting as sources for many water borne diseases. These diseases may be listed as typhoid, hepatitis (jaundice), cholera, diarrhoea, and dysentery. Pollutants from different sources first enter surface waters. The important pollution causing sources can be listed as 1) power plants, fertilizer factories, steel mills, paper mills, sugar factories, refineries, automobile factories. The liquid effluents and the solid wastes from these factories are polluting the rivers, lakes and even oceans. 2) community wastes (sewage, garbage, used articles) from rural and urban areas are contributing to a great extent for water pollution. 3) fertilizers, pesticides insecticides and other agrochemicals used in the agricultural activities are also contributing to water pollution. Not only the surface waters but also the under ground water sources are widely polluted due to the absorption of these pollutants by the land and consequently by the under ground waters. 4) nuclear and thermal power stations use large volumes of water for cooling purposes. The discharged waste waters are not only hot but are also highly contaminated. These waters then enter the natural drinking water sources, pollute them badly. 5) acidic waters coming from mines and acid rains and the effluents from volcanic eruptions too are contributing to the surface water pollution heavily. 6) petroleum wells drilling operations and the oil spills arising through leakage of oil tanks are causing no less pollution. The sources of water pollution can be summarised pictorially as shown in the figure 18.2



18.2 Water pollution sources and causes

Generally we expect underground water sources to be free from pollution effects because the bacteria present in the soil usually removes most of the organic contaminants from surface waters before they reach the water bodies underneath the soil. But at many places underground water is found to be as much polluted as the surface waters with mostly inorganic pollutants such as metals, metal nitrates, chlorides and fluorides. This pollution seems to occur due to the seepage of 1) pollutants 2) the wastes burried in deep pits 3) the agricultural wastes (fertilizers, insecticides etc) 4) heavy metals such as lead, mercury from industrial wastes.

Mercury is the most dangerous metal that is entering the water sources from the industrial wastes (paper industry, agrochemical industry). Mercury generally gets concentrated in the food chain when it enters the same in the following way.

plants → large fish → human beings.

In 1950, an out-break of mercury poisoning occurred in Japan. The residents who ate sea food from Minimata Bay contaminated with methyl mercury developed a disease named afterwards as Minimata disease, Hundreds of people died. People suffering from this disease developed numbness of limbs, lips and tongue. Loss of muscle control, deafness. Blurring of vision and mental disorders are other ailments caused by the mercury pollution.

Eutrophication : Materials such as sewage, organic wastes from industries and run off from agricultural lands greatly increase the nutrients and hence the productivity of the water bodies. This in turn causes algae to grow in abundance. The entire water source gets covered by algae. This is called "algal bloom". Eventually the death of this algae converts the water bodies into debris. The dead and living algae consume lot of dissolved oxygen present in the waters. The fish will not have sufficient oxygen to breathe. Ultimately they die, the oxygen content is expressed in terms of COD (chemical oxygen demand) and BOD (biological oxygen demand). This excessive nourishment or nutrition leading to the loss of life in water bodies is named as **"eutrophication".** This can be prevented by treating the sewage for removal of nutrients from it, before the sewage is led into the water bodies. But this treatment is very expensive. Hence alternately this water is being now used for irrigation and to grow algae and aquatic plants in man made ponds. The biomass grown thus is now a days used in the preparation of biogas.

Thus water pollution can be traced to inorganic, organic, and metallic pollutants reaching the under ground waters through industrial, municipal and domestic wastes as well as from sewage, mining operations, and oil exploration activities of ONGC.

Check your Progress

1. Name any two sources .... and .... which cause water pollution.
2. The most dangerous metal that is polluting water bodies is ....
3. The mercury pollution leads to ...., ... and .... (name any three disorders)
4. The country that suffered from mercury pollution in 1950 is ....
5. What is eutrophication ?
6. Oxygen depletion in water sources is expressed quantitatively as .... and ....

Land Pollution

The land pollution is generally called 'soil pollution'. This problem is increasing rapidly in rural, urban and industrial areas. In rural areas the soil is polluted on account of non availability of toilet facilities. In industrial areas heavy metals, plastics and other non-biodegradable organic wastes are posing a threat to human life. The dangerous wastes in soil often accumulate in the bodies of living organisms including man. Once they enter the food chain they get concentrated at every stage. This is called bioconcentration. Therefore all industrial wastes are to be burnt completely or use of non-biodegradable materials must be strictly prohibited by laws. The bio accumulation or concentration is pictorially represented as shown in the figure 18.3

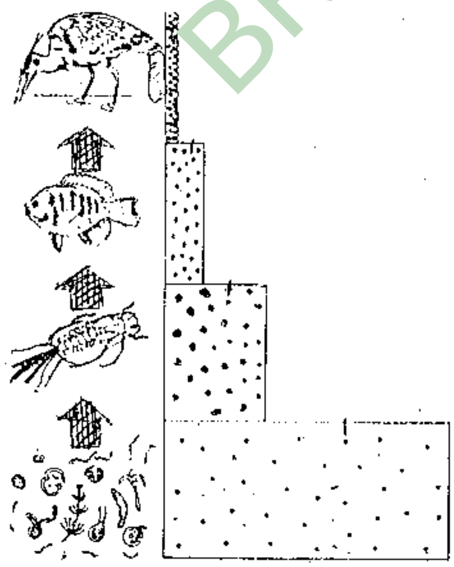


Figure 18.3 Bioaccumulation

Check your Progress

1. Name three common land pollutants....................., ..., ...
2. What is meant by bioaccumulation?
3. The land pollution in rural areas is mainly due to.................................. (human excreta. industrial wastes, power plants)

Sound Pollution

This is generally referred to as "noise pollution". Sound is an important means of communication. But high levels of sound are considered as noise and it could damage hearing, and can cause high blood pressure even. Unwanted and unpleasant sound is referred to as **noise.** The loudness of sound is measured in decibels (db). The sensitivity of ear varies from man to man. With ageing people lose hearing power progressively. The ear is susceptible to damage if it receives high intensity noise. However the ear has some natural protective devices through reflex actions.

Noise is classified into three categories (i) road traffic noise (ii) rail traffic noise (iii) aircraft noise

The Central Pollution Board (India) has prescribed the following permissible sound levels for cities divided into four zones.

Zone	Day	Night
Industrial	75 db	65 db
Commercial	65 db	55 db
Residential	50 db	45 db
Sensitive areas including hospitals, educational institutions, courts etc.	50 db	40 db

Permissible maximum noise levels are given in the table below

Situation	**Permissible level db**
Road traffic	70
Factory-work 8-hours/day per 6days	85

Check your Progress

1. What is noise pollution?

   ....

   ....

2. Name two sources for noise pollution .... and ....

3. Give the permissible sound levels for industrial, commercial and residential zones ...., ..., ...

4. Classify noise pollution.

Radiation Pollution

Pollution caused by radioactive emanations and nuclear radiations is generally referred to as **radiation pollution.** Environmental pollution is increasing rapidly due to extensive nuclear activities going on in many developed and developing countries. Nuclear power plants produce large quantities of nuclear wastes. These remain radioactive for long periods of time. Therefore the disposal of radioactive wastes must be done carefully and effectively. But no satisfactory waste disposal or waste storage methods are still available in many developing countries. The nuclear wastes pose a threat to human lives for thousands of years. For-example plutonium-239 remains in the biosphere for 20,000 years. The radio active particles emanating in nuclear explosions are carried to great distances by air currents.

The radio active materials therefore settle down in soils. Plants take up these from the soil. Animals, which eat these plants therefore deposit the radioactive materials in their flesh, milk and bones etc. Beyond a particular concentration, these radiations even destroy the tissues and cause death from cancer or tissue damages. USA used nuclear bombs against Japan in 1945 war. This not only caused many deaths by heat and blast in Hiroshima and Nagasaki (Japan cities) but effected the babies born afterwards. Adverse genetic changes tookplace in many babies. So there was a world wide movement to ban nuclear tests. India also has played a big role in this movement. The nuclear explosions may also likely to create what is known as "nuclear winter". If this happens the whole civilization may be extinguished. If such a catastrophy is to occur really, the attacker and the attacked and all other nations in the world would be there no more.

If even a very small fraction of the nuclear bombs available in the world are used in wars, the debris, dust, soot thrown out into the atmosphere will obstruct the reaching of solar heat to the earth for a considerable period. This causes what is called a "nuclear winter".

Check your Progress

1. What sources contribute to the pollution caused by radioactivity ? .... and ....

2. What is nuclear winter ?

18.5 HEALTH HAZARDS

Air Pollution

1. Smoke and fumes tend to increase the atmospheric turbidity and reduces the visibility and the quantum of solar radiation reaching the earth's surface.

2. Plants are severely affected by gaseous pollutants and particulates. The dust, soot, metals etc deposited on plant leaves block the stomata of plants. This reduces the rate of photosynthesis and respiration in plants.

3. The enzyme activity in plants is effected by PAN

4. CO, in air reacts with hemoglobin of blood and reduces its oxygen carrying capacity. This leads to suffocation and eventually to death.

5. Gaseous pollutants such as NOx, SOx get deposited in human lungs and respiratory tracts. This causes chronic lung diseases such as cancer, bronchitis etc.

6. Photochemical smog caused by hydrocarbon pollution is known to kill hundreds of people every year in many western countries.

7. NOx and SOx pollutants are indirectly responsible for acid rain which causes damage to marine life as well as to big constructions, statues, monuments, etc. Tajmahal in India is no expection to this effect.

8. Silica & asbestos are causing the diseases silicosis and asbestosis respectively.

9. Accumulation of carbondioxide in large quantities is causing green house effect. This inturn increases the earth's surface temperature. This rise in temperature is indirectly contributing to the increase of sea level. This increase in sea level may lead even to the submerging of many island countries

10. Chlorofluorocarbons (CFC) entering the atmosphere cause the depletion of the ozone layer in the atmosphere and eventually lead to skin cancer.

Water Pollution

1. Water is the carrier of pathogenic bacteria and causes immense harm to public health. The water borne diseases typhoid, dysentry, cholera, polio and infective haepatitis are caused by water polluted by human faeces and urine.

2. Sewage and run off from agricultural lands cause eutrophication. This in turn converts water bodies first into debrises and finally into drylands.

3. Organic pollutants and oil spills reduce light transmission through surface waters. Photosynthesis by marine plants therefore is impaired and dissolved oxygen (DO) content will be decreased. This causes damage to water birds, coastal plants and animals. It also effects the sea food which enters the human food chain.

4. Introduction of toxic substances such as phenols, cyanides, lead, zinc, mercury etc makes the water poisonous.

5. Sewage, garbage, and organic materials present in polluted waters kill the fish because of suffocation.

6. Acid rain eliminates the aquatic flora and fauna.

7. Mercury reaching water sources through the effluents from leather industries, plastic industries enters the food web through use of bacteria, algae, fish etc. This mercury polluted water causes the dreadful disease known as minamata disease.

8. The pesticides, and the fungicide residues of the soil enter the bodies of aquatic organisms through the process of bio-accumulation. As a result of this these organisms die at an alarming rate.

Land Pollution

1. Toxic metals such as zinc, cadmium render plants grown in these soils unsafe for human and animal consumption.

2. Fungicides, fertilizers and fumigants pollute the agricultural lands and cause extensive damage to the vegetation since most of the useful micro-organisms are killed by these chemicals in the soil.

3. Forest deterioration occurs due to acid rain

4. Soil erosion causes the formation of deserts.

5. Acid rain kills also the nitrogen fixing bacteria in the soil.

Some important pollution ill happenings that occured during last few decades

Bhopal disaster

All of us are aware of the disaster that occured in Bhopal (M.P) on 3rd december 1984. Poisonous MIC (Methyl Iso Cyanate) gas had leaked out in large amounts from pesticides manufacturing plant owned by a multinational company called Union Carbide. Thousands of human beings and animals died and many more thousands were subjected to respiratory, neuromuscular and gynaecological problems.

The Chernobyl disaster

This is a nuclear radiation disaster that has happened in the Ukrain (Russia) on "April 26th 1986. One of the power reactors got over-heated and is supposed to have melted. As a result radio active materials from the reactor got evaporated and spread into the atmosphere. It is the biggest nuclear power generation disaster that occurred. 31 persons were killed and still larger numbers of persons were affected by radio active emanations. It is estimated that in next 70 years over 6000 deaths are likely to occur due to cancer on account of this disaster.

Ganga disaster : Water Pollution

The water of the river Ganges once considered as the purest and sacred has over the years became polluted by industrial effluents, garbage from cities and partially burnt human dead bodies. Efforts are now being made to clean the river and make it fit for human, industrial and agricultural consumption.

18.6 ENVIRONMENTAL PROTECTION LAWS

India is one of the few countries which promulgated legal acts to protect the human environment. Before 1984, there were three main acts. These are :

1) The Water (Prevention and Control of Pollution) Act 1974.
2) The Water (Prevention and Control of Pollution) cess Act 1977.
3) Air (Prevention and Control of Pollution) Act 1981.

After Bhopal accident some more acts were introduced. These are

(i) 1987 revised Act of 1948, Factories Act and
(ii) Environmental Protection Act 1948. This is also called EPA, 1986. The main aspects of this act are :

1) Bringing hazardous chemicals also under the perview of this act.
2) Punishing the industrial persons responsible for these chemicals.
3) Ministry of Environment and Forests (MOEF) is given the powers to punish people who violated the acts relating to the release of the hazardous chemicals into the environment
4) Providing powers to punish the industrial managements responsible for the pollution.

Indian government issued a notification in 1994 January. According to this, no one should start an industry without the permission of the pollution board. Industries must submit annual environment statements to the board.

18.7 SUMMARY

1) The human environment consists of air, water, and land.

2) The industrial developments, the revolutionary changes that took place in agricultural practices and food production methods, the technological and scientific developments and above all the tremondous population growth that took place in the past few decades polluted the human environment to the dangerous levels.

3) The wastes from human community and industry are eventually deposited in water, air and land. This deposition of unwanted and unwarranted chemical substances in the environment is defined as environmental chemical pollution.

4) Besides these chemical substances, high sounds, high levels of heat and harmful nuclear and radioactive emanations are posing a great threat to human and other forms of life on this earth.

5) Persistent pollutants are those that remain in the environment for many years in an unchanged condition. Many of these are toxic in nature.

6) Carbonmonoxide, hydrocarbons, particulates, oxides of sulphur (SOx) and oxides of nitrogen (NOx) are the primary air pollutants.

7) The major sources of water pollution are municipal sewage, industrial wastes, and agricultural run offs.

8) Organic matter in polluted water requires dissolved oxygen for its decomposition. Therefore dissolved oxygen is depleted in polluted waters. This causes the death of fish and other marine organisms living in these waters.

9) Addition of excessive nutrients through detergents, sewage etc, to the water bodies is causing eutrophication.

10) Radio active wastes are a great threat to human life and their disposal (waste disposal) demands the adoption of special methods.

11) As well as some of the important and most dangerous hazards likely to be caused by environmental pollution are

— green house effect caused by carbondioxide accumulation leading to global warming and eventual submerging of island countries.

— eutrophication leading to "algal bloom" caused by overnutrition of water bodies

— ozone depletion in the atmosphere caused by CFCs which is likely to cause skin cancer

— nuclear winter caused by nuclear radiation pollution

— acid rain caused by the oxides of nitrogen and sulphur

— photochemical smog caused by hydrocarbons in the environment.

— silicosis and asbestosis diseases caused by the particulate matter ejected by cement and asbestos industries respectively.

12) But it is hoped that environmental protection laws, use of modern technology and awareness amongst people would certainly take us towards the preservation and improvement of the environment.

18.8 TERMINAL EXAMINATION MODEL QUESTIONS

I. **Answer the following in about 30 lines.**

1. Give a detailed account of air pollution with reference to air pollutants, sources of air pollutants, and hazards caused by these pollutants.
2. What is water pollution ? How is water polluted ? What are the adverse effects caused by water pollution.
3. Explain the term "land or soil pollution" with examples. What are the causes for this soil pollution ? List out the hazards caused by the land pollution.
4. Explain the terms with suitable examples.
   sound pollution or noise pollution, radiation pollution.
   eutrophication.

II. **Answer the following in 15 lines**

1. What is environmental pollution ?
2. Give the causes for air pollution.
3. What are the hazards caused by air pollution ?
4. What is water pollution? Illustrate with examples ?
5. What are the ill effects caused by water pollution ?
6. What is soil pollution ? give reasons for the same.
7. What bad effects are caused by land pollution ? Illustrate with examples.
8. What is green house effect ? explain.
9. Explain the term "eutrophication" and give reasons for the same.
10. What is acid rain ? How is it caused ?
11. What are the ill-effects caused by acid rain ?
12. What is ozone depletion ? How is it caused ?
13. Describe the ill-effects caused by metal pollution in air and water.
14. What is bio-concentration ? Explain with examples.
15. How is dissolved oxygen content in waters affected by water pollution ? What are its ill-effects ?

18.9 GLOSSARY

1. Pollutant	:	a chemical substance that enters the environment and causes its deterioration.
2. Eutrophication	:	increasing of productivty of waters due to large accumulation of nutrients and causing of algal bloom.
3. Green house effect	:	global warming caused by accumulation of CO_2, CH_4, CFC in air.
4. Ozone depletion	:	depletion of ozone concentration in the atmosphere due to the chemical action of chlorofluorocarbons mainly on ozone.
5. Bioconcentration	:	the process of concentration of organic pollutants in living organisms during their passage from the producers to the consumers.
6. Noise pollution	:	adverse effects caused by high level sounds.
7. Nuclear winter	:	due to accumulation of radio active particles and dust in the atmosphere, the heat does not reach the earth atmosphere. Hence environment cools down the earth. This is called nuclear winter.

BLOCK V FOOD AND NUTRITION

For any society food and nutrition are very important for a healthy living and long life.

Agriculture, poultry, fisheries and flora and fauna play a significant role in the food production. Food production alone is not the only essential responsibility of human activity, control of population growth and prevention of some food problems such as food adultration, food fads are also equally important.

Food does not mean "mere availability" of some eating material. It should be hygenic and nutritious. So one should know the required nutrients and how these can be incorporated into our food. Mal-nutrition causes ill-health. Ill-health manifests itself in the form of diseases. These may be infectious, chronic and even deadly. **Always prevention of diseases is better than the cure of diseases.** Food production will be very large in certain seasons and will be almost absent in other seasons. Therefore one should know how to preserve food and use it at the time of need. You must also know how science and technology come to our help in increasing food production by means of green revolution and white revolution etc.,

Therefore this block is designed in such a way that you will learn about the food needs, food values, food production and food preservation. You will become aware of the great revolutions brought in by science and technology in the production of food grains, milk and animal wealth.

The block contains 4 units namely

Unit-19 Agriculture and Population

Unit-20 Nutrition and World Outlook

Unit-21 Health and Diseases

Unit-22 Food Production and Preservation

After you completed this block you must be able to

1. know about the basic resources of agriculture, plant and animal wealth of India and elsewhere
2. appreciate the compelling aspects of food nutrition.
3. understand the diseases and ill-effects caused by consuming unhygenic and unbalanced diet.
4. know about the different diseases caused by malnutrition and also about what is malnutrition. List out the diseases caused by various agencies and how these diseases can be prevented.
5. acquaint yourself with the scientific and technological advances that took place in the fields of agriculture, milk production and fisheries and poultries.
6. know the different preservation techniques followed to store food when it is available in plenty.

We are sure that after you completed successfully, the reading of these four units in the block, You feel for yourself that your knowledge about food production techniques, food preservation methods and the ill-effects caused by malnutrition and unhygenic food has improved to a great extent.

UNIT-19 AGRICULTURE AND POPULATION

Contents

19.1 AIMS AND OBJECTIVES

Aims

In this unit you will learn about

1. the present and past views of agriculture in India.
2. plant and animal wealth of India is enormous. So you learn about these in some detail.
3. food is important to all of us. But there are many issues concerned with these foods namely food fads, and food allergies
4. adulterations of food
5. the food production problems in relation to population growth.

Objectives

After you completed the reading of this unit you must be in a position to

1. understand the basic problems of agriculture in India
2. know the live-stock positions in India
3. learn about the poultry and fisheries facilities and developments.
4. assess the harmful effects, allergies caused by certain types of foods
5. realise the problems associated with the food production and population explosion.

19.2 INTRODUCTION

Food is one of the primary needs of all living organisms. Food is basically of different types. There are plant foods and foods derived from non-plant things. Non-plant food resources comprise of live stock, poultry, fisheries. Food is not only necessary for survival but it must also be nutritive, hygenic and free from all ill health causing contaminants. Food adulteration is one great menace, human beings are facing these days. Some foods also cause allergies. So you will learn all about those aspects in this unit. Another most important aspect of food science is the social aspect. With all our scientific and technological development in food production many of our fellow citizens are starving. The main reasons for this alarming situation are population explosion and poverty. So you will also learn about these problems in this unit.

19.3 AGRICULTURE IN INDIA

India is basically an agricultural country. Indian economy is to a large extent dependent on its agricultural economy. But the majority of our farmers are very poor. This may perhaps be due to the fact that many farmers are unable to put the required inputs to get the maximum production or yields from their land. For a long time agriculture in India was labour oriented and many of our poor citizens were able to earn their livelihood as agricultural labourers. But the introduction of several labour-reducing technology in agriculture had thrown out more of our agricultural workers from their jobs or employment. This created to some extent rural poverty and hence social unrest. Eventhough we have a large geographical area, the net area under cultivation is only nearly one third of it only. We have large wastelands, hill areas and forest areas. So modern methods are being found to bring all these lands under cultivation. But it is realised that besides agriculture, animal wealth of India is required to be developed to meet the food needs of India. Hence livestock rearing, poultry industry and fisheries are simultaneously developed.

You learn about all these aspects in this unit.

19.4 PLANT AND ANIMAL WEALTH OF INDIA

We have in India a very large number of plant species. This is due to great diversity in climate and soils. But only a few species are cultivated. These include rice, minor millets, pulses, beans, cotton, jute, black pepper, cardamom, ginger, turmeric and many medicinal plants. India has large animal wealth also. These include cattle, fowls, sheep, goats, pigs, fish etc.,

Amongst the cattle and buffaloes the humped varieties originated in India only. There were indications that even in 2400 BC there were humpless cattle in Gujarat and Rajasthan. The ploughed fields were there even in 2400 BC in Rajasthan. The origin of the world's poultry was traced to the red Jungle fowl of Madhya Pradesh. But the plants and the animals that we use now presently in our country are all not natives of our country. Some of them were brought from different parts of the globe. India was making business with many countries in the east and the west. During these large periods of business and trade, large number of plants and domestic animals were introduced into our country. For example barley, wheat, onion, garlic, beetroot, carrot, radish, coriander, poppy, and alfa-alfa are some of the plant varieties, India imported from western asia. Sorghum, castor, sesame and coffee were imported from Africa. Soyabeans, apricot, walnut and tea were brought into India from china. Maize, potato, tobacco, sweet potato, tomato, chilli, pumpkin, custard apple and ground nut were also brought to India from America, a new nation. But soon all these became native plants and adjusted themselves to our soils and climates.

The humpless breeds of cattle are considered to have originated in europe. But some were there in India too in the Harappan period. Swamp buffaloes were found in the beginning in south-east asia.

It is for this reason we in our state say padi (animal wealth) and panta (plant wealth.)

Check your progress.

1. What is live stock?

....

....

2. What is our position about the livestock in India?

....

....

....

3. What for are sheep & goats used?

....

....

....

4. Give plant and animal wealth of India.

....

....

....

19.5 LIVE STOCK

The animal wealth which provides us milk, meat, eggs, wool, skins, and similar by-products and which provides necessary power needed for traditional agricultural practices are generally referred to as Live Stock. Practically every village and every family of the village in India are involved in the domestication of animals. These domestic animals provide livelihood and employment to the people of the village.

The Live Stock of India to-day is considerably large. We have millions of cattle, buffaloes, sheep, goats, horses, camels and other live stocks. Besides these we have also fowls, ducks, turkey-birds. Therefore we can say that India is very rich in animal wealth. After independence, cattle farms, poultries and fisheries increased by leaps and bounds. Many marginal farmers take their livelihood and other benefits from the Live-Stock only.

We can generally consider the live stock under the following categories:

1) cattle 2) sheep and goats and 3) pigs.

Cattle

The cattle are generally considered (1) as humped cattle and (2) humpless cattle. The humped *zebu* cattle originated in India while humpless *taurus* breeds are considered to have originated in europe. But there were evidences that the humpless cattle were domesticated in India as early as the Harappan period. The milk producing cattle are called *milch breeds*. We have several types of these in India now. The animals used for work are called *draught breeds*. There are also breeds useful for both purposes. These are known as *dual breeds*.

Some of the milch breeds are *Gir, Redsindhi* and *Deoni*. The draught breeds include *Nagari, Malvi, Khillari, Ponwari, Siri* and *Kangayani.*

Among the *"dual breeds"*, *Hariana, Rewati, Ongole* and *Tharparkar* are the popular ones. We have also the best water buffaloes. For example *Murrah, Surti, Nili Ravi, Mehsana* are those which are imported by many other countries for developing animals useful to them. Swamp buffaloes which are generally seen in south-east asian countries are also found in coastal regions of our country.

In the olden days milk production was confined to small families only in the villages. This may be perhaps due to their economic conditions as well as due to lack of transport facilities. So milch cattle were selected on this basis only for domestication. They used to select the breeds which give enough milk for the family needs. So even the best milk yielding varieties were never fully utilised in our country. They were giving milk which is actually 25% of what was given by similar cattle in europe. But now the whole picture changed slowly after independence. White revolution took place and community milk projects, state owned dairy farms and private managed big dairy farms came into existence. Even people in villages deposit the milk obtained from their domestic animals in the milk centres. Thus the *milk* is pooled up, pasturised, treated and packeted by the dairy farms. We all now know that in cities and towns, people purchase only the packeted milk but not the loose milk sold by the village people. Nobody now feels the scarcity of milk even on festive occasions, when we need large quantities of milk. Milk is also treated by adding or removing fats suited for different purposes. Different types of milk products are also prepared and sold authentically. The country today has about half a million dairy cows and about 30 million buffaloes. These give 1000 to 1500 litres per lactation. The lactation period is the milk secreting period after the birth of a calf. High yielding breeds give 5000-6000 litres. Jersey cows give 4000 litres per lactation.

Sheep

The common breeds of sheep are *Kashmir, Gaddi, Magra, Kali, Bellary* and *Nilgiri*. Sheep are generally useful for producing wool. The wool may be short or long. The short wool is useful for making carpets while long wool is used for making clothes. Therefore native sheep requires to be improved in quality by cross breeding with imported australian sheep. Generally *Merino* and *Suffolk* breeds are used for this purpose of cross breeding. India is the sixth largest country in the sheep population. But we do not see large flocks of sheep in our country as in Australia or NewZealand.

Goats

These are considered as poor man's cows in India. It is an animal which can be easily maintained by even marginal farmers. Its milk contains 4% fat. Goat meat and skin are in great demand in our country. *Pashmina* and *Chegu* breeds produce soft and warm fibres which are useful for making shawls. Goats demand clean and fresh food put in clean containers. Goats and sheep differ in their food habits.

Health care and proper medication are both important to maintain our animals in a fit and productive condition.

Check your progress

1. Write about the different types of breeds you know of sheep, goat etc.,

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2. What for goats used in our country?

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19.6 POULTRY AND FISHERIES

Poultry

The industry organised for the production of eggs is broadly called *poultry* industry. Our poultry industry had grown enormously in the last two decades. It is estimated that our poultry products today cost about Rs. 10,000 million. The production of eggs and broilers about one and half decade back is 14000 million eggs and 52 million broilers. The production rate had gone up by 500% now. Intensive researches carried out on poultry nutrition helped us to reduce the feed requirement from 6kg to 2kg. for the production of 1kg live weight broiler or one dozen eggs. We are now able to produce all the medicines required for poultry health. The fowls trace their origin to Red Jungle fowls of India. Ducks need more water than the fowls. Ducks can live on water-borne organisms.

Fisheries

The fish producing and catching activities together are called *"Fishery"*. Fish are naturally available in fresh water sources as well as in seas. (marine). Both fresh water and marine water fish are the excellent sources of animal proteins. They grow rapidly and feed on plankton, weeds and other water-borne small organisms. India is producing every year 5-6 million tonnes of fish. India is occupying an eighth place in fish production in the world. It is estimated that fish production in India will go up to 12 million tonnes because we have a long coastline and a large adjoining area of water which can be used for fishing. The fish production in India pertains to fresh water, brackish waters and estuaries. Our present catch from the seas is about 2-3 million tonnes. It is possible to increase this in future. Modern technology such as remote-sensing and satellite pictures are now employed in locating fish concentrated regions. Mechanised boats and vessels are used in fish catching activities. The storage facilities such as cold storage and canning are also improved to preserve the fish. M.V. Saraswati is one of the vessels used in our fisheries.

Fish industry relating to inland waters is of two types (1) "Catching" type and (2) "Culturing" type. Catching type refers to the catch of fish from rivers and reservoirs. On the other hand in culture type fisheries, the fish are first grown in ponds, pools and swamps. These are then caught when they grow up to the required size. Pond culture of fish is very common in our country. The average production is above 1000 kg/hectare in an year. The ponds are generally filled with three types of fish. Some feed at the bottom, some at middle level and the other at the surface level of the pond. This is known as *composite fish culture. Integrated fish culture* is also being followed now in India. This involves rearing of compatible species of fish, prawn, frogs and ducks.

Check your progress

1. What is poultry?

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2. What is fishery?

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3. How are fish produced in India?

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4. What is the position of poultry in India?

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19.7 FOOD FADS

These are some of the food practices followed by our old family members. It is not known clearly how these ideas came to our people of older generations. But these practices are followed in all parts of the country. These relate to some recommended and not recommended food combinations. These combinations are either followed or rejected blindly. There is no scientific basis for these recommendations or rejections. For example people were believing that fish and milk or radish and milk should not be taken together. If these are taken together, it may lead to the onset of disease called *leucoderma* or white patches on the skin. Milk should not be taken immediately after taking curd or after taking fruits. People are afraid that milk gets converted into curd in the stomach.

Similarly some food combinations are recommended to cure some ailments or diseases. Sometimes these are really good but many times they are proved to do harm than good. There is really no scientific basis for these recommendations also. If such combinations are followed for long periods, some essential nutrients may be missed. The concept of balanced diet goes sometimes against these combinations. So doctors must be consulted before such combinations are practiced.

19.8 FOOD ALLERGIES, FOOD ADULTERATIONS

Food fads are different from food allergies. These allergies have some scientific basis. Some foods will have strange adverse reactions on some people. Some people get skin rashes everytime they eat eggs. Allergy is the scientific name given to a disturbance which arises when a person is sensitive to a substance. Some people are allergic not only to certain food stuffs but also to some non-food environmental conditions. For example people are allergic to some vegetables, some smells and some factors such as dust, pollen etc. Foods which caused allergies to people are fish, eggs, milk and milk products. Generally the allergy causing compounds are proteins. Food allergies are manifested in the form of skin rashes skin eruptions, asthma, frequent sneezing, one-sided severe headache called migraine, vomiting, diarrhoea etc.,

Adulteration is a practice of adding cheap, but many a time, harmful substances to food materials to gain some temporary gains. The added substance should mix well with the food material and it should not be possible to identify its presence externally. The substance added is called *adulterant*. But not always the adulterant is harmful but definitely it reduces the quality of the main food substance. For example pure ghee is adulterated with dalda. Some costly cooking oils are adulterated with cheaper oils or even mineral oils. They are also flavoured with chemicals which are considered as adulterants. Rice and pulses sold are generally mixed with stones. Even milk is adulterated with water, many a time with unclean water. Wheat flour is adulterated with chalk powder. In many cases the adulterant may even cause death or even dreadful diseases. For example adulteration of mustard oil with argemone oil results in paralysis. Bengalgram dal is mixed with Khesari dal which causes lathyrism a disease characterised by paralysis of the legs. Turmeric is often adulterated with a poisonous substance called "metanic yellow". This may cause cancer.

Even food advertising agencies mislead people by false claims.

Thus these dangerous trends can be controlled only through governmental actions or by consumer welfare societies. In other countries these consumer societies are very powerful. These days such societies are gaining importance in India too.

Check your progress

1. What is food fad?

2. Give an example of a food fad

3. What is food adulteration ?

4. Give an example of food adulteration

5. Name two allergies arising out of food adulteration.

19.9 POPULATION GROWTH AND FOOD PROBLEMS

There are no reliable data as to the total world population through out most of man's recorded history. In the early part of 17th century the world population is put at 400 millions, while India's population is placed at 100 millions. By the year 1830 the world population was double the figure mentioned. The estimates of population during 1996 were as follows - world population 4.5 billion, India: 680 million. India was considered to have about 15% of the world population. But India has only 2.4% of the world's surface area of 35.9 million square kilometres. Population experts are very much worried that the growth of population is alarmingly high. They predicted that by 2000 AD for every 100 people on earth 58 would be Asians, 13 Africans, 10 Latin Americans, 9 Europeans, 5 Russians and 5 North Americans. Some years ago pessimistic estimates, had suggested that the world population may stabilize at 80 billion. But United Nations Fund for Population Activities (UNFPA) predicts that the stabilisation will occur at around 12-15 billion in the last quarter of the next century. Of the existing world population nearly 500 million are exposed to malnutrition a billion do not have clean water. 800 millions or more are illiterates and 350 millions are unemployed or earn less than 400 rupees. Not less than 250 millions live in slums and 1.6 billions do not have basic health care. It would be instructive indeed to see which way our numbers have tended in the last three decades. On April 1, 1971 (Census Day) there were 547, 949, 809 people in India. This is about 15.3% of the world's population. The increase from 1961-1971 was 108.8 million at a rate of 24.7% for the decade. So this country added to its people a number equal to the total population of Japan plus some more. The population had numbered 357 million in 1951 and it is 680 million in 1981. In 30 years, the number is nearly doubled.

The population growth's effect on housing, education, jobs and also on food situation is alarming. The very substantial increments in agricultural production has not provided much benefit on a person basis. The increase is found to be something like a drop of nector dispersed in an ocean of water.

Therefore efforts must be made to prevent population growth or at least minimise the rate of population growth. This population control can be successfully achieved through different birth control programmes as well as through planned social welfare programmes.

1) can these be achieved if we do not tackle the staggering illiteracy problems?

2) would a rural farmer with no security in oldage or otherwise risk a small family?

are some of the important questions facing the governments and the social organisations.

Even though food production had increased significantly as a result of green revolution, many are not in a position to purchase the food in view of their poverty. Hence population explosion, poverty increase and increased food production are all most viciously and in complex fashion related.

19.10 SUMMARY

In this unit you have learnt that

1. Our country is an agriculture based country and the agricultural products contribute significantly to our economy.
2. The livestock constitutes our additional food resource.
3. We have produced highly improved breeds of live stock.
4. Some breeds are meant for milk production and some are for labour and some are for both.
5. Fisheries, both marine and inland have improved greatly. But its potential is not yet fully traped.
6. Poultry industry expanded enormously in India.
7. About all the world's fowls trace their origin to the Red Jungle fowls in India.
8. Researches conducted in India had enabled us to evolve better broiler strains.
9. We are able to produce more live-weight broilers and eggs of good quality using less feed for them.
10. People in India and even in other countries are very much influenced by food fads. There are some combinations of foods which are not permitted or are recommended for good health. These are based on mostly unlogical beliefs rather than on any scientific principles.
11. Many people also suffer from food allergies. Some people are adversely sensitive to some foods. If these foods are consumed by them, they experience some skin problems.
12. Adulterated foods are those which are contaminated with subtances harmful to human health.
13. These adulterations are done intentionally or these occur accidently.
14. Population is increasing enormously and at the same time food production is also increasing. But there is no compatability between these two.
15. Further many people are not in a position to purchase food even if it is available.
16. Hence food problems in India are to be tackled in an integrated fashion instead of individually

19.11 TERMINAL EXAMINATION MODEL QUESTIONS

I. Answer the following in about 30 lines each.

1. Give a detail account of animal and plant wealth of India
2. Write about cattle, poultry, & fisheries of India.
3. Discuss about marine and fresh water fishery.
4. What are food fads, food adulterations and food allergies? give examples.

II Answer the following in about 15 lines each.

1. What is the cattle population in India?
2. Give an account of sheeps & goats of India.
3. What is poultry? How is it in India?
4. Give a note on fisheries in India.

5. What are food fads & food adulterations?

6. Explain the term food allergies with examples.

19.12 GLOSSARY

1. Food fad:	some unscientific views about prohibited food combinations.
2. Food adulterations:	food contaminants added in harmfully.
3. Food allergies:	some type of skin diseases & other ailments caused by certain type of foods.
4. Poultry:	fowls rearing industry to produce eggs.
5. Fisheries:	rearing and culturing of fishes.

UNIT-20 NUTRITION AND WORLD OUTLOOK

Contents

20.1 AIMS AND OBJECTIVES

Aims

The unit describes

1. the food requirements and the role of a proper diet for an individual.
2. the recommended daily dietary allowances and composition of an average diet of an Indian.

Objectives

After going through this unit you would be able to

1. explain the importance of proper diet for an individual.
2. discuss the recommended daily dietary allowances for individuals of different age groups and different physiological status.
3. explain what nutritionists thought our diet should be like
4. explain energy needs of various physical activities and the calorific contents of foods
5. discuss the food needs of mankind and world outlook about it.

20.2 INTRODUCTION

In the last unit you have studied about the limitations in respect of availability, quality and distribution of food in our country. A large section of our population is still undernourished. The food available to them is deficient not only in the quantity but also in the nutritional values of it. People living in the rural areas are also not aware of the proper nutritional diet. Even at present many of us attach lot of importance to the taste aspect of the food rather than to the quality (nutritional value) of the food. One may consume large quantities of food and yet remain unhealthy. This is because food choices of people are influenced by the economic, the social, the educational and the cultural factors but not so much by their nutritional values. You learn in this unit therefore the real requirements of a nutritive food and the health disorders caused by taking foods not having the required nutritive values. You will also learn about, the concept of a balanced diet. Many times you notice that families with large incomes are also poorly nourished and the families with small incomes are better nourished. This only suggests that the members of the large income family are not aware of the nutritional values of different food stuffs. You will also learn in this unit some problems of mal-nutrition and the magnitude of these problems.

20.3 NUTRITION

People need food to live. Our hunger can be satisfied by any kind of food we take. But to remain healthy and free from diseases we require certain kinds of food. The health of a person is largely determined by the quality of the food he eats. Quality of food does not mean the physical appearence of the food. Foods vary in their compositions. No one type of food may contain all we need in the amounts that we need.

A meal lacking in the required components in the desirable proportions, if eaten for prolonged periods can cause diseases and even death.

The food requirements of an individual for healthy living is referred to as "nutrition". Therefore nutrition concerns itself with the food needs of any organism for its proper growth and sustenance. All organisms depend on their environment for food. So does man. Man can also manipulate the environment for his physical and biological fitness and survival.

In a day, an adult man may consume about 1.2 to 1.5 kilograms of food or in an year an average 450 kilograms of food. But he shows little change in his body weight. The food provides the necessary energy for the growth. The food demands may vary from day to day depending on the physical work or the temperature of the environment. For example a labourer may need less food on holidays than on the work days. A soldier may need more food in war time than in the peace time.

Therefore a knowledge of the food requirements of our body and various sources of obtaining them is essential. A majority of the children of the developing countries of Asia, Africa and Latin America are generally poorly nourished. Some of them do not get enough to eat while the diet of others is deficient in some foods that are essential for the body. Therefore a steady retardation in the physical and mental growth of these children is noticed.

Check your progress

1. What is nutrition?

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2. Name few nutrients of our daily food.

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3. How much food is consumed by an average adult in a day?

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20.4 NUTRIENT GROUPS AND THEIR FUNCTIONS

Our body is made up of different chemical substances. These are also related to the food we take. Scientists have determined the chemical substances present in different foods and their role in the body. These substances are called "nutrients". These nutrients are classified into different groups.

Man requires continuous flow of energy for his survival. Nutrition provides this: The food that man takes in contains six major components. These are *carbohydrates, proteins, fats,* *vitamins, minerals* and *water.* Generally non-nutrive components of food and the waste materials that result in the course of metabolism are thrown out of the system through sweat, faeces, and urine. Many body functions are involuntary. The major voluntary action a man can perform in ensuring for himself a healthy body is in choosing and eating proper food. Unlike some of the lower micro organisms and plants, man does not have the capacity to synthesise for himself certain essential body constituents such as essential amino acids essential fatty acids and vitamins. Several metals are also required in trace quantities. We know that food habits vary from place to place all over India. Chapatis are the staple food in many parts of north India and rice is the staple food in south and east India. People in other countries also have their choices and preferences. These habits may be mostly due to the availability of a particular type of food stuff. Any way no particular food is absolutely necessary, because many alternatives to it can provide the same nutrients. We must also know that no single item of food contains exactly the same nutrients as any other single item.

Recommended daily dietary allowances

For any organism and for any man there can be a minimum daily requirement of nutritional needs.

The nutrition experts recommend different daily allowances for individuals of different age groups and different physiological status. It is desirable, if possible that every meal and the daily food be complete and balanced. This means that all the needed ingredients of diet should be present in right proportions for optimum nutrition. A list of recommended daily allowances is given in the table 20.1

Table 20.1 Recommended daily dietary allowances.

Age, Weight & Nutrients	Man	Woman Normal	Lactating	Pregnant	Children	Boys	Girls
Age(years)	18-35	18-35	18-35	18-35	1-3	15-18	15-18
Weight(kg)	70	59	59	59	13	59	54
Calories	2800	2000	2200	3000	1250	3400	2300
Proteins (grms)	65	55	75	95	25	60	55
Calcium	0.8	0.8	1.3	1.3	0.8	1.4	1.3
Iron (mg)	10	15	20	20	8	15	15
Vitamin A (mg)	1.7	1.7	2.06	2.75	0.09	2.06	2.7
Vitamin B_1 (mg)	1.4	1.0	1.2	1.4	0.5	1.4	0.6
Vitamin B_2 (mg)	1.7	1.5	1.8	2.1	0.8	2.0	0.8
Niacin(mg)	18	13	10	20	9	22	30
Vitamin D (mg)	1.0	0.1	0.1	0.1	0.1	0.1	0.1

The list is not complete or exhaustive.

The table shows that a pregnant woman's needs are greater than a non-pregnant woman. This is because her nutrition must also take care of the health growth of the foetus. A mother who breast feeds her infant has also a greater food demand. Prolonged or severe deficit of essential ingredients will cause nutritional deficiency disorders.

In order to get an idea about the nutrients of food. let us examine some ingredients of Indian food.

Tabel 20.2 Nutrients class and food groups of Indian foods

Ingredient	Class of Nutrients
Rice	Carbohydrates
Chapati	Carbohydrates
Potatoes	Carbohydrates
Peas	Carbohydrates
Tomatoes	Vitamins & minerals
Onions	Minerals
Spices	Minerals
Ghee/oil	Fats
Cereals & millets	Carbohydrates, proteins, Iron, Vitamin B group.
Pulses	Proteins, Iron.
Milk products (curds etc)	Fats, proteins, vitamins
Meats, fish, eggs	Proteins, vitamins
Sugar	Carbohydrates
Vegetables & fruits	Vitamins & minerals
Roots & tubers	Carbohydrates

Average Indian diet - composition and nutritive values

The food habits have an intimate relation to agricultural practices, the socio-economic situations, income, purchasing power and family traditions.

Table 20.3 Composition of an average Indian diet

Food component	Weight (gms)
Cereals	471
Milk	80
Pulses	68
Leafy vegetables	20
Other vegetables	91
Oils & fats	14
Sugar & jaggery	20
Meat, fish, eggs	14
Fruits&nuts	6

Nutrients present in and their nutritive values of an average Indian diet are given in the following table 20.4

Table 20.4 Nutrients of an average Indian diet and their nutritive values

Nutrients	Nutritive value (gms)
Proteins	58
Fats	29
Carbohydrates	405
Calcium	0.6
Phosphorus	1.3
Iron	0.031
Vitamin A	0.00041
Vitamin C	0.0017
Calories	2,100

Check your progress

1. What are nutrients groups, name them?

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2. What are the recommended daily dietary allowances of calories and proteins for adults (men) and girls (15-18 years)?

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3. What is the composition of an average Indian diet?

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4. Give the nutritive values of proteins, carbohydrates, fats, vitamins in groups.

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20.5 ESSENTIAL NUTRIENTS

Human body is a *biochemical factory.* This prepares compounds for its use. But this factory can not prepare all the required compounds. Hence these compounds are supplied from outside indirectly in the form of foods. Hence suitable choice of foods is very necessary. Such compounds are called essential nutrients. Each nutrient may have many components. For example proteins consist of 12 to 20 different amino acids. Ten of these can not be synthesised in the human factory. These are to be provided from outside through diet. These are called *essential amino acids* since they cannot be prepared in the body. The other amino acids which the body can prepare from only protein food are called *non-essential amino acids.* Similarly many *vitamins, minerals* and *fatty acids* cannot be made in the body. These must be included in the diet.

Proteins

These may be plant proteins (grains, pulses, nuts) or animal proteins (milk, fish, meat and eggs). But the nutritive values differ. Animal proteins have all the essential amino acids. Hence these are called *complete proteins.* Plant proteins are *incomplete proteins.* But a combination of plant proteins may supply all the amino acids an animal protein supplies. Thus a mixture of cereals and pulses supplies all the required amino acids. We in India that is why we eat chapati-dal or rice-dal. Soyabean is the richest source of plant protein. Eggs are a cheaper source of high quality proteins. Proteins are complex chemical substances and they can not be easily manufactured in the laboratory presently. Proteins can not be stored in the body. They are wasted if consumed in large amounts. On an average an adult requires **one gram of protein per kilogram of body weight.**

Vitamins

These are required in small amounts. They help in the release of energy from carbohydrates and fats but they themselves are not a source of energy: There are different vitamins. Each vitamin has a specific function and can not substitute for another. The vitamins and the main functions are given below.

Vitamin	Function	Source
A	needed for healthy eyes	butter, ghee, milk, egg-yolk, fish
B-complex (B_1, B_2, B_3, B_6, B_{12})	to prevent undernutrition and growth retardation	cereals, pulses, sprouted pulses, milk, eggs
C	provides resistance for infections and for rapid healing of wounds	citrous fruits
D	for proper formation of bones	egg, milk, butter.
E	prevents vitamin A destruction	vegetable, cereals.
K	prevents bleeding in wounds by clotting of blood	green leafy vegetables.

Minerals

Bones and teeth contain large amounts of calcium. Adults have 1kg of Ca and babies have 30g in their bones. During the period of growth from a baby to an adult, a large amount of calcium is needed. Calcium is always present in the body in combination with phosphorus as calcium phosphate.

Iron is another important mineral required for making haemoglobin in the blood. The total amount of Iron in the body is about 3g. About 17 minerals are necessary for healthy functioning of our body. These amounts are however very less in comparison to the bulk of food taken by us. These minerals are therefore called micro-nutrients.

Check your progress

1. What are vitamins, name them

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2. Deficiency diseases caused by deficiency of

Vitamin A ....

Vitamin B ....

Vitamin C ....

Vitamin D ....

20.6 BALANCED DIET

For food both quality and quantity are essential. But both of these must also be balanced in diet. A balanced diet is a combination of various foods which can fulfil the energy needs of a person and can provide proteins, vitamins and minerals in proper proportions. The compositions of balanced diets for various age groups are presentd in the table 20.6

Table 20.6 Balanced diet for different age groups.

Food item	Amounts required (in grams) Adult Male	Adult Female	additional allownaces /for Pregnant	Lactating	School children 1-3	4-6	10-12	girls 13-18	boys 13-18
Mixed cereals	475	350	50	100	150	200	320	380	450
Pulses	80	70	-	10	50	60	70	70	70
Green leafy vegetables	125	125	25	25	50	75	100	150	200
Other vegetables	75	75	-	-	30	50	75	75	75
Roots & tubers	100	75	-	-	-	-	-	75	100
Fruits	30	30	-	-	50	50	50	30	30
Milk	200	200	125	125	300	250	250	250	250
Fats&oils	40	35	-	15	20	25	35	35	35
Sugar	40	30	10	20	30	40	50	30	40
Total calories	2800	2200	2200 +300	2200 +700	1200	1500	2100	1095	1250

Dietary requirements change during fever and infection. During fever, there will be a break down of tissue proteins and water and salt are lost. The basic metabolism rate (BMR) increases. Therefore a diet rich in proteins and calories is desirable. Patients should be given easily digestible foods such as milk, eggs, pudding, fruit juices etc. Glucose fulfils immediate energy demands. Fats like butter, ghee and vegetable oils should be avoided during fever.

Check your progress

1. What is balanced diet?

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2. Name the components of a balanced diet

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3. Name the amounts required in groups of cereals, pulses, fruits, milk, fats for adults and children of both sexes.

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20.7 MALNUTRITION AND ILL HEALTH

Malnutrition means either lack of sufficient food or imbalance of nutrients in the food or diet. This brings in the impairment of health. Protein - Calorie deficiency and the resulting malnutrition are very prevalent in India and in other developing nations of Asia, Africa and Latin America.

Let us now examine the reasons for this malnutrition in India.

Some of the important causes are

1. poverty 2. large population 3. inadequate production and distribution of food 4. giving importance to taste but not to the nutritive values.

In this globe population and the poverty are unevenly distributed. Affluent countries have smaller populations than the non-affluent countries. USA, Canada, Australia have less population and more riches. Asia, Africa and Latin America have more populations and less riches. India is perhaps the second most populated country in the world. It is estimated that by 2000 AD our population may go up to 1000 million. Rising population increases the total demand for the food. Large percentage of our population are unable to have a balanced diet.

Hence food production must be increased. But simultaneously buying power also must increase. Therefore people should have more money to purchase. This indirectly means more employment and better wages. All these can be achieved if only we bring in considerable economic changes in the country. At the social level we should cultivate the habit of not wasting food. We all know that on many festive occasions, probably we waste more food than we really eat. People suffering from malnutrition naturally will have ill-health. So for treatment of ill health and disease we spend lot of money. So money spent in this way could possibly have improved the nutrition to avoid disease.

Protein - Calorie malnutrition

The little babies and the children of the poor and uneducated class are more effected by this. The severe diseases arising due to deficiency of proteins and protein-calorie are Kwashiorkar and Marasmus. These retard the child growth and weakens, natural immunity to various infections. Children also get mentally retarded.

Kwashiorkar

This was recognised in 1935 in african children. This was named from two words of an african dialect meaning *first* and *second*. Sickness that strikes the first child when he is displaced from the mother's breast by the second born. Children need extra food from after 6 months besides mother's milk. For many children this is not available due to

1. financial burden if the next child is born
2. ignorance. Men are given better food than the children and women
3. babies refuse for long external food.
4. vegetarian food may not provide the required proteins.

Marasmus

This is caused due to severe deficiency of both proteins and calories in the diet. More than 90% of the children of lower income groups suffer from this disease. This is manifested by the severe retardation in growth.

Anaemia

Deficiency of vitamin A and iron causes this. Some of the deficiencies and the diseases caused by them are presented in the table 20.7

Table 20.7 Nutritional deficiencies and diseases.

Deficiency	Disease	Deficiency	Disease
Vitamin A	Night Blindness	Niacin	Pellagra
Vitamin B	Anaemia	Vitamin C	Scurvey
Vitamin D	Rickets	Vitamin B_1	Polyneurits
Iron	Anaemia	Protein	Kwashiorkar
Protein-Calories	Marasmus		

The protein content of some foods and the calories contribution from this protein is indicated in the Table 20.8

Table 20.8 protein content and protein contribution to total calories of some food stuffs

Foodstuff	% protein in edible portion	protein-calories as % total calories
Topioca flour	1.5	1.8
Human milk	1.1	5.2
Polished rice	7.0	8.0
Wheat flour	70% extract	11.4
Groundnuts (roasted)	26.0	17.8
Cow's milk	3.3	20.6
Meat (low fat)	18.0	27.1
Whole egg	12.9	31.7
Soya bean flour (full fat)	36.7	34.9
Fish	19.0	37.6

Despite all developments, one must emphasize that until per capita income in underdeveloped countries increases sharply, the road to better nutrition to their people will not be made smoother. This can be solved to some extent by better agronomical practices Fiscal and import policies also play an important role.

Check your progress

1. What is malnutrition?

2. What diseases are caused by malnutrition?

3. What is the deficiency disease caused by deficiency of proteins?

4. What is the deficiency disease caused by the deficiency of protein - calorie?

20.8 SUMMARY

In this unit you learnt about, what is nutrition and what are the ill-effects caused by malnutrition.

1. Food consists of mainly six classes of nutrients: carbohydrates, proteins, fats, vitamins, minerals and water.
2. Nutrition, concerns with the food needs of any organism for its proper growth.
3. The food provides the necessary energy.
4. All organisms including man depend on their environment for food.
5. But man alone can manipulate the environment for his fitness and survival.
6. The food needs vary from person to person depending on their physical work, age, physiological status etc.,
7. Food stuffs containing the same type of nutrients are put together into a food group.
8. According to the functions performed in the body, the nutrients are classified as energy foods, (carbohydrates and fats) body-building foods (proteins) and protective foods (vitamins and minerals)
9. Energy value is expressed in calories.
10. The calorie requirement depends on age, sex, type of activity, climate etc.,
11. A combination of various foods which can fulfil energy needs of a person and can provide proteins, vitamins and minerals in proper portions required to keep a man healthy is known as balanced diet.
12. Lack of sufficient food or imbalance of nutrients in the diet resulting in the impairement of health is known as malnutrition.
13. The causes for malnutrition are poverty, large population, inadequate production and unequitable distribution of food.
14. The developing countries of the world today are faced with diseases due to protein-calorie malnutrition.
15. The more affected group are the little babies and children of the poor and uneducated class.
16. The severe diseases due to deficiency of proteins and protein-calorie are Kwashiorkar and Marasmus.
17. The other diseases are anaemia, rickets, pellagra, goitre etc.,

20.9 TERMINAL EXAMINATION MODEL QUESTIONS

I Answer the following in about 30 lines each

1. Discuss the personal daily needs of diet considering one's age, weight, sex and physiological status?
2. What is nutrition? What is balanced diet? Explain the ill-effects caused by malnutrition and imbalanced diet?
3. What are nutrient groups and their functions? Give an account of essential nutrients in our foods?
4. Give the reasons for the malnutritional effects observed in the people of developing nations. What are the remedial measures?

II. Answer the following in about 15 lines each

1. What are the chief ingredients of a balanced diet? What are their functions?
2. Name the vitamins needed for the development of human body? What ill effects are caused if these are absent.
3. What is balanced diet? Give the composition of it.
4. What diseases are caused due to deficiency of protein and protein-calories? explain.
5. What are essential nutrients? How are they obtained?
6. Name the common Indian food groups and the nutrients they provide?

20.10 GLOSSARY

Amino acid:	the building blocks of protein molecules. They contain $-NH_2$ and $-COOH$ groups.
Anaemia:	deficiency in the circulating of haemoglobin or red blood cells.
Basal metabolism:	energy expenditure of the body at rest in the post absorptive state.
Beriberi:	deficiency disease caused by lack of vitamin B.
Essential nutrients:	nutrients that are to be supplied in the diet to provide the body's need for it.
Kwashiorkar:	deficiency disease related to protein deficiency.
Marasmus:	deficiency disease caused by protein - calorie deficiency.
Nutrient:	chemical substance in foods which gives nourishment. eg. ca, fat, amino acids.
Nutrition:	the intake, digestion, absorption and effective use of food.
Pallegra:	A deficiency disease caused by the deficiency of the vitamins of B group.
Rickets:	A deficiency disease caused in the absence of vitamin D in the food.

UNIT-21 HEALTH AND DISEASE

Contents

21.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about

1. what is good health?
2. diseases that cause ill health
3. how diseases are spread?
4. how to prevent diseases?
5. some health measures taken up in India.

Objectives

After you studied this unit you must be able to

1. know what is meant by good health?
2. understand what diseases are?
3. understand and adopt methods to prevent diseases as well as their spread.
4. know the types of diseases and their prevention and cure.
5. know the medical care facilities extended to people in India by different agencies.

21.2 INTRODUCTION

Balanced diet is important for maintaining good health. This you learnt in the Unit-20. If balanced diet is not taken, people suffer from malnutrition. This is one of the causes for ill-health. But human beings health is also upset or spoiled by lack of clean water, clean air, and hygenic food. Besides these, poverty, illiteracy and over population are also the major factors that cause ill-health and diseases. you learn in this unit therefore some aspects concerning good health, onset of diseases and prevention & cure of the diseases.

21.3 GOOD HEALTH

Everybody wants to live for long yeasrs. More over in many countries the average life span of human beings increased significantly in past few decades. But it is not enough if we live long, but we must live well also. Health is the greatest asset of our life. One therefore should try to preserve it. Good health is really a boon.

Health is defined by the World Health Organization (WHO) as follows.

"It is a state of complete physical mental, and social well-being and not merely an absence of disease or infirmity. The above definition indicates that there are three aspects of health. These are physical, mental and social aspects. If one is having good fitness in all these three aspects, he is considered to be in a state of positive health. It is for this reason we always say that "Health is Wealth". There is no greater wealth than health. An healthy person will be able to use his physical and mental assets in a fitting manner however great or small these assets may be. An healthy man should have a proper working of all organs of the body. An young man will have mental tensions of his own. It is for this reason mental health and physical health are intimately related to each other. When a person is upset or depressed, naturally he becomes lazy and also weak.

An healthy mind in an healthy body is therefore a great asset for any individual. But a perfectly healthy person, of course physically, should not be considered as a person without any social or psychological problems.

A person who is psychologically and mentally sound shall be one who is

1) free from internal conflicts.
2) completely satisfied and happy with his own achievements which are commensurate with his abilities.
3) having self control on his or her activities
4) able to discharge his or her responsibilities satisfactorily and
5) finding no problems to adjust himself or herself with others.

We therefore now know that it is not difficult to assess whether one is in good health or not from the behaviour and the activities of the man before we consult a doctor for his confirmation or otherwise of the person's ill health.

check your progress

1. What is good health

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2. What characteristics a person with good wealth should possess

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21.4 DISEASES TYPES

Any departure from the state of a good health can be generally called as "disease". Similarly any undesirable change occurring in the normal structure or functioning of a tissue or an organ of human body is referred to as disease. The person himself or herself would be able to realise that he or she is suffering from a disease. But the doctors have different methods and also instruments to find out if a person is suffering from any disease or not. The doctor conducts many tests on the person before he confirms the disease.

All of us might have suffered at one time or other from fever, body aches, vomitings, diarrhoea, cold, weakness, etc., All these are symptoms and indicators of ill health of the person. Illness arises from a number of factors. These may be failure of functioning of some parts of our body or problems due to aging or attacks from infections or hereditary complaints.

The tests that a doctor conducts on the patient include

1. Physical tests: Testing of eyesight, movement of limbs, heart beat, pulse rate etc.,
2. Bio chemical tests : Testing of blood & urine for sugars, fats, albumin etc.,
3. X-rays tests: Testing for fractures in bones and for the condition of the lungs.
4. Microscopic examinations: Testing of blood, urine & stools etc.,
5. Surgical tests: To locate diseased organs and to identify the nature of tumours.

After all these tests are conducted, and the results examined and analysed, the doctor confirms the nature or type of the illness or ailment or disease.

Types of diseases

The diseases are classified into many types by the doctors. But we would classify these diseases for convenience into three categories. There are

1) Infectious diseases.

2) Congenital diseases.

and 3) Dreadful diseases

1) Infectious diseases

There are also called as communicative diseases. These are passed from one person to the another in different ways and through different media such as water, air, food, clothes etc. These are caused by micro organisms and worms some examples are cholera, malaria, tuberculosis, chicken pox etc.,

But all diseases are not infectious. Some diseases are not caused by external infections. So these can not be spread from person to person. For example diabetes, anaemia, joint pains etc., are some non-infectious diseases. Some of the common infectious and non-infectious diseases are listed below

Cold and cough, malaria, plague, measles, mumps, polio, cholera, tuberculosis, chicken pox, diarrhoea, plague.

Non-infectious diseases

Cancer, asthma, joint pains, scurvey, obesity, diabetes, hysteria etc.,

Infectious diseases

These are caused by microorganisms Antone Van Leeuwenhock, an expert in making lenses was the first person to observe micro organisms or bacteria about 300 year ago. Out of curiosity he examined the water of marshy lakes, rain water and human excreta with a microscope and found tiny living creatures in them. These were named by him then as "animalcules".

In the middle of the nineteenth century a famous French scientist, Louis Pasteur showed that the infectious diseases are rampant where the air contained microbes. The great works of Pasteur prompted Robert Koch of Germany to conduct many similar experiments. He showed that a specific kind of bacteria is responsible for tuberculosis and another for plague etc., Many scientists later initiated investigations on different types of infectious diseases and identified the micro organisms responsible for the diseases. Infectious diseases are caused also by another class of microbes namely virus. For example common cough, cold and

Some fevers are caused by these viruses. These are smaller than bacteria. These cannot be seen with low power microscopes. They behave as chemical molecules. They cannot replicate themselves outside the living cell of the host. Later it was discovered that infectious diseases are also caused by other types of microbes. These microbes are categorised into four groups (1) Bacteria (2) Virus (3) Protozoa (4) Fungi

Diseases are also caused by worms. The diseases and the agencies responsible for the same are shown in the figure 21.1

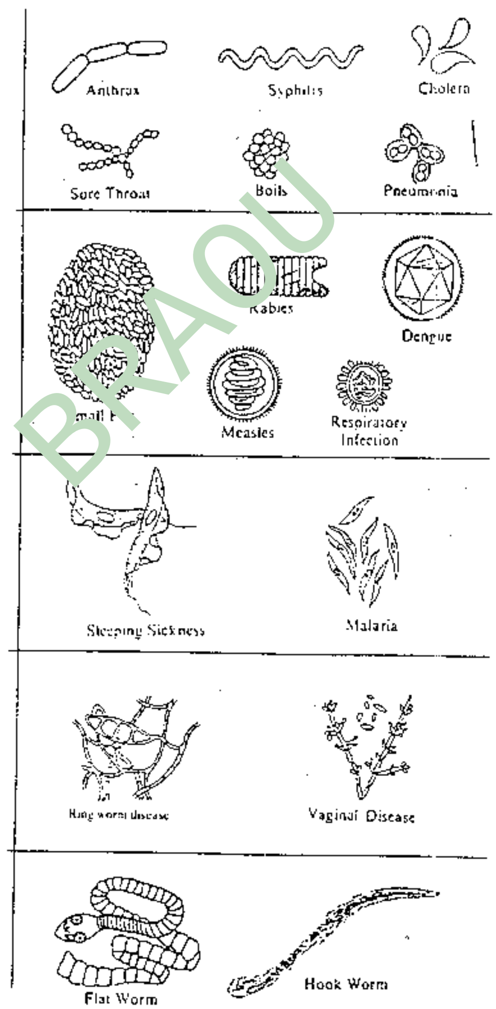

Figure 21.1 Kinds of microbes and worms causing diseases.

Table 21.1: The infectious diseases caused by different agencies.

Bacteria	Viruses	Protozoa	Fungi	Worms
Cholera	Chicken Pox	Malaria	Skin-diseases	Tape worms
Dysentery	Cold	Amoebic dysentery	Ring worm disease	Filaria
Whooping cough	Influenza	Sleeping sickness		
Leprosy	Measles			
Plague	Mumps			
Syphilis	Rabies			
Gonorrhoea				
Tuberculosis				
Thypoid				
Menanzitis				

The unsuitable microbes are present everywhere. They can survive even in unhospitable conditions. These are, in the soil, in the air we breathe, in the food, we eat and in the water we use for drinking or bathing. Millions of them are on our body and in our mouths and internal tracts. One third of the dry human faeces is bacteria. But all these micro organisms are not harmful and do not cause diseases. Many microbes are even useful to human race. Many are very important even for existence of life on the earth. Without these micro organisms life on earth would even perish. For example we are making use of useful bacteria in the preparation of curds, alcohol, bread and cakes. These micro organisms decompose dead plants and animals and sewage into harmless chemicals such as CO_2, water etc.

Microbes enter our body through the natural openings of the body such as mouth, nose, eyes, urinary and reproductive passages. These when entered our body, get multiplied very fast. In a few days a single bacterium can produce millions of it and these in turn infect millions of cells at the site of infection. But virus is reproduced only in the living cell.

(2) Congenital Diseases

A number of diseases of man are acquired at birth. Such diseases are passed on from one generation to another in some members. Sir Archibald Garrod was bold enough to say that such inherited disorders are due to defective metabolism. However we now know that not all inherited disorders are due to defective metabolism. At present more than 250 inherited disorders are known. These inherited disorders are of two types. 1. Those arising out of chromosomal defect. 2. Those arising out of abnormal chromosome number (instead of normal 23 pairs) Genetic disorders could also arise as a result of mutations in the genes. This results in the synthesis of functionally defective protein or an enzyme. The majority of genetic diseases identified belong to this category. Haemophilia (defective blood clotting) and sickle cell anaemia are due to the synthesis of functionally defective proteins. A number of inherited disorders are identified as due to the abnormal chromosomes which differ in their structure or numbers. These are referred to as chromosomal aberrations. The causes of chromosomal aberrations are not known. However factors such as hazardous radiations leading to chromosomal damage are important. Down's syndrome or Mangolism is a typical chromosomal defect. Some inherited diseases, their causes and effects are listed in table 21.2.

Table 21.2 Some inherited diseases, their causes and effects

Disease	Cause	Effects
Down's Syndrome	abnormal chromosome number	mental retardation
Haemophilia	defective blood clotting mechanism	bleeding
Sickle cell anaemia	change in the shape of RBC into sickle shape	anaemia
Thalassemia	abnormal haemoglobic	anaemia
Phenylketonuria (PKU)	defective conversion of phenyl alamine to tyrosine	mental retardation
Albinism	conversion of tyrosine to dopa is defective	milk white skin, grey eyes, light sensitive
Gout	abnormal production of uric acid	arthritis (joint pains)
Gaiccher's disease	cerebrosides accumulation	enlarged spleen, enlarged liver, neurological manifestation.
Galactosemia	impaired metabolism of galactose	cataracts, mental retardation enlarged liver.
Glycogen Storage	defect in glycogen break down	heart diseases, muscle weakness, mental retardation.

Inherited disorders can not be cured. Early diagnosis is therefore crucial in management and care of the affected individuals. Diagnosis of genetic disorders is aimed at two levels.

1. Early diagnosis and detection even during the neonatal period i.e. diagnosis immediately after birth.
2. It is more important to identify individuals who are not affected by the disease but who are carriers of that particular trait i.e. heterozygotes.

Dietary manipulation is presently effective in the management of certain inherited disorders such as galactosemia.

Galactosemic children are unable to metabolize galactose. Hence galactose free diet (milk-free) is needed. A number of genetic disorders are also due to missing enzymes. Therefore therapy with the missing enzymes offers great promise in the case of number of disorders. This is known as **enzyme therapy.**

(3) Some dreadful diseases

Cancer and very recently AIDS are considered as dreadful diseases. The disease cancer has been known for few decades while the disease AIDS has been identified only recently i.e. about two decades back.

AIDS

This is a fatal disease caused by Retrovirus. The Human Immune deficiency Virus (HIV) breaks down by body's immune system leaving the patient or the victim susceptible to a number of life threatening infections, neurological diseases and unusual cancers. The HIV causes damage to the body's natural ability to fight illness. Once a patient is infected with this virus, doctors feel that it remains in the body life long. HIV infection takes years to manifest itself as the disease. No symptoms are seen. This symptomless behaviour of the carriers for years therefore, can infect other also for years anonymously. The virus is generally found in blood and semen in high concentrations. But lower concentrations are seen in tears, saliva, breast milk and urine also.

This disease has already infected millions of women, men and children in developed and developing countries. 25 million adults are known to be suffering from AIDS all over the world. AIDS was first noticed in USA in 1981. AIDS in India was observed in 1986 in 6 persons of Tamil Nadu. All persons suffering from AIDS are infected with HIV. But all persons with HIV infection need not have AIDS. The size of the virus is 10^{-8} m. It is a protein along with some enzymes. It is usually killed by heat. The causitive virus is transmitted from person to person through sexual intercourse. AIDS is also transmitted through contaminated blood transfusion.

Some symptoms of AIDS

1. fever for long periods (more than a month)
2. weight loss upto 10% of the total body weight.
3. diarrhoea for long periods (more than a month)

AIDS is the abbreviated form of Acquired Immunity Deficiency Syndrome.

At present there is no vaccine available for the prevention of AIDS. Hence "Health Education" about AIDS is the only remedy for AIDS. First December of every year is declared as "World Aids Day" in an effort to create public awareness.

Cancer

It is a disease caused by the defective living cells being produced in the body. Many chemical substances are found responsible for such production of cells. These substances are therefore called as **carcinogenic** substances. Environmental pollution is found responsible for many cancers. Cancerous cells may be found in any part of the body. Accordingly the cancer is named as skin cancer, tongue cancer, mouth cancer, throat cancer, breast cancer etc. The most dangerous and bold type of cancer is blood cancer, also known as leukaemia. The cancer is treated at the early stages of discovery by radiation therapy Radioactive cobalt is used for the purpose. By making use of these radiations the cancer cells are burnt away and their further multiplication in the body is prevented.

Throat cancer, mouth cancer and lung cancer are traced to tobaco smoking and tobaco chewing. The liver cancer is observed in people who are drink addicts.

Surgical and radiation theruptic treatments are widely used to treat cancer.

This is not a contageous disease.

Check your progress

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1. Communicative diseases are caused by--------

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2. Communicative diseases are termed ......

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3. Diseases present from birth are called ....

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4. Infectious diseases are prevented by .....

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5. Immunization means ....

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21.5 SPREAD OF DISEASES

Infectious diseases are caused by microbes and worms. Therefore, when these travel from one infected person to other non infected person, the disease also is transmitted from the infected person to the healthy person. There are various modes by which these microbes travel from person to person. They travel through air, water, food, contact, insects and other carriers. Accordingly these diseases are designated as air borne, water borne, food borne etc. diseases. Roots of transmission of diseases from person to person are illustrated in the figure 21.2

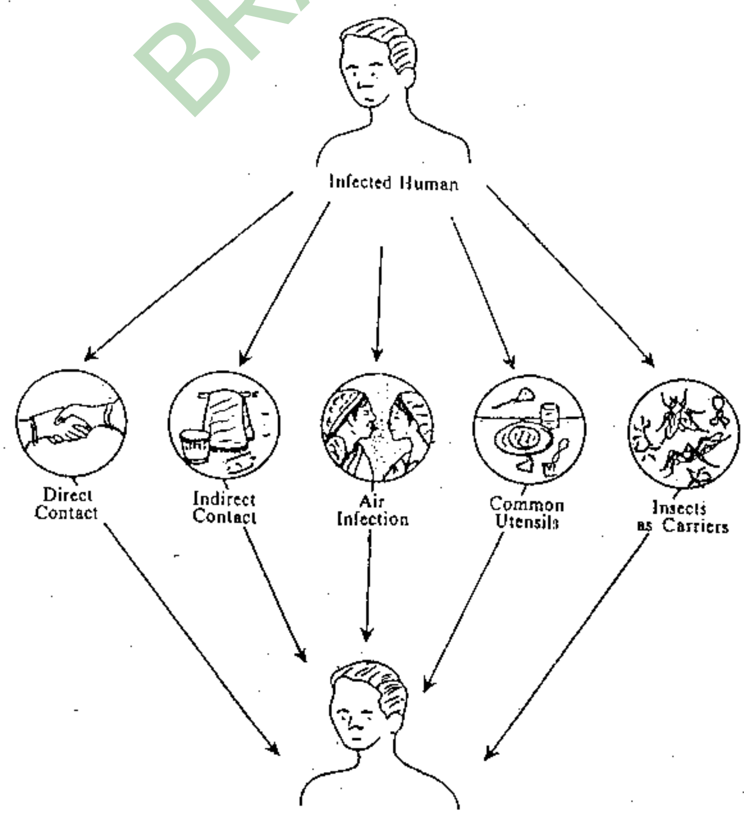

Figure 21.2. Transmission of diseases from person to person.

Air borne diseases

A number of diseases are caused by bacteria and virus (Refer Table 21.1). When an infected person sneezes or coughs there will be noticeable spray of drops. These contain the germs which floats in the air around for a long-time. The person standing by is therefore likely breathe this air infected with germs. One sick person can therefore infect lot of others. The cold virus is spread in this way. One type of leprosy is also spread in this way. But this happens if only the infected person and the healthy person are close by for long periods. These diseases spread easily in damp closed spaces.

Water - borne diseases

Some diseases are spread from person to person through water. Such diseases are termed as water borne diseases. For example diseases like cholera and typhoid as well as diarrhoea and dysentery. Germs causing these diseases multiply in the gut of the infected person and comes out in the faeces. Eggs of the worms also come out in the faeces. If these infected faeces and urine are passed in open fields, these germs or their eggs are carried to the water sources of the locality (ponds or rivers). Bathing or washing of utensils in such waters will therefore infect other persons. In some villages, the latrines are too close to water sources. Therefore the drinking water gets infected. Sometimes these diseases are spread due to personal unhygiene. The infected persons, many times, may not wash their hands carefully after defecation or urination. Then these not properly cleaned hands are likely to carry some germs or eggs of the worms. When these persons touch the foods, utensils or furniture the germs are transferred to them. Healthy persons who touch these things will naturally get these worms or the eggs of the worms.

Food - borne diseases

Typhoid, bascillary dysentery and other stomach infections are spread through food also. Flies sitting on foods always deposit germs there on the foods. The flies pick up these germs while they sit on excreta or filth. The people who prepare the foods infected by the germs, they are likely to infect the foods they prepare. Foods exposed to polluted air for long periods are likely to pick up bacteria which easily multiply in the foods. Such foods when consumed by people, they get different types of disorders and also diseases. Such cases, we normally refer as food poisoning. The common symptoms of food poisoning are abdominal cramps, nausea, vomiting and diarrhoea. Generally bacteria are killed in hot foods but toxins produced by them shall remain even in hot foods.

Diseases spread by Insects or other carriers

Malaria is transmitted by the female Anopheles mosquitoes. Dengue fever and filaria are caused by mosquito bites. Mosquitoes get the germs by sucking the blood of some one suffering from the disease. Houseflies are also carriers of germs of intestinal diseases. Similarly many fleas also spread diseases. Rats are generally referred to as reservoirs of diseases. Plague is caused by rats. Ticks, cockroaches also carry germs of various diseases. Guinea worm disease is quite common in India. The adult worm is a metre long. It moves from the stomach to the leg and produces larvae which are released into water.

Some common diseases, modes of spread and sources of infection are given in the table 21.3

Table 21.3 Common diseases modes of spread and sources of infection.

Air Borne	Source	Water Borne	Source
Respiratory	Air	Typhoid	Human Carriers
Measles	Human carriers & animals.	Cholera	Human Carriers
Chicken Pox	Human Carriers & animals.	Dysentery	Human Carriers
Leprosy	Human Carriers		

Food Borne	Source	Contact	Source
Typhoid	Human Carriers	Syphilis	Human Carriers
Bascillary Dysentery	Human Carriers	Gonorrhoea	Human Carriers

From the facts mentioned in the preceding paragraphs, it is clear that the infectious diseases are spread through different sources as shown below.

1. Direct contact with an infected person - Gonorrhoea, Syphilis
2. Direct contact with animals - Some Viral Fevers
3. Through milk - Typhoid, Diarrhoea
4. Through water - Cholera, Typhoid, Amoebic dysentery
5. Through food & vegetables - Gastroenteritis and several forms of Dysentery
6. Through articles (Clothes, Beds, Utensils) - Streptococal infections
7. Through Insects & Others - Yellow fever, Plague Malaria and Sleeping Sickness.

Check your progress

1. What are airborne diseases ?

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2. What are waterborne diseases.

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3. What are diseases which spread via contact.

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4. Name the carriers of the following diseases.

   Syphilis, Measles, Typhoid.

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5. What diseases are spread through water ?

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6. What diseases are spread though milk ?

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7. What diseases are spread via direct contact with patient.

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8. Name diseases that spread via insects.

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21.6 PREVENTION OF DISEASES

Infectious diseases are caused by microbes. Therefore it should be possible to prevent these diseases by controlling their transmission. The preventive methods adopted in ancient times are slightly different from the methods presently followed. So let us try to know in brief about these two types of prevention.

Prevention in ancient times

In India we have been following various good practices, by which our ancients were also able to minimise infections. For example washing of our hands before and after meals, daily bathing mostly in running waters, not carrying foot wear into living rooms, denial of permission to enter the kitchen. These practices, our ancient people, might have evolved through observations, experiences for very long periods. Similarly isolation of the mother and the new born soon after delivery was a common practice. This prevents the infection of the mother and the baby. Many of these laws of personal hygiene were codified by Manu.

Ancient civilizations too had good drainage system arrangements for public baths and above all good medical systems. Especially civilizations of Egypt, Cairo, China & India were remarkable in this direction. The use of mosquito nets and keeping rats away from the houses were known to these civilizations. Immunizations and inoculations are also known to them.

Modern methods of prevention of diseases

Infectious diseases are controlled or brought under control in modern times by different methods. In modern times scientists and medical men believe that **prevention is better than cure**. Even in developing countries such as India, a great awareness had come in the common man about the concept of prevention. The methods followed include immunization, chemotherapy, quarantine and providing good environment.

I) Immunization

This refers to all those properties of an individual which confer resistance to an infective agent. People will have natural immunity and this is the most effective means of resistng infection. The toxicity of an organism depends on the production of toxins. An individual's natural immunity is capable of neutralising such toxins or limiting the multiplication of microbial populations. The individual produces substances called ***antibodies*** which effectively neutralize toxins and prevent the infection. The invading organism is said to be **antigenic**. Immunity is also achieved through the use of vaccine. In fact, the oldest procedure of vaccination against smallpox was first introduced by *E. Jenner* in 1796.

Vaccines are classified into three main groups (1) *toxoid vaccines* (2) *killed bacterial* or *viral vaccines* and (3) *attenuated live bacterial* or *viral vaccines.* Immunization methods are broadly divided into (a) *active immunization* and (b) *passive immunization.*

(a) **Active immunization** is achieved by the use of antigenic material of the infecting organism itself. passive immunization affords temporary protection and eliminates microbial infection.

Toxoid vaccines are generally prepared from bacterial toxins which are made non-toxic by, certain chemical treatments. Vaccines for diphtheria and tetanus are this type.

Killed vaccines are made by culturing. The infecting organisms are then inactivated by heat or chemicals. Typhoid, cholera, plague, whooping cough, polio vaccines are of this type.

Attenuated live vaccines are made by the use of violent strains of the organisms. These are produced by repeated numerous successive passages of the virulent strain in suitable host animals. The B.C.G. (Bacillis Calmitte Guerin), small pox, rabbies, Saiks' polio vaccine, measles and rubella vaccines are some of the examples.

(b) Active immunization procedures are very important in protecting especially children from a number of infectious diseases such as tuberculosis, smallpox, diphtheria, whooping cough, tetanus, polio, measles and typhoid.

II) Chemotherapy

The treatment and control of diseases by chemical substances known as pharmaceuticals is known as chemotherapy. The foundations of modern chemotherapy were firmly established by the discoveries of sulphadrugs by *Domark* in 1935 and use of pencillin in 1940 by *Chain* and *Florey*. Since then there has been rapid development in the design and discovery of various types of drugs.

A drug may be a synthetic compound such as *aspirin.* It could also be a naturally occuring compound of plant like *quinine* or of microbial origin such as pencillin. There are a number of criteria for selecting an useful drug.

1. The drug must be able to kill selectively and effectively the disease producing micro organisms of a number of diseases.
2. It should have a broad specificity.
3. It should have the minimal or no harmful effects on the infected person.
4. The drug should be effective in all tissues of the body. The drug should preferably be soluble in water.
5. It shall be stable at room temperature
6. The drug shuld be effective even when administered orally.
7. The cost of the drug should be low.
8. Drugs generally inhibit some metabolic or biosynthetic process that occurs in the micro organisms responsible for the disease.

Antibiotics like pencillin also act in this manner Some antibiotics like chloramphenical and streptomycin act by inhibiting the synthesis of proteins by the bacteria Micro organisms susceptible to particular drugs also may acquire resistance and become no longer susceptible to these drugs. These are largely due to the result of indiscriminate use of drugs. Unlike in bacterial and other parasitic infections chemotherapy of viral diseases is still not very fruitful. However, a number of drugs have been designed which find limited use in the treatment of viral infections. Chemotherapy of cancer is also in use.

III) Quarantine

This method is also very effective in controlling the spread of certan infectious diseases. This aims at the limiting of the freedom of the movements of persons who have been exposed to a communicable disease at least for a period of time equal to the incubation period of the disease. This prevents infected people to make effective contact with the people who have not been exposed to the infection.

(IV) Sanitary measures

These measures include control of environment. The environmental factors of prime importance are housing, water supply unpolluted air and good sanitation. Control of selling of exposed food is also a factor.

Villages have hardly any lavatories, and drainage is very poor. A house should be sunny and well ventilated to ensure movement of fresh air.Proper ventilation reduces the concentration of micro organisms to a safe level. Diseases such as lung infections, diphtheria whooping cough and T.B. are often associated with poor housing. Dampness and moisture also help in the spread of diseases.

Water should not only be clear but also clean. Vast majority of people depend on ground water. But these ground waters contain many harmful chemicals and bacteria due to human activity or some natural phenomena. Well water is generally more superior to ground water. Therefore protected water must be only used and suplied to domestic uses.

Air pollution is also the main cause for many diseases. This can be controlled by various methods and these methods must be strictly and legally implemented.Above all things sanitation is the most important factor. Improved sewage disposal methods, construction of sanitary pits, spraying or sprinkling of disinfectants near places where water is likely to stagnate are some important sanitary measures.

Check your progress

1. What is immunization ?

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2. What are vaccines ?

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3. How are vaccines classified ?

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4. What is chemotherapy ?

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5. What sanitary measures are needed for good health?

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21.7 HEALTH CARE IN INDIA

The social, political and economic forces existing in a country determine the health condition of people.

At the time of independence, diseases and malnutrition were prevalent through out the country. Therefore both government of India and state governments framed various policies. The statement of National Health Policy of 1983 by Government of India states that "the population and health picture of the country still caused serious and urgent concern. Many policies and programmes failed and these failures were attributed to the reasons that we paid more attention to the cure of disease than to prevention of the diseases."

Most of our health institutions still are giving importance to curative methods rather than to preventive measures. Especially these methods are most undertaken for rural areas. Even now our rural populations are 77% and only 23% live in urban areas. But medical facilities are far from this ratio. Medical facilities are more in urban areas and are very inadequate in rural areas. Even though there is enormous growth in the number of hospitals, health centres and doctors most of these facilities are in urban areas instead of in rural areas. Many villages even now do not have atleast primary health centres, doctors and even potable drinking water suppy or basic sanitation. There are large numbers of primary health centres (PHC), subcentres and doctors, many paramedical staff such as nurses, healthworkers, health supervisors etc. But with all these enhanced programmes and facilities provided by the governments the results are not encouraging. This situation has been attributed to the non-participation of the individuals and the families in these programmes.

More over medical education, training, research and the establishment of hospitals are such that we are forced to depend on other developed countries for books, equipment, medicines and even ideas.

But in recent years there is a remarkable change in the attitudes of the governments as well as of the people. A "multidisciplinary" approach is now adopted. A joint effort of medical scientists and social scientists is now being implemented to solve the health problems.

A more comprehensive social sciences approach to health services in rural areas is required immediately. The programmes and the delivery of health services should take into account the existing culture of the community. The medical teams involved in extending the health services shall include allopathic, ayurvedic, unani and homeopathic doctors.

Priority therefore must be given to create, self-reliance in health, awareness of health problems and also to provide protected water supply, good sanitation and proper nutrition within the means of the people. Thus an integrated approach taking into account the cultural, the social, the economical and the nutritional problems of the people concerned is an urgent need of the hour.

21.8 SUMMARY

In this unit we tried to give you a brief account of what is meant by good health? and how this is adversely effected by the onset of diseases and malnutrition. You have learnt that

1. Diseases result from a complicated interaction between man and his environment.
2. Diseases are basically classified as simple, infectious and congenital diseases.
3. Infectious diseases are caused by microbes
4. The microbes involved are bacteria, virus, protozoa and worms.

5. The microbes enter the human body through air, water and food. These get multiplied in the body and make the person sick.

6. The infectious diseases to which the man is generally exposed are cholera, typhoid. dysentery, leprosy, plague, tuberculosis, chicken pox, influenza, measles, mumps, skin diseases, etc.

7. Our body has a defence system which is capable of fighting against the germs.

8. Modern drugs also assist these defence systems. Congenital diseases can not be cured by drugs. Bio-engineering or genetic engineering techniques are necessary. Some preventive measures are more effective than curative methods.

9. Preventive methods are more useful than curative methods even for the common diseases.

10. The preventive methods include immunization methods and providing of clean drinking water, adequate living conditions and proper sanitation.

11. Immunization is the artificial induction of antibodies in the body to make body resistant to micro organisms. This is achieved by vaccination.

12. Vaccines are of 3 types. These are toxoid vaccines prepared from bacterial toxins, killed vaccines prepared from killed bacterial & viruses, attenuated vaccines prepared from virulent bacteria or viruses.

13. The cure of diseases by the use of drugs is called chemotherapy.

14. The discovery of sulfa drugs by Domark in 1935 and use of pencillin in 1940 by Chain & Florey paved way for chemotherapy.

15. Conventional approach of health care in Indian could achieve limited objectives.

16. A comprehensive approach involving social, economic, psychological, political and environmental aspects is required to organise preventive methods in rural areas.

21.9 TERMINAL EXAMINATION MODEL QUESTIONS

I. Answer the following in <u>30</u> lines each.

1. What is good health? How are diseases caused? How are diseases classified?
2. What are infectious diseases? How are they caused, spread and prevented?
3. Explain clearly the terms "immunization" and "vaccines". How are different vaccines prepared?
4. What are congenital diseases ? Name few of them. How are these rectified?
5. Name the agencies which cause the infectious diseases and give one or two examples for each.
6. What steps are necessary to prevent spread of infectious diseases through water, air, soil etc.
7. What steps are being undertaken by the governments and the social institutions to provide "Health Care" in India?

II. Answer the following in <u>15</u> lines each.

1. Explain briefly the terms "good health" and "ill health" with examples.
2. How are diseases classified? give examples for each.
3. What are infectious diseases? How are they caused?
4. How is spread of infectious diseases prevented? Give examples?

5. What are congenital diseases? How are they rectified?

6. What are vaccines? How are they prepared?

7. Name the agencies which cause infectious diseases? Give one or two diseases caused by each agency.

8. Name the different modes by which infectious diseases are spread.

9. What steps are taken and are to be taken to provide good health for people in India.

21.10 GLOSSARY

1. Anaemia :	deficiency in the circulating capacity of haemoglobin or red blood cells.
2. Antibody :	a protein, substance produced in an organism to counteract harmful substances.
3. Congenital :	existing at the time of birth.
4. Gastroenteritis:	inflamation of the digestive organs.
5. Protozoa :	single celled animals.
6. Malnutrition :	general term for illness resulting from inadequate feeding.

UNIT-22 FOOD PRODUCTION AND PRESERVATION

Contents

22.1 AIMS AND OBJECTIVES

Aims

In this unit you learn about

1. the modern developments that took place in India for increasing the food production.
2. the radical changes that took place in the fields of agriculture and agroforestry.
3. the types of agricultural practices undertaken in some special areas.
4. reclamation of soils.
5. green revolution, white revolution.
6. The food preservation and the need for it.

Objectives

After you completed the studying of this unit you should be able to

1. understand how better agriculture was made possible by modern scientific and technological development.
2. also outline the problems associated with modern agriculture.
3. analyse the problems associated with modern agriculture.
4. become aware of some important issues related to agriculture and population growth.
5. realise the important changes that found place in food preservation methods.

22.2 INTRODUCTION

Availability of enough food for every individual is the prime need for any country more so for developing and underdeveloped countries. It is also one of the prime obligations of any country to provide two meals a day for an individual. Availability of food has considerably influenced human societies in the past. Probably it was with the advent of agriculture, that supply of food was assured to man, It was due to constant inputs from science and technology that we have had a number of break throughs in agriculture production. But there are many issues relating to agriculture, food production and food preservation. Even today we find that there are several millions of people that are unfed due to lack of enough food. But the applications of modern technology coupled with the changes coming in the social outlooks can improve the prevailing situation.

In this unit you will therefore learn about the revolutionary changes that crept into the field of agriculture, food production and food preservation.

22.3 SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENTS IN AGRICULTURE AND AGRO FORESTRY.

Agriculture is the bedrock of Indian economy. Out of about 300 million working people in India about 100 million are cultivators and about 60 millions are agricultural labourers. Thus, the working people associated with agriculture constitute 60% of the total workforce. For all these people agriculture is not an occupation but a way of life. Our farmers and agricultural labourers constituting 60% of work force, contribute 35% of our total net national product.

Then the question is what are the basic resources for agriculture?

Besides human resources, the basic needs are sunlight, soil, water and machines. In the recent years, there has been a marked increase in our agricultural productivity. This break through is mainly due to the scientific and technological developments that took place in the fields of agriculture and food production. Scientists are, by means of genetic manipulations, could make a plant grow and give optimum yield in any part of the year. It is for this reason we are able to have potatoes, onions, certain vegetables and rice in any part of the year.

Let us now examine in detail some of the details of these developments in respect of individual products.

Cereals and Millets

The crops sown during the south-westerly monsoon are called **kharif** crops. Its period can be roughly put as July-October. Post monsoon crops i.e. crops cultivated during the period october to March are known **rabi** crops. The kharif crops generally include rice, maize, jowar, bajra, ragi and other millets. On the other hand wheat, barley, oat, rye are the examples of rabi crops. Rice is the main cereal of our state, Andhra Pradesh. It is grown in 80% of the cultivated area. The rice varieties upto 1960 were tall and weak stemmed. They were not able to make use efficiently sunlight and nutrients. At present high yielding dwarf and stiff stemmed varieties are being used. These varieties are also not season bound. Hence rice production increased enormously between 1950 and 1999.

Pulses

Pulses are legumes and they play an important role in maintaining soil fertililty. Many present day varieties come to harvest in less than 150 days compared to the earlier varieties which took 300 days. In the case of channa, the older plant is now replaced by an erect type with many branches. Pulse crops cultivation needs a careful management technology. This has not spread among farmers as fast as the high yielding seeds. Our population has gone up tremondously but our pulse production did not go up to the required level. Hence per head availability of pulse today is reduced very much. It is about 40 gms as against the optimum requirement of 80 gms a day as recommended by WHO. Hence attempts are

Check your progress

1. What are the cereals? What developments took place in their production?

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2. What are pulses? How are their production improved?

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3. What are fibre crops?

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4. What are plantation crops?

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22.4 AGRO TECHNIQUES

The new techniques, the technologies and the strategies, being developed and put to use in the recent decades to improve food production can be collectively referred to as agrotechniques. Cultivable land is limited and hence some new strategies are required to be planned to increase the food production. These strategies may include multiple cropping practices, mixed cropping processes, use of high yielding varieties, adopting modern methods of improving the fertility of the soil and using crop protecting chemicals. Therefore the agro techniques can be categorised as

1. Multiple and mixed cropping methods.
2. inputs of fertilizers
3. crop protection methods.

1. Multiple cropping and mixed cropping methods

Growing two or more crops in an year from the same piece of land is called **multiple cropping** practices. These practices not only enable enhanced production but would generate more employment in rural areas. The last irrigation given to a crop serves as pre-sowing irrigation to the next crop. This saves lot of water. In mixed cropping systems comparable crops are sown in parallel rows.

2. Input of fertilizers

In earlier years the agricultural yields were always lower than even the optimum yields expected. For many years agriculturists were unable to over come this unfortunate situation But the research studies conducted by different agriculture institutions and their scientists indicated that this situation is due to the absence of the required micronutrients such as, iron, manganese, boron, molybdenum and cobalt. At the same time excessive presence of these nutrients may also cause damage to the crops as well as to the yields because they prove toxic to plants. The nutrient needs not only vary from crop to crop but also from soil being made throughout the country to popularise soyabean cultivation. It has double the protein content than arhar or pigeon pea. The protein rich soyabean also has in it 19.5% oil in its grain.

Oil seeds

The traditional oilseeds are groundnut, sesame, castor, linseed and safflower. Now new crops such are soyabean, sunflower and oil plam are also cultivated. For centuries oil seeds cultivations are restricted to marginal lands, which are poor in both soil nutrients and water supply. Now new plant types capable of giving high yields are developed and used. In Andhrapradesh groundnut is our most important oilseed crop. Considerable improvements are also made in the methods of expelling oil from seeds. A new strategy of rotating the oil seed crops with other crops in areas where good soil and assured rainfall are available is being worked out.1) timely weed control, 2) need based use of plant protection measures and 3) prevention of post harvest losses are the other major changes introduced into the cultivation of oil seeds.

Fibre Crops

Cotton is the foremost. In this direction India is the first country that developed the hybrid cotton. We have a wide variety of long staple, short staple, medium staple cotton categories now available. Cotton in rotation with other crops is receiving high priority to save use of additional land for cultivation. Adequate pest control and crop management are the other developments that found a place in the cultivation of cotton.

Plantation crops

Tea, coffe, cocoa, rubber, coconut, arecanut, cashew, cardamom, black pepper and other spices come under plantation crops. Our scientists have developed multi-tier cropping technologies to make use of available land profitably. For example pepper is twined along the trunks of coconut and arecanut trees. Similarly in between arecanut trees pineapple fodder, legumes and grasses are planted. This type of cultivation increased the productivity per unit area per unit time.

Fruits and Vegetables

After we succeeded in establishing self sufficiency in food grains production, researches were intensified in the direction of horticulture. High yielding horticultural crops with better quality produce have been successfully developed. Under the name "Technology Mission", Ministry for food processing had succeeded in developing technology suitable for long distance transport, packaging, processing and canning of fruits.

Agroforestry

Forests are cut and destroyed for various purposes. Therefore the forests are diminishing at an alarming rate. Even though environment scientists recommended a minimum of 33% area for forests, now they are occupying only about 22% of the geographical area. This prompted scientists to think of large scale planting of fast growing trees with some suitable crops in between. But not all trees and crops are compatible with each other. In Gangetic plains wheat in rabi and sesame in kharif are grown in the interspace between subabul trees. In tropical areas food crops are found capatible with casuarina trees in the first few years. In the humid and semi-humid regions maize is found suitable for intercropping with acacia. More over lot of space along the road sides in villages can also be used profitably for planting trees whose wood forms fuel.

to soil. It is therefore essential that the soil testing is one of the prerequisites of modern agriculture practices.

Generalised application of commercial fertilizer is also harmful. The time and depth of application are also very important. It was also noticed that over-irrigation was being followed at many places simply because water is available there in plenty. This practice is also found not only wasteful but also harmful. Thus crop management is a very important aspect of modern agriculture. Enough publicity material, adequate information and many remedial methods are now available for the Indian farmer as a result of the untiring efforts made by the scientists and the governments.

3. Crop protection methods

Crops while in the fields or in storage are very often damaged by insects, pests, weeds etc. These pests can not be easily eliminated. But as a result of great advancements that took place in the agricultural sciences, pest resistant varieties and also many pesticides could be invented. But the administering of pesticides must be done in a planned way and in a scientific way as per the advice of the agricultural scientists. This is known as **pest management.** But indescriminate use of pesticides is more dangerous than the pests themselves both for the crop as well as for the human beings.

22.5 AGRICULTURE IN SPECIAL AREAS

Our country is so big that people consider it as a country of diverse climates and varieties of soil. Hence naturally there should be diversity in agriculture. Through out the year there will be agricultural activities in the country. On account of the population explosion, demands for food increased rapidly and enormously. Hence it became necessary to bring more land under cultivation. In most of the regions the important factors of agriculture namely the required moisture and temperature conditions are not available. So plants which could withstand these difficult situations alone are grown here. Some of these regions which generally do not possess conditions suitable for conventional agricultural practices are (1) arid zones (2) dry lands and (3) hill areas. Hence agriculture in these areas are referred to as **"special area agriculture".**

(1) **Arid zones:** Regions not having enough rainfall to support cultivation are known as arid zones. The temperatures are also not very suitable. Some such zones in India are Rajasthan, Haryana, Karnataka and Ladakh. These areas cover nearly 4 lakh square kilometers. Ladakh is a cold desert covering about eighty thousand square kilometres. Hence crops which can withstand severe cold and are matured in short periods are only used.

For example cereals, oil seeds and fodder crops are cultivated here. Hot desert regions of Rajasthan, Gujarat and Haryana have enough sunshine and abundant ground - water sources but unfortunately the rainfall is unpredictable. The water is generally saline. Hence these areas are successfully utilised for growing fruit trees (pomegranate) and fuel wood yielding trees like acacea & eucalyptus. These regions are well suited for rearing animals such as goats and cattle. In many places the cattle outnumber human population. Lot of animal dung is available. But most of this is burnt as a fuel. But if this is mixed with soil, the soil will be enriched. Even if this is used in the preparaiton of gobar gas, it serves two purposes (1) lot of fuel gas is available and (2) the residue of the gas plant serves as a good mannure. The abundant sunshine is now used to run the solar stills, which inturn are used to convert saline water to drinking water:

(2) **Dry Lands :** These lands contribute about 74% of our cultivated lands. These are entirely rain-dependent. Hence crop fortunes are linked to the monsoon sympathy. Here rains may set in very early or very late or may come on time or are withdrawn too soon. Hence, modern agricultural methods are required to be developed which should concentrate on two aspects. These are conservation of water and selecting of crops which grow quickly with little water.

The run off waters must be collected in community owned ponds. In red soil drylands deep ploughing helps to conserve water, while in black soils, sowing two crops simultaneously improve the situation. Leaves and crop residues should be mixed with soil to improve its texture and water holding capacity. Hence deep root plant such as castor are cultivated in these areas. Agricultural scientists are successful in inventing varieties of sorghum, millets, sunflower, mustard, groundnut, various pulses and cotton which grow in short times and can withstand water scarcity.

(3) **Hill areas :** The age old method of cultivation on these hills is known as "podu" cultivation. Under this system a piece of land on the hills in cleared of vegetation and the plants are burnt, the ash mixes with the soil and enriches the soil. When the crop is harvested, the land is abondoned and the tribals shift to some other piece of land. After 5 or 6 years, the first piece of land recovers its natural fertility and supports shrub vegetation. Since soils are given no time to recoup their natural nutrient losses, the yields decline year after year. Soil erosion also aggravates the problem. To solve the problems of agriculture on hill areas, a new agricultural system was developed. The upper regions are devoted to forestry the second zone is developed for growing fruit trees, fodder grass and legumes. A mix of crops is raised in the third zone. Earthen dams are constructed with locally available material.

These dams collect enough water for irrigation and fish culture. Poultry, piggery, bee keeping, mushroom cultivation and the related activities create a self sustaining complete farming system. This will be a system which perfectly suits to the ecosystem. Thus the scientific advancements that took place in the agriculture sciences in the past decades could successfully utilise the arid zones. dry lands and hilly areas for suitable cultivations.

Check your progress

1. What is multiple cropping ?

2. Write about inter cropping.

3. What are arid zones ?

4. What is dryland farming ?

5. Name the hill area agricultural products.

22.6 RECLAMATION OF SOILS

Generally saline and alkaline soils are not very useful for cultivation purposes. The salinity and the alkalnity of the soil may be natural or man-made. Alkaline soils contain high amounts of carbonates and bi-carbonates of sodium. Saline soils contain chlorides and sulphates of sodium, calcium and magnesium. Thus in both the above types of soils, salts are present in quantities large enough to interfere with crop growth.

But the researches conducted in the area of saving these soils in the last three decades, made it now possible to reclaim these soils for cultivation. The alkaline soils are reclaimed with the cultivation of fodder grasses and growing of trees such as eucalyptus. Soils after reclamation with grasses can be used for other crops, such as rice in kharif and wheat in rabi. The important factor in the management of saline soils is drainage Saline soils have a high water table. Hence drainage channels of one metre depth and 30 metres apart effectively bring down the water take and help in reducing soil salinty. The costs may be very high but neglect of saline soils may ultimately effect our crop production itself.

Saline soils reclaimed are suitable for sorghum, maize and wheat cultivations.

Check your progress

1. How many types of soil are there ?

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2. How are soils reclaimed?

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22.7 GREEN REVOLUTION

In a span of 15 years after independence i.e. from 1949-50 to 1964-65 the agricultural growth in India is at the rate of 32% per year. This growth rate was achieved in all types of crops. It is only in pulses the rate of growth is low and is about 1.6%. At this time Indian government started a technology mission to increase the production of wheat. This is generally referred to as *green revolution*. This activity involved in

(1) producing high yield plant varieties

(2) the use of chemical fertilizers and the chemical pesticides

(3) the introduction of mechanised methods of cultivation

and (4) making available the required water resources.

But unfortunately, in the beginning all our resources were indiscriminately spent on wheat cultivation only inview of this green revolution. To some extent this showed adverse effects on othercrops and their production. After nearly 10 years, a similar green revolution took palce in rice cultivation also. High Yielding varieties were obtained from Japan, China and Philippines. But to some extent this green revolution led to the indiscriminate use of the pesticides.

Before green revolution took place in the rice production we were having in our country a large number of native varieties of plants but this number has been reduced to a minimum now. It seems there are only now about 30 varieties.

Indiscriminate use of insecticides was also responsible for the death of frogs, sparrows etc. In turn these deaths were also responsible for the increased adverse activity on plants of the insects which are usually eaten by the frogs. Further these insecticides entered the human body through water, milk, cereals, meat etc. contaminated with these insecticide residues. Further green revolution demanded a technology which helps in the large scale production of fertilizers and pesticides required for the green revolution. This technology had to be imported and needed a lot of foreign exchange. Therefore the result is that we have a green revolution resulting in much greater agricultural production, but at the same time, it created a greater dependence on other countries. Further such agriculture practices resulted in (1) requiring large chemical inputs and (2) strict regimes for watering and protecting of crops. This is possible only for farmers owning large lands. But much of the land in our country belongs to small farmers. Hence the green revolution to some extent is also responsible for rich to become richer. Naturally the poor farmer has to suffer a lot in this game. But the modern agricultural scientists believe that (1) there is no alternative to increasing of the total agricultural production and (2) that modern technology is also catering to the needs of small farmer also. The technology is neutral to the scale of farming, provided proper practices are followed by small farmers also. There are also other problems associated with this increased agricultural production sale. Increased production brings in also problems of (1) storage, (2) grain-rotting, (3) glut in the market and distress sale by farmers. But at the same time a 10% decrease in agricultural production leads to a large number of starvation deaths. Hence integrated management techniques are very essential to solve these apparently conflicting issues arising out of green revolution.

Check your progress

1. What is green revolution ?

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2. What are the advantages of green revolution ?

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3. What are the disadvantages of green revolution ?

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22.8 WHITE REVOLUTION

Livestock provide us milk, besides other things such as meat, eggs, wool and skins. Practically every family in the village is involved with maintaining of domestic animals which are important sources of livelihood and employment to the villagers. The number of cows, buffaloes, goats and other animals is often an indication of the economic status of the rural family. India today has about 190 million cattle, 62 million buffaloes and about 100 million goats. During 19th century the milk production was only 40 million tonnes of milk. To-day we have good number of Milch breeds i.e. milk producing animals. Gir, Jahintal, Red Sindhi and Deoni are milch breeds.

In the absence of long-distance transport facilities and marketing facilities for milk, the selection of dairy animals over the centuries was based on their ability to produce just enough milk for the family needs. Consequently the best of our milk yielding animals produce was much less than their counter parts in europe.

Therefore a new era entered in the areas of milk production and distribution strategies soon after the green revolution. This is generally known as *White Revolution*. This occured in two stages namely White Revolution-1 and White Revolution-2.

This White Revolution-1 is basically related to the import of high milk yielding breeds of cows such as the Holstein-Friesian, Brown Swiss and Red Dane averaging 5000-6000 litres per lactation and Jersey cows averaging 4000 litres per lactation. These were used in crossbreeding programmes with our native varieties. The cross breeds yielded on the average 3000 litres of milk. But these crossbreeds could not be easily maintained by the village farmers because they could not provide intensive feeding, management and health care.

The next stage; White Revolution-2 is related to the collection, treatment, packeting and distribution of the milk by the dairy farms. These were initially started by the government but now there are many private farms engaged in the task.

These White Revolutions helped the city and town residents as far as their milk needs are concerned. They are now not in the only position to get as much quantity of milk as desired by them, but also are able to get good, and hygienic milk and milk products. It helped indirectly in improving the employment position. But, to some extent, the people in the villages are suffering because, they are unable to get milk eventhough many villagers are milk producers. They are supplying the milk they are producing to milk collection centres and getting higher prices for their milk.

Check your progress

1. What is White Revolution-1 ?

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2. What is White Revolution-2 ?

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3. What types of breeds are used in high milk production ?

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22.9 MODERN FOOD PRESERVATION TECHNIQUES

As a result of great scientific and technological developments that had taken place in the field of agriculture generally and in the production of food materials in special, there was a great need to think of modern methods of preservation of these agricultural food products.

Agricultural products are always obtained during the concerned seasons only. For example cereals are produced in some seasons and pulses are produced in other seasons. Similarly some kinds of fruits are obtained in winter, other types of fruits are obtained in summer. As a result of increased production of all these agricultural produces, they will not be completely utilised or consumed in the same season and at the same time there may not be available in other seasons. So it is but necessary that scientists shall develop suitable methods for their preservation. These methods must cater to large quantity materials as well as to small quantity materials. The methods must also take into account not only the size of the quantity but also the nature of the produce. Perishables, require one type of preservation methods and non-perishables require a different type.

Generally cereals, pulses etc. in large quantities are preserved in big godown and these godowns should be provided with all facilities such that the stored products are not spoiled by insects, rodents etc. To preserve perishable commodities we need cold storage facilities. In non cold-storage godowns suitable disinfectants and fumigants must be used to kill the insects, rodents etc.

In small scale preservation techniques vacuum sealing methods & use of preservants such as vinegar are used. Some times pickling, drying and canning methods are also used.

Check your progress

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1. Why food preservation methods are necessary ?

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2. How large quantity foods are preserved ?

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3. How small quantity foods are preserved ?

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4. How foods likely to be rotten are preserved ?

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22.10 SUMMARY

1. Agriculture is the main way of life of our country. Ours is an agriculture based country. Agricultural products contribute significantly to our economy.
2. Sunlight, water and soil are the basic resources for agriculture.
3. Agricultural production is effected if any of these factors is disturbed.
4. We have in India many plant species. Most of them are native but only few are imported.
5. Due to outstanding researches that took place in the field of agriculture, several newer high yielding and short term varieties of plants were developed by our agricultural scientists.
6. Higher yields were achieved not only through high-yield varieties of plants but also by factors such as cropping systems. Input of nutrients in the form of fertilizers, timely irrigation and proper plant protection measures.

7. Today we are able to use all types of land for cultivation. These include arid zones, drylands and hilly regions. This was possible because of modern agricultural management techniques.

8. Salinity and alkalinity of agricultural land are the major problems of agriculture. But these are now profitably used by developing crop varieties which can grow in these lands.

9. Modern agriculture aims at maximum production with the minimum amount of time, space and energy.

10. Even though food production in India had improved considerably many of our people are unable to have access to food. This is because, they are poor and do not have the purchasing capacity. Further due to lack of adequate preservation facilities, we are not able to store agricultural products and use them in need.

22.11 TERMINAL EXAMINATION MODEL QUESTIONS

I. Answer the following in about 30 lines each.

1. What are the scientific and technological developments that occurred in India in the field of agriculture in the past few decades? Illustrate your answer.
2. Write a detailed account on agriculture in special areas with suitable examples.
3. What is meant by reclamation of soils? Illustrate with examples.
4. What is green revolution? What are its social and economical implications?
5. What is white revolution? How was it possible to have this revolution.
6. What are the basic issues relating to preservation techniques of food stuffs.

II. Answer the following in 15 lines each.

1. What is agroforesting? explain.
2. How is hill area used in agriculture? give examples.
3. How is cultivation in arid zones affected? give examples.
4. What is reclamation of soils? explain.
5. Explain the term green revolution with examples.
6. What is white revolution? How is it useful to the common man?
7. Give a short account of modern preservation methods of food stuffs.
8. Explain the terms "saline" and "alkaline" soils.

22.12 GLOSSARY

1. Arid Land :	land having not enough rainfall to support vegetation.
2. Saline Land:	land contributing excess salt concentrations.
3. Alkaline soils :	soils where pH is greater than 7.
4. Green Revolution :	obtaining improved yields in less time by researches in agriculture. first obtained in wheat.
5. White Revolution :	improved production of milk and effective processing of milk.

BLOCK VI FUTURE OF HUMANITY

This block gives you an account in brief of natural resources & energy and also about the revolutionary developments that took place in space technology and biotechnology. More than these developmental activities and the progress made in some of these modern areas of science and technology, you learn in this block about the quality of life, a twenty first century man expects and the options or choices left for him to achieve this. The main problems associated with modern technology are improved technology, better life with borrowed or purchased imported technology. **or** self reliant and prosperous nation with the slogan or basic principle "prosperity for all"

The block contains 4 units. These are

Unit-23 Natural Resources and Energy

Unit-24 Space and Satellite technology

Unit-25 Biotechnology

Unit-26 Science, Technology, Quality of life and Options of choice.

In the unit-23 you lean about the energy sources.

In the unit-24 you learn about what is meant by space exploration. Is there a need for such exploration and what advances India made in this direction of space exploration activities.

In the unit-25 your learn about biotechnology, and the different areas of activity of biotechnology in brief.

In the unit-26 you learn about the crucial aspects namely

1) quest for prosperity for all
2) dominance by foreign nations exporting technology to developing countries.
3) self reliance and achievement of better life with no restrictions and embarrasments from developed countries.

   After you completed the study of the block carefully you will be in a position to answer the questions.

1. what are energy sources? how these are used ?
2. how to explore, space, and use satellites for the purpose.
3. what is biotechnology and how is it different from the conventional technology?
4. what are the advancements that took place in the field of biotechnology? for example genetic engineering, enzyme immobilization and fermentation technology.

We are of the opinion that after you completed this block, you would certainly be proud of your country which made great and unbelievable progress in the fields of space and fermentaiton technologies. But as an individual you must decide for yourself whether we should shine under borrowed feathers and benefit a small fraction of population or raise our heads and move with self respect under the policy of self reliance and prosperity for all.

UNIT-23 NATURAL RESOURCES AND ENERGY

Contents

23.1 AIMS AND OBJECTIVES

Aims

Your learn about the following in this unit.

1. Natural resources, energy resources, world energy resources.
2. Management of natural resources.
3. Management of environment.

Objectives

After you completed the unit, you will be able to know

1. what resources nature has provided to us?
2. which energy sources are classified as conventional?
3. which energy sources are considered as non-conventional sources?
4. why & how there resources are managed ?
5. why & how environment is managed ?

23.2 INTRODUCTION

Man requires for the sustenance of life, air, water and nutrients. Besides these, man requires energy and other materials for his comfortable living. Air and water are obtained as such from the nature. But the nutrients and the other substances needed are synthesised in the laboratory from the natural mineral resources. (metallic as well as non-metallic) The natural resources are classified as living and non-living resources. These are present on the land as well as in the ocean. In this unit we shall make a survey of these different resources available in nature and also describe how these are explored and exploited reasonably as well as indiscriminately for human use.

23.3 WHAT ARE NATURAL RESOURCES?

The resources or the wealth nature has bestowed on us for our healthy and comfortable living are known as Natural Resources. Some of these resources of the earth are replaced from time to time by natural replenishment. Such resources are inexhaustible and are called *renewable* resources.

For example forests, pastures, wild life and aquatic life are renewable resources. Water can be taken as renewable resource since it is recycled in nature. But there are other resources, which when once used up are lost for ever. They cannot be regenerated or replenished by nature. There are called *non-renewable* resources. Mineral deposits and soils can therefore be taken as non-renewable resources for the following reasons.

Mineral deposits were formed slowly in millions of years. Soil formations are also slow and are long term processes. It takes thousands of years for the formations of soils in nature. These sources namely minerals and soils can not be renewed in the life span of even generations of people. Again the natural resources can be classified into living resources and non-living resources. Minerals, water, soils, rocks etc. can be called *non-living* resources and vegetation, wild life stocks, marine organisms can be quoted as examples for living resources.

It is now believed that these resources are being used carelessly and indiscriminately. This may be partly due to the tremendous population explosion and partly because of the selfishness and foolishness of the present generation of people without thinking about the future generations of people. The developing countries and the poor countries possessing vast deposits of natural resources are thinking of their present day situations without any concern for the future needs and requirements. As such these countries are exporting valuable mineral sources to foreign countries since they are not presently being used in their own countries. They are not realising that these resources which are not presently used, and are therefore exported to other countries at a very cheap cost, will be required by them in the future for their developmental activities. In such an event these countries will be forced to again import these, probably in the finished form from the very same countries and abnormally at high cost. For example in India we have been exporting a metal called cadmium to other countries probably to earn foreign currency. But this metal now is finding a great application in nuclear reactors and power cells. so if our mineral resources of this metal are exhausted completely, in future we will be forced to import the same metal from the other countries at abnormally high prices. Hence natural resources must be used with great care and with a vision into the future requirements of the country.

Check your progress

1. Natural non-living resources are ...

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2. Natural living resources are ...

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3. Which are the store houses of natural resources?

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23.4 METAL RESOURCES (MINERALS AND NON LIVING RESOURCES)

Metals occur in nature as their compounds mainly carbonates, oxides, sulphides and halides. For example calcium occurs as calcium carbonate. Iron occurs as iron oxide, copper occurs as sulphide and aluminium occurs as fluorides. These chemical compounds occurring in nature are called *minerals.* Hence, metal resources can be referred to as minerals. These are obtained from the earth by an activity called *mining.* Minerals are the backbones of our industry and are therefore of great commercial value. The mineral resources include minerals of iron, copper, aluminium, zinc, cadmium, lead, silver, manganese and more importantly uranium, thorium etc. used in atomic reactors. India is self-sufficient in atleast 35 minerals. The mineral producing states of India are Andhra Pradesh, Bengal, Bihar, Gujarat, Madhya Pradesh and Rajasthan. Various metals are also found in the sea basins. The metals are present as their oxides or sulphides in the form of nodules at 4000-5000 metres below the sea level. These include manganese oxides and sulphides of cobalt, nickel, copper and iron. The coastal sands of Kerala and Orissa contain many valuable minerals such as monazite (very useful in atomic energy production) and Zircon. Many other deposits of metals such as iron, gold, platinum are found on the coasts.

In olden days, people used to know about these minerals only accidently when they were digging out lands for water sources (wells) or for the construction of houses. Similarly when farmers were ploughing the land, they used to discover deposits of precious metals and minerals. But they could hit upon the mineral wealth which was lying close to the surface of the earth only in those methods. But now many modern techniques are being used for the systematic exploration of the hidden mineral sources. These exploration methods are rather complex and dependent on the physical, chemical, and biological properties of the resources. These days the explorations are carried by aerial photographic techniques, satellite photographic techniques and also by remote sensing methods. With the data obtained from these investigations, the governments prepare what are known as *Mineral Maps.* These maps show locations of various kinds of mineral deposits. Radio waves and magnetic measurements also provide information about the minerals deposits.

Check your progress

1. Name two or three important metal resources of Andhra Pradesh.

2. Why minerals are to be conserved?

3. Name a resource which is useful for atomic energy production. Where is it available in India?

23.5 NON METAL RESOURCES (ORGANIC AND LIVING RESOURCES)

Besides metal resources namely mineral deposits, there is lot of natural wealth available on land, in forests and in oceans. These resources are both living and non-living in nature. For example water, coal, forest treasures, soils, oceanic resources come under the category of non-metal resources. These are all non-metallic in nature and mostly organic compounds (carbon compounds) pertaining to the living or the non-living organisms. Some of these are water, soils and ocean products. The total volume of water found in the underground reservoir called aquifiers is estimated to be 50 x 10^{10} cubic metres. It seems that only 25% of this amount is only now being put to use. The water-resource maps of India showed that Andhra Pradesh and Tamilnadu have a low ground water potential. It is therefore very necessary that water sources in these two regions must be exploited judiciously and with great care.

Forests

Forests are providing a wide variety of commodities. These are used as fuels, fodders, fibres, fruits, timber, herbal drugs, cosmetics and many other resins etc. Many types of animals and birds which live in the forests serve as useful *living resources*. Satellite photographic studies conducted in eighties indicated that 14% of the geographic area was covered with forests. These forests are exploited indiscriminately and hence these are known to be fast disappearing. This is also causing environmental imbalance.

Soils

Soil is the uppermost layer of the land which is very fertile usually and is the most precious of all the natural resources. It stores water in it and provides us food and fodder in the form of vegetation. Soils rich in organic matter are very fertile. Soils in India are different and varied in their fertility, composition & usefulness etc. The soils found in the delta regions of the coasts of Andhra Pradesh, Bengal, Gujarat, Kerala, Orissa and Tamilnadu are very fertile, highly productive and supports all types of crops. The soils that form the part of the low-lying wet land or marshy land or deltas of Ganga, Godavari, Krishna and Kaveri contain rich organic matter.

Oceans

The **oceanic** living resources include fish and plants, which serve as good foods for men. There are also other non-mineral resources in oceans which are not useful as food materials. These serve as raw materials for the preparation of drugs and other useful resinous materials. As in the case of minerals, location maps are prepared for soils and water sources. These are known as *soil maps* and *hydrological maps*. The soil maps indicate not only the locations where good soils are available, but also they indicate the types and structures of the soils available in any country.

Similarly hydrological maps indicate the places of under ground water sources, their depths and other important physical properties. Thus the nature has provided us huge natural resources both living and non-living. Some of these are renewable, but many of them are non-renewable. Therefore we have to be very careful in using there resources. Unfortunately man is exploiting nature most indiscriminately for his selfish ends. This is a very dangerous trend and unless some remedial measures are introduced forthwith, a day will come when we have to deprive ourselves from the use of some of these valuable and essential natural resources.

Check your progress

1. What products are obtained from forests?

2. What types of soils are available in India?

3. Why forests are important in the environmental protection?

4. What deposits are available in oceans?

23.6 ENERGY RESOURCES - AN INTRODUCTION

Air, water, food and energy are important and vital needs for the sustenance of life on this planet, earth. The energy demand or need of a country is taken as the index of the development of that country. For example India with a population of about 16% of the total world population is consuming only 1.5% of the total energy produced in the world. But at the same time America with a population of about 6.25% of the total world population is utilizing 33% of the total energy produced in the world. This therefore indicates that the level of development of our country is very low compared to the level of development of America.

Energy sources are broadly classified into two categories. These are 1) *conventional* and 2) *non-conventional* energy sources.

For example cowdung cakes, wood, coal, kerosine, petrol, oil gas, biogas etc. come under the category conventional energy sources. Solar energy, atomic energy (or nuclear energy), tidal energy, wind energy, geothermal energy etc. are classified under the category non-conventional energy sources.

23.7 CONVENTIONAL ENERGY SOURCES

Amongst the conventional energy sources the fossil fuels namely coal, petrol, natural gas are all non-renewable energy sources. But *wood* is considered as a renewable source. Wood is thus the major renewable conventional energy source for any country. Forests which produce the woods cover one-third of the land area on a world-wide basis, *coal* is substantially more abundant than oil or natural gas. Coal is a solid fossil fuel derived from partial degradation of plants occurred over millions of years underneath the earth. Coal burning is dirty and unhealthy. It releases CO, and SO_2, the harmful gases into the air.

Petrol is being imported almost completely from other countries till few decades back since petroleum resources were scarce in India then. But we all know that many petroleum wells were discovered in coastal places. Along with petroleum, natural gas is obtained which is very widely used now as cooking gas. Government of India has established a commission to explore the oil and natural gas sources in India. This is known as Oil and Natural Gas Commission (ONGC) of India.

23.8 NON-CONVENTIONAL ENERGY SOURCES

The non-conventional energy sources include solar energy, wind energy, tidal energy, geothermal energy, atomic energy and biogas.

Solar energy : Solar energy is the major energy source for the production of vegetation which serves as food and fuel for mankind. Solar energy is used directly now a days in a more scientific fashion for many purposes including cooking. These are called solar cookers. But efforts are also made to trap solar energy and convert it into electrical energy "solar batteries". These will be very useful in the regions where the earth's surface receives great quantities of solar energy. For example in a desert like Rajasthan, it would be very advantageous to develop solar cells or solar panels for harvesting solar energy.

Wind energy : Wind currents can also be harvested (like solar energy) into mechanical energy for uplifting water from the wells or from rivers. The devices used for the purpose are called *wind mills*. These are fan like structures and these fans are rotated by the force of the wind. These can also be used to run generators for production of electrical energy. The coastal and hilly areas are most suitable for wind energy harnessing. India has also installed many wind mills in recent times.

Tidal Energy : Waves and tides of oceans are another source of energy which is perpetual. This can also be converted into electrical energy. The places where rivers flow into the seas are suitable for these purposes. Energy carried by these tidal or wave waters can be converted into mechanical energy & then into electrical energy.

Geothermal energy : Nature provided us with hot water or superheated water springs. These are called **giesers**. The energy possessed by these hot spring waters is known as geothermal energy. About 46 hydrothermal areas where the temperature of the hot spring water exceeds 150^{0} are identified in our country. These hot springs are useful to generate electricity.

Atomic energy or nuclear energy : The energy obtained in the nuclear reactions (fission and fusion) is known as **atomic energy.** In the nuclear fission reactions Uranium-235 is fissioned with slow neutrons. It is estimated that 1 kg of uranium gives approximately energy equal to that produced by 35000 kg of coal. Atomic energy is also obtained in hydrogen fusion reactions. In these reactions hydrogen atoms are made to combine to give helium atoms. All these nuclear reactions are carried out in special devices called *nuclear reactors* or *atomic reactors*. These are to be operated with great care so that there are no accidents and leakages. The waste materials obtained in these reactors must be also handled and disposed off carefully because these are all radioactive substances.

Biogas : This is yet another non-conventional energy source. This is a modified version of gobar gas known earlier. Gobar gas was being prepared using animal dung. But biogas is prepared from biomass. Water weeds like water hycinth, duck weeds and algae are found useful to supplement the animal dung. Biogas is used not only as a cooking gas but also in the generation of electricity. The residues obtained in the biogas plants are very useful nitrogen mannures. This fact to some extent solves the problems of energy, efforts are being made to instal tens of thousands of biogas plants in the rural areas.

Besides these non-conventional energy sources, some effluent nations are trying to use hydrogen gas also as a non-conventional source of energy. H_2 gas is used to produce electricity in what are called fuelcells.

Check your programme

1. How are energy sources classified ?

2. Give few examples of non-conventional energy sources.

3. What are fossil fuels? Why are they called so?

4. What is the future energy source available for the human beings?

5. How can solar energy be harnessed?

23.9 WORLD ENERGY RESOURCES

The initial stocks of the different fossil fuels available before 18th century can be approximately listed as

fuel	stock	energy equivalent (K.W.H.)
Coal	7.6×10^{12} metric tonnes	55.9×10^{15}
Liquid petroleum	10×10^{12} barrels	3.25×10^{14}
Natural gas	10×10^{16} c.ft.	3.0×10^{15}
Shale oil	0.2×10^{12} barrels	0.3×10^{15}

The bulk of the total production of oil and natural gas is expected to take place during 1940-2000 AD. The world production is expected to be at its peak in 21st century after 2000 AD. About 20% of the world's coal reserves occur in the USA. Atomic energy production is maximum in the developed countries compared to the developing countries. This energy source ofcourse is inhibited. Solar energy is both renewable and non-polluting and is considered as a valuable energy source.

On a global scale, trapping of even a small fraction of solar energy may meet all the energy requirements of the world.

It is commonly accepted that the standard of living in a country is directly linked with the quantum of energy consumed by the country. This is reflected in the per capita energy consumption - per capita gross national production (G.N.P.) A roughly linear correlation is observed between these. Underdeveloped countries lie at the bottom and developed countries such as America lie at the top of the linear graph between the per capita energy consumption and per capita GNP. Some times there will be no direct relation between these two namely energy production and GNP. Energy production may be less and GNP may be more or vice versa. Thus it is clear that utilization and waste of the energy are equally important than the actual production capacity of the energy for any country. More utilization and less waste may lead to higher standards of living.

The energy consumption can not grow exponentially for ever. The principles of conservation of energy will be playing a greater role in future activities. **Use more, waste less will be the important factors.**

On the industrial front, emphasis must be placed on increased output with reduced energy consumption. Infact, energy auditing is occupying and going to occupy an important place in all walks of life. It is estimated that the percent waste of the energy is maximum in transport compared to other activities. For example

	Percent utilised	Percent waste
Industry	60	40
Transport	15	85
Household & Commercial	70	30

In the area of transportation, efficient consumption of energy must be the need of the time. This can be achieved by proper planning and by the use of efficient vehicles. Eventhough energy consumption methods are quite efficient as far as household and commercial concerns are concerned, efforts must be made to save energy and adopt less energy consuming practices.

Check your progress

1. How energy is to be conserved?

2. What is the need for energy conservation?

3. In which areas energy is wasted in large amounts ?

23.10 RESOURCES MANAGEMENT

Resources are limited and if they are not used properly, they will get exhausted soon. It is therefore necessary to have wise and careful planning in the utilization of the sources.

For example land is an exhaustible resource and is very sensitive to changes in climate and physical process of nature, such as rains, sunshine, erosion, land slides, vegetations etc. Therefore land is required to be used according to suitability and capability. More food production required more land for cultivation. Therefore fertile agricultural lands should not be used for non-agricultural purposes. Extreme care should be taken is selecting places for industries and reservoirs etc.

Hill areas as far as possible should be put under forest cover because forests serve as resources for fuel, fodder, timber and also provide space for animal breeding. Forests improve the underground water table. These prevent soil erosion and floods also can be avoided. Forests help to maintain ecological balances. Therefore following steps are essential for land management.

1. Land capability and soil productivity maps must be prepared.
2. Land optimum use programmes must be drawn up. These must be based on the factors such as type of soil, water resources available, surface flow and surface storage capacity.
3. Changes taking place in the land and also in the environment must be continuously monitored and remedial measures are adopted for adverse changes.
4. Natural hazards that are likely to threaten a particular region of the land must be investigated and anticipated.
5. Comprehensive land management plans must be worked much in advance.
6. In the case of soils, soil erosion must be checked and the productivity must be restored in case it is lost.
7. By rotation of crops, soil fertility must be restored.
8. By over irrigation, soils become sick due to increase of salinity and alkalinity. This must be checked.

Forest resources

Forests are not only good resources for food and timber, they also help in so many other ways such as averting floods, increasing underground water resources, keeping the environment clean. Therefore the following management steps are very necessary.

1. Forest products must be harvested by scientific methods.
2. Forest growth and depletion must be regularly monitored.
3. Forest fires must be avoided.
4. Unauthorised cutting of forest trees must be severely dealt with.
5. Afforestation methods must be followed strictly.
6. Deforestations must be discouraged.

Water Resources

Efforts must be made to see that

1) Water of right quality must be supplied for all uses.
2) Misuse of water must be curbed.
3) Recharging of ground water must be taken up sincerely.
4) The excess flow of normal as well as flood water must be diverted to areas where there is scarcity.
5) Methods to convert used water and saline water into potable water must be worked out and implemented.

Mineral Resources

Mineral resources are generally limited and they may get exhausted if indiscriminately used. It appears that many of the useful and important minerals may get depleted soon if the present rate of their consumption is continued. Hence minerals must be conserved and judiciously used with minimum wastage. This means conservation is one way of minimising wastage, by recycling or recovering the mineral or its product as much as possible. Scraps of used metals can be recycled or used again. Another way of conserving precious minerals or metals is to find artificial substitutes for them in unimportant areas. Mineral resources management therefore involves the following activities.

1. Continuous monitoring of the changes in the quality and quantity of resources.
2. Continuous monitoring of the utilization of the mineral sources.
3. New recycling methods for the rare and less available minerals must be worked out.

Check your progress

1. What is resource management ?

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2. What is meant by energy conservation?

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3. How is the energy managed?

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4. How is minerals management achieved?

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23.11 ENVIRONMENT MANAGEMENT

Environ management is an emerging discipline. This relates to an understanding of the integrated relationship existing between the environment and the developmental activities.

For example the government of India even in its sixth Five Year Plan (1980-85) frame work emphasised the following policy.

"It is imperative that we carefully utilise our renewable resources of soil, water, plant and animal life to sustain our economic development. Over exploitation of these is reflected in soil erosion, silting, floods and rapid destruction of our forest, floral and wild life resources. The depletion of these resources often tends to be irreversible and since the bulk of our population depends on these natural resources to meet their basic needs particularly of fuel, fodder and housing materials, it has meant a deterioration in their quality of life".

In any new developmental project, top priority must be given to environmental, social and cultural impacts.

Environ management is totality of the management of land, water, forests and mineral resources. But in this total management or integrated management experts from all walks of life must be involved.

Environment protection and stopping of environmental degradation must be our prime concerns in the environment management activity. Promulgation of laws and acts of legal nature would not alone solve the problems of environmental degradation. Every citizen of the country must realise that it is his or her concern and responsibility to protect our environment. This can be achieved to a large extent through creating the necessary awareness amongst all the citizens of the country irrespective of whether they are literates or illiterates. Environmental science programme should be included at all the levels of education. The conventional media and the modern technology including the information technology must be extensively used in increasing this awareness.

Check your progress

1. What is environmental degradation ?

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2. How is environmental degradation averted ?

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3. What is meant by environment management ?

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23.12 SUMMARY

1. The resources or the wealth nature has bestowed on us for our healthy and comfortable living are known as natural resources.
2. Some resources are replenished from time to time by the nature itself. These are called renewable resources.
3. Forests, pastures, wild life and aquatic life are renewable resources.
4. Water is a renewable resource but mineral deposits are not because these are formed very very slowly.
5. Natural resources are classifed as living and non-living resources.
6. Minerals, water, soils, rocks are non living resources.
7. Vegetation, live stocks, marine organism are living resources.
8. The resources are now being exploited and used very indiscriminately and carelessly.
9. Non-living resources can be classified into metal & non-metal resources.
10. Minerals can be classified as metal resources.
11. Land, soil, water, asbestos, some important carbon compounds etc. are classifed as non-metal resources.
12. The mineral deposits of any country indicates its effluent nature or otherwise.
13. India is very rich in mineral deposits.
14. Any country is therefore required to prepare mineral maps with the help of modern technology called remote sensing and aerial photography.
15. Lots of living resources are available on land, in forests and in oceans.
16. Water, coal, forest treasures, soils and some oceanic products come under non-metal resources.

17. Forests provide a wide variety of commodities. These are used as fuels, fodders, fibres, fruits, timber, herbal drugs, cosmetics and resins.

18. Birds & animals are the living resources of forests.

19. Soil, an uppermost layer of the land is another important resource.

20. India and especially Andhra Pradesh possessed large and fertile varieties of soil.

21. But much of the soil is erroded and it is therefore required to be protected.

22. Oceans are the other largest natural resources. These contain both living and non-living resources.

23. Energy is the most other important natural resource.

24. Coal, petroleum, wood are the conventional energy sources of the nature.

25. Sun, tidal waves, fast winds, geothermal water sources are non-conventional energy sources in the nature.

26. Besides these, atomic energy is the major man made non-conventional energy.

27. These natural material sources as well as the energy sources are exploited by the man indiscriminately and carelessly for his daily needs and comfortable living.

28. Hence this is leading not only to the rapid deplenishment of the natural resources but also to the degradation or deterioration of the environment.

29. Suitable remedial measures are to be worked out and launched to conserve and manage the resources as well as the environment.

30. The most important amongst these measures is educating the people about the adverse effects of environmental degradation and the consequential health hazards.

23.13 TERMINAL EXAMINATION MODEL QUESTIONS

I. Answer the following in 30 lines each.

1. What are natural resources? Classify them and give examples for each.
2. What are metal resources? Explain the same with important such resources of our country.
3. Enumerate and explain the usefulness of the forest products.
4. What are the living and non-living resources of the oceans? explain.
5. What are soils and how are these classified and used for the comfortable and healthy living of human beings.
6. How is natural resources conserved and managed?
7. What are the different forms of energy? How are these managed?
8. What is environmental management? How is it achieved?

II. Answer the following in 15 lines each.

1. What are minerals and give an account of mineral wealth of India.
2. What are the resources obtained from forests? What are their uses?
3. What natural wealth is available in oceans? How is it useful to man?
4. How are mineral resources conserved?
5. How is non-conventional energy harnessed and conserved?
6. What are conventional energy sources?
7. What are non-conventional energy sources?
8. How is environment managed for better quality of it.

23.14 GLOSSARY

Currents	:	type of water movements.
Geothermal energy	:	heat with in the earth's interior is a potential source of energy.
Nuclear Reactor	:	a device in which controlled nuclear reactions are carried out.
Ores	:	commercially beneficial minerals.
Soil erosion	:	detachment and movement of top soil by the action of wind or flowing water.

UNIT-24 SPACE AND SATELLITE TECHNOLOGY

Contents

24.1 AIMS AND OBJECTIVES

Aims

In this unit, you would learn about

1. the need for space explorations
2. the methods of space studies
3. the rockets
4. the artificial satellites
5. the usefulness of the artificial satellites for human development.

Objectives

After you completed this unit you would be able to

1. know what is meant by an artificial satellite.
2. understand how these satellites are put into space.
3. clearly know how a rocket, satellite vehicle works.
4. understand the applications and uses of this satellites in

(i) weather forecasting

(ii) telecommunication

(iii) remote sensing

(iv) knowledge and information storage and retrieval.

24.2 INTRODUCTION

You learnt in unit-15 about our solar system. In this system, the planets revolve round the sun in their orbits. The enormous volume of empty space existing between one planet and the other is known as interplanetary space. The space above the earth's surface is called outer space. Upto a certain distance in this space, the earth exerts its pull on the bodies put in the space. Any body that goes beyond this distance is not under the action of this pull. A body projected into space upto a distance generally falls down because of the earth's gravitational force. Imagine a high tower on the earth (Figure 24.1) and man flinging objects horizontally with different speeds from the tower. When the speed of the flinged body is small, the body falls down and touches the earth's surface at position I when the speed of the body is increased it goes further out into space and falls back and touches the ground at 2. A further increase in speed makes it travel to a longer distance and touch the ground at 3. But when the speed attains a speed of the *critical value* of 7.8 km/sec the body goes on revolving round the earth as shown in 4. At this speed, the centrifugal force acting on the revolving body is equal to the force of gravitational attraction. Therefore the body is kept moving in the orbit. Such a body revolving round the earth is called an artificial satellite. Moon is a natural satellite of the earth. This critical velocity is called **escape velocity.**

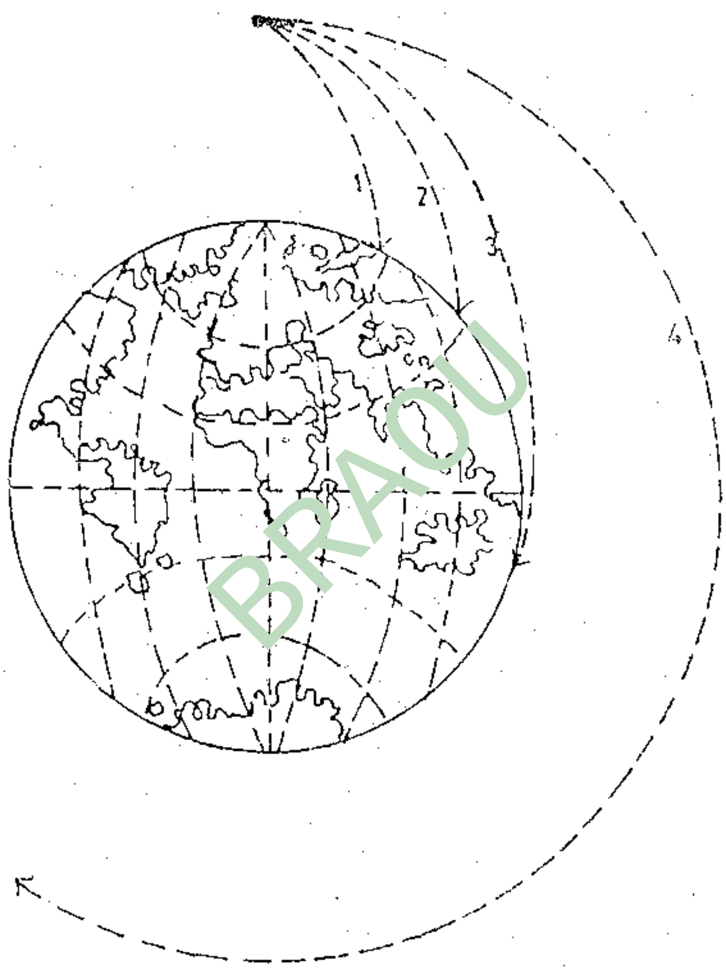

Figure 24.1 Escape velocity

Therefore if we wish to place an object or a body into space it must be projected into space with high velocities (greater than escape velocity). These artificial satellites have been launched into space by different countries including India for different purposes. This activity began four decades back. For example we would not have been able to witness the cricket match or any other match being played at far off places or in other countries at the same time when these are played. Presently we are able to store lots of information, data and knowledge of different types in these satellites and retrieve them whenever we needed them. The space investigations or the space explorations have become almost a necessity for any country rather than a luxury or boon. You learn about these artificial satellites in detail in the next section.

24.3 SPACE AND SPACE EXPLORATIONS

Space explorations have been taking place since 1957. The first space body called sputnik-1 has been put into space by Soviet Russia on 4th october 1957. Its beep, beep, signals stirred thrill and excitement in every human heart. Its luminous perambulations of the earth gladdened those who scanned the night sky. Influenced by the achievements of Russia, the United States of America launched its own ambitious projects of exploration of space. The soviet cosmonaut Gagarin is the first man launched into space on April 12, 1961. The United States had made its preparations for complex manned space mission through its Ranger, Surveyor, Explorer, Gemini and other missions. The Apollo mission made it possible to land astronauts (space travellers) on the moon and bring them back safe to earth. US manned space shuttle Columbia weighing 75 tonnes can take off like a rocket. The second space shuttle challenger made its maiden flight in April 1983. It has placed satellites in orbit and it could also recover them from space. Now there are atleast 15 countries which have had their satellites in space. These are Australia, Canada, China, Czechoslovakia, France, Great Britain, India, Indonesia, Italy, Japan, Netherlands, Spain, West Germany, the USA and USSR. This list is not exhaustive and complete. India's INSAT-1B was placed into orbit by challenger on August 31, 1983. India put a 35 kg satellite with a four-stage rocket fired from Sriharikota in Andhra Pradesh.

In the year 1961 space research and the peaceful uses of outer space were entrusted to the Department of Atomic Energy (DAE) by the Government of India. The following year DAE set up the National Committee for Space Research (INCOSPAR) to advise and organise the space programmes.

In 1969 'INCOSPAR" was reconstituted under the Indian National Science Academy. The Indian Space Research Organization (ISRO) was set up by DAE. In 1972, the Government of India set up space commission and the department of space (DOS). The latter was entrusted with the responsibility of conducting India's space programmes. DOS functions directly under the supervision of the Prime Minister. ISRO functions under the DOS as its research and development wing. As chairperson of ISRO all our scientists such as Sarabhai V.A., M.G.K. Menon, Kasturi Rangan are praise worthy. With ISRO headquarters at Bangalore, its activities are executed by the Vikram Sarabhai Space Centres (VSSC) at Thumba in Kerala, the ISRO satellite centre at Sriharikota, Andhra Pradesh and Space Application Centre (SAC) at Ahmedabad, Gujarat. Another centre is available at Hasan, Karnataka.

The VSSC is the main centre for research and development in space technology. This participates in the research related to the developments of rockets and satellite launching vehicles. The first Indian satellite Aryabhatta and the Rohini Satellite (RS-1) were made here. The communication satellite APPLE (Ariane Passenger PayLoad Experiment) which was launched by Ariane rocket in 1981 was also built here.

Satellites launched by us which are fully or partly successful include. Aryabhatta (1975), Bhaskara-1 (1979), Rohini-1 (1979), APPLE (1981), INSAT-IB (1983), Anuradha (1985).

24.4 ROCKETS

Every flight into space begins with a rocket launching. It is this rocket that lifts a satellite and puts it into space. It is hence called *launch Vehicle*. The rocket is known to us in one form or other for centuries. We all used small rockets as fire crackers on deevali and other festive occasions like marriages. The rockets we use in launching the space vehicles are very big and are made using highly advanced technology. But the scientific principles underlying the preparation of the rockets used on festive occassions and the rockets used in satellite launching are the same. A typical diagram of a rocket is shown in the figure 24.2.

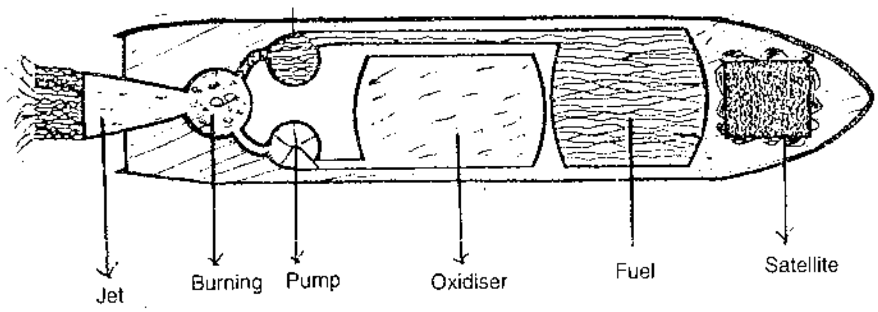

Figure 24.2 Space vehicle launching rocket.

A stream of hot gases comes out at high speeds from the rear end when the fuel in the rocket is set to fire. As a reaction to the thrust of these ejecting hot gases, the rocket moves in the opposite direction (i.e. forward direction) as per Newtons third law of motion. As long as the fuel in the rocket is burning and shooting out the hot gases, the rocket continues to move forward and acquires great speeds. But it is not possible to achieve the high speeds needed to orbit the earth or to escape from the earth's pull, from any single rocket. Therefore high speeds are achieved by using big and small rockets fired in stages. First the large rocket moves into space and uses up its fuel. Then it is separated from the smaller rocket and drops off. The smaller rocket moving ahead at high speeds is fired now to get even higher speeds. Three stage rockets are generally used in most space launchings. The final stage of the launch vehicle carries the *payload* (satellite).

Check your progress

1. What is meant by space ?

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2. What is rocket?

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3. What is artificial satellite ?

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4. Explain remote sensing ?

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5. Name the first artificial satellite launched by India.

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6. What is the latest artificial satellite?

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24.5 ARTIFICIAL SATELLITES

The man - made (see 24.3) objects put into the space and are moving in the orbit around the earth are known as *artificial satellites*. Most of these satellites go round the earth once in 24 hours and hence these appears not moving at all or stationary. Generally satellites are launched into space at great heights of 36000 kms with high speeds to make them move around the earth once in 24 hours. These satellites are called *geo stationary* or geostationary satellites. For example our INSAT-IB, INSAT-IC are geostationary satellites. Satellites also carry equipment to survey earth's natural resources and monitor weather. Satellites also give useful information regarding agricultural lands and mineral resources. Such satellites are called remote sensing satellites. The satellite IRS (Indian Remote Sensing Satellite) is one such. Satellites are also used in telecommunications, telephone and telegraphy etc. We can make long distance telephone calls not only to other towns within the country but also to several towns in other countries through direct dialling without the help of a telephone operator. This is possible only through the use of telecommunication satellites. Multiple purpose satellites for expanding the communication network in the entire country were launched by India. These are INSAT-IA (1982), INSAT-IB, (1983) and INSAT-1C (1988). These satellites are providing wide spread coverage to the media. These are also highly useful in the fields of meteorology, resource surveys, telecommunications and research. Satellites are useful in studying the effects experienced by plants and animals placed in space. Soviet Unions space laboratory called "Salyut" is going round the earth as a satellite. Satellites are also useful in identifying air pollutions, spot out forest fires, locate areas of crop diseases. Weather conditions can also be monitored to predict cyclones and storms and prevent damages caused by them.

Check your progress

1. Name the remote sensing satellites launched by India.

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2. For what purposes are Rohinis launched?

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3. Name the multipurpose satellites.

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24.6 SPACE PROBES

If a space craft is directed to move out in space away from the earth, it is called a *space probe*. It there are no men in these space crafts, these are called unmanned space probes. Several such probes are launched on the planets, Mercury, Venus, Mars, Jupiter, Saturn, Uranus and Neptune. These will send valuable data and photographs of these planets. From this we would be knowing the conditions prevailing on these planets. It is not possible to know about the physical and weather conditions prevailing by any other methods so easily. Many satellites have been sent into orbit around Mars. Two automated laboratories have been landed on its surface. The information given by these indicated that there are craters of all sizes ranging from 5 to 120 km in diameter and that there are volcanoes which are three times as high as Mount Everest. The surface features indicated that Mars had both atmosphere and oceans in the past. Vicking space probes sent by USA, did find evidence that liquid water once existed on Mars. It also contained soil which is similar to that of earth soil. Mars atmosphere contained 95% carbon dioxide, the rest is nitrogen and argon & water vapour. Mars is a cold planet and the temperature ranges from 21^{0}C to - 84^{0}C.

- *The space crafts launched by India for different purposes are as follows.*

Space Craft	Year	Purpose
Aryabhatta	1975	Scientific
Bhaskara-1	1979	Geostudies
Rohini	1979	Geostudies
Rohini	1980	Geostudies
Rohini	1981	Scientific
Bhaskara-2	1981	Scientific
INSAT-1A	1982	Communications
Rohini	1983	Multipurpose
INSAT-1B	1983	Scientific
SROSS-1	1987	Technology
IRS-1	1985	Technology
SROSS-2	1988	Remote Sensing
INSAT-1C	1988	Technology
INSAT-1D	1990	Multipurpose
IRS-1B	1991	Remote Sensing
SROSS-3	1992	Scientific
INSAT-2A	1992	Multipurpose
INSAT-2B	1993	Multipurpose
IRS	1993	Remote Sensing
SROSS-4	1993	Scientific
IRS-D2	1994	Remote Sensing
INSAT-2C	1995	Telecom
IRS-1C	1995	Remote sensing
IRS-P3	1996	Remote sensing
INSAT-2D	1997	Telecom
IRS-1D	1997	Remote Sensing
INSAT-2E	1999	Multipurpose

24.7 DIVIDENDS FROM SPACE

Now many countries including the developing countries are also spending quite good amounts on these space studies and in launching artificial satellites. Naturally, the most important question is, what for all this enormous expenditure? The answer to this question is always positive. There are many benefits from the space programmes. Infact space studies and the launching of artificial satellites, are now more a necessity than a mere prestige issue. These space studies and space researches are also helping indirectly the growth of industry and technology relating to, light but strong alloys, better steels etc. The sophisticated medical instruments designed for space travelers are also found very useful to people on the earth. New methods developed for food preservation for astronauts are finding great applications on earth also.

Above all, weather forecasting, remote sensing of natural resources, telecommunications are the main uses of the satellites. Space travel has given man a new view of his planet earth. It has shown the earth as a beautiful planet rich in colour and natural resources. Our planet is a closed system depending for energy on sun, only as a primary energy source. The natural resources even though rich are limited. These can not be replenished. Earth is also as fragile as any glass object in respect of its natural resources and has a single environment. Therefore it is the duty of every human being on the earth to protect and preserve our earth because if spoiled we do not have an alternative earth. We must protect it from those who in their greed and ignorance are trying to destroy it in the name of science and technology. Therefore the space programmes, the space probes and the launching of artificial satellites must help us all, the humans on the earth to identify new resources, preserve the old ones, and protect the environment from human made degradations.

Check your progress

1. What benefits we get from space probes ?

2. Why man is destroying the quality of earth?

3. What damages are there if earth is not protected ?

24.8 SUMMARY

1. Advances in space exploration technology have helped man to understand the solar-system as well as the planet earth much better than in the past.
2. To put a body into space, it must have a speed greater than the escape velocity 7.8 km/s.

3. This can be achieved when this body is carried by fast moving rockets or rocket systems.

4. Rockets function on the principle of Newton's laws of motion (3rd law).

5. Generally this rocket system is called vehicle. It consists of atleast 3 rockets of different sizes and capacities.

6. The body put into earth's orbit in space is called satellite or artificial satellite.

7. These artificial satellites have proved very useful to mankind for many developmental programmes.

8. Some of these include remote sensing, forecasting of weather, telecommunications and information storage and retrieval.

9. Beginning with Russia and USA, many developed and developing countries launched artificial satellites of different kinds.

10. India did not and does not lag behind in this endeavour.

11. Nearly two dozens of artificial satellites useful for many purposes have been launched by India into the space. Starting with Aryabhatta in 1975, about two dozen satellites, the latest being INSAT-2E in 1999 were launched by India.

12. The various applications for which these satellites are launched include scientific investigations, earth studies, remote sensing of natural resources, weather forecasting, telecommunications and information storage.

24.9 TERMINAL EXAMINATION MODEL QUESTIONS.

I. Answer the following in 30 lines each.

1. Explain the terms artificial satellite, rocket, escape velocity and also how a rocket functions.

2. What are the Indian achievements in the field of space technology and explorations?

3. Give a chronological account of the launching of artificial satellites by Government of India with the purposes for which these launchings are made.

II. Answer the following in 15 lines each.

1. Explain "artificial satellite", "rocket".

2. Name four artificial satellites used for remote sensing.

3. Name three artificial satellites used for multi purpose functions.

4. Name three artificial satellites useful for telecommunications.

24.10 GLOSSARY

Geostationary	:	moving so as to remain always above the same point on earth's surface.
Satellite	:	a body moving together with earth in its orbit.
Satellite (artificial)	:	a body introduced by man into space such that it functions as a satellite.
Rocket	:	a carrier vehicle which puts artificial satellite into space.
Remote Sensing	:	survey of natural resources with the help of artificial satellites.

UNIT-25 BIOTECHNOLOGY

Contents

25.1 AIMS AND OBJECTIVES

Aims

In this unit you would learn about

1. what is bio-technology
2. the bio-technological process known to even the primitive man.
3. the modern developments taking place in the field of bio-technology
4. the three main wings of modern bio-technology
5. the applications of bio-technology

Objectives

After you completed the unit you must be able to

1. understand the difference between the conventional chemical reactions and the fermentation.
2. know what is modern bio-technology consisted of
3. understand the role of genetic engineering in treating congenital disorders.
4. assess the potentialities of the fermentation technology.

25.2 INTRODUCTION

Technology is considered as an extra corporeal organ of human body. Animals are provided by nature itself with some organs to protect themselves from the ill effects caused by the environment. But man is not provided with such specific protective organs. But man is bestowed with thinking faculty which not other living organism has. Therefore man has invented technology using his intelligence and the thinking faculty to protect himself from the adverse effects of the environment as well as to make his living comfortable and happy. The wealth and prosperity of a nation depend on the effective utilization of its human and material resources through technological developments. The creation and adoption of a new scientific technique can in fact, make up for a deficiency in natural resources and reduces the demands on the capital. Technology grows out of the study of science and its applications.

Therefore the nation should be able to innovate technology according to its needs. Till recently this technology development is mainly in the fields of materials development and harnessing of energy from natural sources. Biotechnology is another engineering technology of recent times. This holds promise of unlimited benefits if utilised properly in many fields including materials production, agriculture, health, population control, diseases eradication and correction of congenital defects.

25.3 BIOTECHNOLOGY : WHAT THIS IS ?

Industrial scale utilization of biological systems and processes can be broadly called as **Biotechnology**. This is strictly speaking, not a new activity or endeavour. This is known to man for the last thousands of years. The most ancient biotechnological process known to man is called as **fermentation.** Man knew this process for thousands of years. Use of living organisms in making domestic foods and edible & non edible products was considered as biotechnology or fermentation technology in earlier times. For example man was using living micro-organisms for centuries to make curds, condiments, cheese and vinegar. Bread and alcohol are also prepared by this fermentation process. But people did not know about the mechanism or the scientific principle underlying this fermentation process. These fermentation process are now more fully investigated with the help of powerful microscopes and carefully designed experiments in the laboratory. It is observed in these investigations that the micro organisms function as bio-chemical factories. Hence the success of biotechnology depends on the control and manipulations of micro-organisms. Hence the ability to control and manipulate microbes and use them for various useful applications paved way to the emergence and development of modern biotechnology. This bio-technology can be subdivided into three main areas. These are a) genetic engineering, b) enzyme immobilization and c) fermentation technology.

All these three are playing a significant role in food production, synthesis of drugs, agriculture, correcting congenital diseases and abnormalities and gene engineering.

Check your progress

1. What is the meaning by bio-technology?

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2. What are the potentialities of modern bio-technology?

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3. Name one or two important applications of biotechnology.

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25.4 GENETIC ENGINEERING

The physical structure, sex, growth, reproduction and all other related functions of living beings are controlled by a complex organic molecule present in genes. This is known DNA Deoxy Ribo Nucleic Acid. This DNA directs the synthesis of proteins in all living organisms. The programme for controlling protein synthesis is coded in the chemical structure of DNA. The discovery of the structure of DNA, its coding and its synthesis in the test-tube are all great milestones in the field of bio-technology. We all Indians should be proud of Hargobinda Khurana, who got nobel prize for his pioneering work in this field. It is discovered that cells of micro organisms accept DNA supplied from outside. DNA introduced from outside enables the cell of the micro organism make the protein specified in the codes of added DNA. The new cells are formed and these can be cultivated or **cloned**. These multiplied cells synthesise the proteins. But this is not so simple because, some enzymes called "restriction enzymes" present in the cells try to destroy the added DNA. But very soon it was discovered that small rings of DNA called **plasmids** exist in the cells of micro organisms. These can be taken out from the cells. Foreign DNA can be easily added to these plasmids and the process is known as **gene splicing.** If this DNA added to the plasmids is inserted into the host cell, the restriction enzyme fails to destroy the added DNA. In the process of replication of the cells, the added DNA is also replicated and directs the manufacture of protein coded in it. The whole process is called genetic engineering. Hence by this genetic engineering technique it is possible to introduce foreign DNA into a host cell and the desired protein can be synthesised. Biologically scarce proteins which are not obtained from natural sources are prepared by the above mentioned genetic engineering techniques. For example, insulin needed by diabetic patients is produced on large scale by using this technique.

Scientists are now therefore breeding bacteria for carrying out special functions. They are able to now breed bacteria which can eat and destroy the plastic materials thrown out as wastes. There bacteria are called "Bugs". The breeding of these "Bugs" help in the biodegradation of environmentally harmful materials such as plastics, carrybags etc.

Check your progress

1. What is DNA ?

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2. What role DNA plays in living cells.

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3. How is DNA introduced into living cell.

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25.5 ENZYME IMMOBILIZATION

Enzymes are organic catalysts formed in the living cells of plants and animals which are essential in bringing about specific biochemical reactions in the living cells. Enzymes are classified by their method of activity or catalytic function as represented in the table 25.1

Table 25.1 Nomenclature of enzymes.

Catalytic function	**Name**
Oxidation - reduction	Oxidoreductase
Group transfer	Transferase
Hydrolysis	Hydrolase
Group removal	Lyases
Isomerization	Isomerases
Joining of molecules	Ligases

Generally the name of the substrate undergoing this reaction is also added. For example the enzyme responsible for the oxidation of glucose is named **glucose oxidase.** The enzyme employed for the hydrolysis of the sugar maltose is known as **maltose hydrolase** or **maltase.** Industrial enzymes originate from bacteria, fungi, and higher plants and from animal sources. These are extracted or prepared by fermentation (microbial enzymes).

For example one of the oldest and most widely sold enzyme is **rennet**. This is used in cheese making industry and in leather softening. This is extracted from washed and defatted calves' stomachs. The enzyme **amylase** used for converting starch into sugar is prepared by fermentation using corn-steep liquor and cornstarch. After proper sterilization, the mixture is inoculated with **Bacilus Subtilis** and fermented.

Enzymes are used in industrial preparations. But purified enzymes are soluble in water. It is therefore difficult to remove these enzymes from the final product of the preparation. Further it is also difficult to re-use them. Thus we lose the enzyme activity in one cycle of chemical operation only. These difficulties prompted the scientists to search for methods which can save the enzyme for subsequent use and also protect the final product from contamination by the enzyme. The scientists observed that these can be achieved by linking an enzyme chemically to a large molecule such as **gelatin**. This can be used as a catalyst and it can be reused again. This process of linking chemically the enzyme to a large molecule is known as **immobilization**.

The immobilized enzymes are successfully used in the semi-synthetic processes of many antibiotics. Fructose, a sweeter sugar than glucose is industrially prepared from maize using this immobilised enzymes.

Check your progress

1. What is enzyme immobilization ?

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2. What is the need for it ?

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3. How is enzyme immobilization made?

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25.6 FERMENTATION TECHNOLOGY

Fermentation of fruits to alcohol was known to primitive man even. Making of various beverages out of fruits and grains has been well established for centuries. All these processes are known as fermentation processes. It is only Louis Pasteur, who showed that fermentation is directly caused by the life processes of minute organisms called **microbes**. Now scientists are directing the life processes of yeasts bacteria and moulds to the production of chemicals. Alcohol can be viewed as having been produced in this way from the earliest times. But making of acetone, butanol, acetic acid, lactic acid, citric acid and many antibiotics are recent technical applications. Yeasts and bacteria are unicellular organisms of very small dimensions. Yeasts are irregularly oval and are 0.004 to 0.010 mm. in diameter. Bacteria are more diverse in shape and are of 0.007 mm in diameter.

Many chemical compounds of great importance are now being prepared on large scale by fermentation technology. Some of these are listed in the table 25.2

Table 25.2 Important fermentation products

Foods and feed	Industrial products	Pharmaceuticals
Beer (Y)	Acetic acid	Pencillins
Bread (Y)	Acetone	Neomycin
Cheese (M or B)	Citric acid	Streptomycin
Cocoa (B & Y)	Lactic acid	Tetracyclines
Vinegar (B & Y)	**Enzymes**	
Wine (Y)	Diastase	
Whisky (Y)	Invertase	
Vitamins	Maltase	
Ergosterol (Y & M)	Zymase	
Riboflavin (Bansy)		
Vitamin A (B)		
Vitamin B_2 (Y)		
Vitamin B_{12} (B & M)		

Y = Yeast, B= Bacteria, M = Moulds.

Many chemical reactions caused by micro organisms are very complex. The basic five requirements of a good fermentation process are

1. The suitable microorganism that forms the desired end product.
2. The substrates (starting materials) must be easily available and economical.
3. Yields must be high.
4. Fermentation must be rapid.
5. The product must be easily recoverable and purified.

Fermentation process under controlled conditions involves different types of chemical conversions. Some of the important processes are

Oxidation	-	alcohol to acetic acid
		sucrose to citric acid
		dextrose to gluconic acid
Reduction	-	aldehydes to alcohols.
Hydrolysis	-	starch to glucose
		sucrose to glucose & fructose

The temperature and pH have great effect on the efficiency of the process. The optimum temperature varies from 5^0 to 40^0 C.

Check your progress

1. What is fermentation ?

2. Name few organisms used in fermentation.

3. Name few products prepared using fermentation process.

25.7 SUMMARY

1. Technology whether chemical or biochemical is essential for any nation for its prosperity & development.
2. Technological chemical processes involving microorganisms are known as bio-technological process.
3. Thus industrial scale utilization of biological systems and processes is broadly considered as **Bio-technology.**
4. This is known to man for the last thousands of years.
5. Use of living organisms (micro organisms) in making domestic edible foods and edible & non edible products was considered as bio-technology or fermentation technology in earlier times.
6. For example man was using fermentation process for the preparation of curds, condiments, cheese, vinegar, bread and alcohol.
7. But the man in the past did not know the scientific principle underlying this fermentation process.
8. Modern scientific investigations indicated that fermentation process involved the participation of micro organisms in the chemical conversions.
9. But bio-technology is a broader concept now than a mere fermentation technology.
10. The ability to control and manipulate microbes and use them for various useful applications paved way for the emergence of modern bio-technology.
11. The modern bio-technology now embraces three major areas. These are (1) genetic engineering (2) enzyme immobilization and (3) fermentation technology.
12. These are all useful in food production, synthesis of drugs, in agriculture and in correcting congenital diseases through genetic engineering.
13. DNA is the most important constituent of a living cell, which directs through its coded information. The synthesis of specific proteins.
14. Living cells accept DNA supplied from outside and new cells are formed. These are cultivated or cloned.

15. But entry of DNA is obstructed by "restriction enzymes" present in living cells.

16. Hence DNA is added first to "plasmids" existing in the living cells of micro organisms and then introduced into the cells. Plasmids are the small rings of DNA.

17. This process of DNA addition of living cells is widely used now to correct the congenital defects as well as to prepare some scarce and important bio-chemicals such as **Insulin.**

18. Now bacteria capable of degrading biologically some plastic materials are synthesized by this technology. These are known as "Bugs".

19. Enzymes used in bio-chemical processes are lost and are not recoverable from the waste products in the process, because these are water soluble.

20. To prevent this, enzymes are immobilised by chemically binding them to big molecules such as gelatin.

21. Fermentation technology is the chemical production process carried out through the help of living organisms yeast, bacteria and moulds.

22. The optimum temperatures and pH values are required for the efficiency of the process. The temperature shall be betwen 5^0 to 40^0C.

23. Foods, feeds, industrial chemicals and antibiotics are prepared by fermentation technology.

24. Some of the important foods, chemicals and drugs are Beer, Bread, Vitamin A, Vitamin B_2, Vitamin B_{12}, Alcohol, Acetone, Citric acid, Lactic acid, Pencillins, Neomycin and Tetracyclins.

25. For any developing country, bio technology plays a vital role in its developmental activities.

25.8 TERMINAL EXAMINATION MODEL QUESTIONS

I. Answer the following in 30 lines each.

1. What is bio-technology ? What are its applications in modern times?

2. What is meant by fermentation technology ? Describe its applications in chemical synthesis.

3. What is meant by bio-engineering and what are its difficulties, uses and limitations.

II. Answer the following in 15 lines each.

1. What is bio-engineering? Give examples.

2. What is enzyme-immobilization? What is its need?

3. Explain the term "Fermentation" with examples.

4. Name few chemical compounds of great importance prepared by fermentation processes.

5. Name the living organisms useful and the experimental conditions required in the fermentation processes.

25.9 GLOSSARY

Bio-technology	:	the technology for controlling and manipulating microbes for industrial processes.
Cloning	:	producing a group of organisms from one original organism.
Enzymes	:	proteins that act as biological catalysts.
Fermentation	:	a chemical change brought out by micro organisms.
Gene splicing	:	joining fragments of DNA.
Gene	:	cell constituent of living cell responsible for heridity.
Yeast	:	unicellular microorganisms.

UNIT-26 SCIENCE, TECHNOLOGY, QUALITY OF LIFE OPTIONS OF CHOICE

Contents

26.1 AIMS AND OBJECTIVES

Aims

In this you learn about

1. quest for prosperity for all
2. how technology is used as a tool of dominance by affluent countries.
3. need for the self reliance of a country and better life for its people.

Objectives

After you completed the unit, your will be able to.

1. understand that every one of us and every country will be always looking forward for all round prosperity and for prosperity for all.
2. appreciate that self reliance of a country will certainly give its people a better life and also reduce to a great extent dependence on affluent countries.

26.2 INTRODUCTION

After you studied all the 25 units till now in this foundation course on "Science and Technology", you would have definitely realised that science and technology are an integral part of human activity and society. Science and technology had their origins even in the periods when the first human beings acted to produce food and shelter. Science and technology influence any society by way of improving the methods of production and also by bringing a great change in the social out look of the country. At the same time the society and the conditions prevailing in the society effect the path as well as the rate of growth of science and technology in that country.

You will learn in this unit how science and technology play a significant role in the country's dominance and dependence or otherwise on other countries.

26.3 QUEST FOR PROSPERITY FOR ALL

The primitive society changed when "fire" and "agriculture" were discovered. From this stage the developments in science and technology took place step by step upto the present status. Robot technology, biotechnology, computer science and technology and space explorations indicate some paths through which the future societies in developing countries are likely to traverse in the 21st century. The great production systems supported by the great and the intricate trade and transport systems developed by many countries have brought people and countries much nearer than man expected. Communication systems changed tremendously from the stage of communication by "shouting" to the present stages of satellite supported communication systems.

Information is now stored by computers and retrieved as when required to make right decisions at right times. On account of these great developments that took place in the communication systems and weather forecasting systems we are able to minimise the damages caused by natural catastrophes such as earthquakes and cyclones. Along with scientific and technological developments, great changes came in social organisations too. Thus present day socialist pattern of society has also evolved from the early stages of primitive community living, the slave societies, kingdoms, republics, capitalism and socialism. Thus science and technology played a vital role in the transformation of human society. But science and technology can not exist independent of the society culture and the value systems. They are a part of the socioeconomic and political frame work of given society.

Throughout human history, the quest has been to create a society where every one is provided with a minimum standard of living. Every country in the world (except few perhaps) wanted itself to be a socialist state or a welfare state. But this can not be achieved with the intervention of science and technology alone. They may not ensure social justice or equality all the time. There are other considerations too. Every society and the people of that society have their own aspirations, goals and values of life. Science and technology can be of great help in achieving these goals. But unfortunately every country thinks of itself and this idea of socialism is not existing, between the countries. Some efforts of course were made to achieve this 'socialism' between the different countries. For example starting of United Nations Organisation (UNO) and International Court of Justice are two international organizations working towards socialism between the world's countries. With all these things, world is divided into three categories or "groups of countries". These are 1) developed countries (2) developing countries (third world) and (3) socialist countries.

The disparity between the developed and developing countries is large even now. This difference probably is increasing day by day. This is because of the rapid development of science and technology in these developed countries compared to the developments in developing countries. In the beginning the developed countries got an advantage over the developing countries. The reason probably for this is that most of the developing countries are ex-colonial countries. This advantage rightly or wrongly is being continued even now. Hence there is no real quest for the "prosperity for all" by the socialist countries or the developing countries even though science and technology are developing even in the third world countries. These developments are facing the threat from the cultural background of society on one hand and the dominance of the developed countries on the other hand.

Therefore there is a need for New International Economic Order. There is an urge or a desire of people of developing countries to share equally natural resources as well as scientific knowledge. Every developing country is thriving hard to develop its own infrastructure for the development of science and technology which provides prosperity for all.

Check your progress

1. What do you understand by the term "quest for prosperity for all"

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2. What stands in the way in realising this in practice?

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3. What changes are expected in science and technology policies to achieve prosperity for all ?

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26.4 TECHNOLOGY - AS A TOOL OF DOMINANCE

In any country technology plays a significant role in the development of that country. It is therefore essential that every country shall develop its own technology which is relevant for all culture background. But most of the developing countries are not in a position to develop their own technologies on account of the lack of the required human resources and the financial resources. Therefore the countries are forced to import technology from the developed countries. It is no wonder that all new inventions emanate from developed countries generally. Most of the developing countries are suffering from an undesirable phenomenon known as "brain drain". It is estimated that about a million scientists and technologists from the developing countries are living and working in the developed countries. For this situation there are many reasons. The important reasons may be that these countries may be offering better salaries and better facilities for working for these scientists and technologists. Moreover there is lack of demand for high quality and sophisticated technology in the home country. Hence unfortunately many developing countries are in a sense, exporting their intellectuals and importing non indigenous technologies from these developed countries. Because of lack of proper indigenous technology most of the developing countries are also exporting their valuable and rare natural resources (raw materials) to the developed countries and importing finished products at much higher price.

Importing of technology means definitely increasing the dependence of the importer on the exporting country. This amounts to increased dominance of the exporter country. This amounts to increased dominance of the exporter country or the developed country. Such a domination of the country will certainly make it dictate terms to the importing developing country. It may even insist that the developing country must minimise their welfare activities and programmes saying that expenditure on these programmes is "unproductive" Further the technologies evolved in the developed countries are capital intensive and making use of much less labour. Therefore such technologies if imported and used in developing countries shall definitely have to use much less local labour and also spend lot of money. Both these things are not in the interests of people of developing countries. Unfortunately all developing countries including India at the slightest necessity import technology, know-how, machines or the equipment at times eventhough such needs can be produced indigenously. Economic conditions or cultural requirements still are compelling many developing countries to produce and use materials from natural sources such as rubber, cotton, vegetable oils etc. But the developed countries are spending lots of money, and synthesising substitutes for these. In many instances these will naturally displace the equivalent products obtained from natural sources such as rubber, cotton etc. This naturally leads to domination of the affluent nations.

Therefore two things are very important to overcome this undesirable syndrome. These are 1) no country should have any reservations on themselves regarding synthesising such products or 2) take firm stands to encourage only indigenous products prepared from locally available natural resources.

Check your progress

1. What is meant by imported technology ?

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2. Can you mention two technologies that India imported in recent times?

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3. What are the drawbacks associated with the technologies imported?

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4. What are the remedial measures to overcome these draw backs.

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26.5 SELF-RELIANCE AND BETTER LIFE

From what you studied in the section 26.4 & 26.3 you must have realised that unless, each country developed its own indigenous technology and reduced dependence on affluent nations, it is not possible to achieve better life for its people.

Every country has to thrive hard to develop its own infrastructure for the development of science and technology, which provides prosperity for all.

The science and technology shall therefore have to make the countries self reliant and enable them to take their own decisions. Thus "self-reliance" is not a desirability but a necessity for "National Development". It is a new concept, which is becoming very popular among the developing countries. Freedom of action is important and crucial for any country to develop itself and this is not possible in any country which depends on imported technology. In such cases the nation should always be at the mercy of the benefactor country. Every country has to develop its own science, technology and economy in an integrated fashion. Then only it can take decisions independently in its own interests. Thus "self-reliance" has become a very popular concept among the countries of the third world. The concept of "self-reliance" is not a concept related entirely to material productions and development of science and technology. It is a state of mind that promotes confidence in one self or in one country.

But is does not mean isolating itself, from world science and technology. It definitely does not mean that a country should not import "know-how" or technological knowledge from other countries. Efforts must be made to minimise this type of action and enlarge the scope of "avoidable". Self reliance forms the real basis for the broad thinking of "quest for prosperity for all". Betterment of the conditions of living of the common people must be the guiding factor for achieving self reliance or developing indigenous technology. The word "Swadeshi" launched by Mahatma Gandhi during freedom movement probably has greater relevance now in the present conditions of the society. It is an ideological weapon. It does not mean rejecting totally everything that is related to foreign technology or know-how. It must be a new strategy for achieving self development and gradually decreasing foreign dependence. 70% of our population lives in villages and hardly uses anything which required imported goods or technology. At the same time betterment of conditions of living people in these villages is bound to give greater satisfaction to these people and this in turn increase our inner strength.

Science and technology thus play a significant role in the task of self-reliance. For any developing country the needs for food, shelter, clothing, health and education for all shall decide its scientific and technological programmes. For rapid fulfilment of these needs, new strategies and researches must be undertaken. In our country we have natural material resources and also human resources. We have also a political system where ideas can be freely and boldly tested and the best can be adopted. Knowledge must be made available to the largest number of people. This in turn will produce at all levels of education the real thinkers and great scientists and technologists.

Let us hope that science and technology will play an increasing role to put the country at much higher levels in the world map of developments.

Check your progress

1. What is self reliance ?

   ....

   ....

   ....

2. How does this help in natural development ?

   ....

   ....

   ....

3. What steps are necessary to achieve this self reliance ?

   ....

   ....

   ....

4. Name two areas where India has achieved this self-sufficiency ?

   ....

   ....

   ....

26.6 SUMMARY

1. The world is still divided into three categories of countries namely developed, socialist and developing countries.
2. Developing countries still depend on imported technology for their development.
3. This generally increases the dependence on other countries.
4. The developed countries, supplying these technologies dictate terms to the countries importing these technologies.
5. Self reliance alone is the remedial measure to solve the problem of this dependence.
6. A New International Economic Order must take place to make all categories of countries to come more closer and help each other.

7. Self-reliance or the concept of "Swadeshi" does not mean total rejection of foreign technology.

8. Equitable sharing of resources and knowledge must be the central idea for self reliance and national development.

26.7 TERMINAL EXAMINATION MODEL QUESTIONS.

I. Answer the following in about 30 lines each.

1. What is meant by "Quest for Prosperity for All" ? explain with illustrations.
2. How is technology acting as a tool of domination? elaborate.
3. What is self reliance? How is this achieved?
4. What New International Economic Order shall have to come into existence to solve the problems of developing countries.

II. Answer the following in about 15 lines.

1. What is meant by imported technology?
2. What are the ill effects associated with this imported technology?
3. What is brain-drain ? Why it is taking place ?
4. What is self-reliance ?
5. What steps are needed to develop indigenous technology?
6. What are the steps necessary for the development of a nation.

26.8 GLOSSARY

1.	Imported technology	:	technology borrowed or purchased from other countries
2.	Self-reliance in technology	:	developing indigenous technology and minimising import of technology.
3.	Brain-drain	:	moving of intellectuals from one country to the other for employment.
4.	International Economic Order	:	Just and equitable distribution of human and material resources between developed and developing nations for the mutual benefit.

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ASSIGNMENT NUMBER - 3

N.B. :-

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment normally should not take more than an hour's time.

Section - A

Answer one question out of the two questions given in this section.

క్రింద ఇచ్చిన రెండు ప్రశ్నలలో ఏదేని ఒక ప్రశ్నకు సమాధానం రాయండి.

Q.1 What is environmental pollution? Classify the same and give examples for each type.

Q.2 What is balanced diet? Explain the term "nutrition".

Section - B

Answer any 2 questions out of the 4 questions given in this section.

క్రింద ఇచ్చిన 4 ప్రశ్నలలో ఏదేని 2 ప్రశ్నలకు సమాధానం రాయండి.

Q.1 What is eco system? Give one example.

Q.2 Classify the diseases and give one example for each.

Q.3 Write about cultivation in hill areas.

Q.4 What are non-conventional energies.

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ASSIGNMENT NUMBER - 4

N.B. :-

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment normally should not take more than an hour's time.

Section-A

Answer one question out of the two questions given in this section.
క్రింద ఇచ్చిన రెండు ప్రశ్నలలో ఏదేని ఒక ప్రశ్నకు సమాధానం రాయండి.

Q.1 Give a brief account of the scientific contributions of India in space explorations.

Q.2 Describe the following; solar system, galaxies, sun, and structure of earth.

Section-B

Answer any 2 questions out of the 4 questions given in this section.
క్రింద ఇచ్చిన 4 ప్రశ్నలలో ఏదేని 2 ప్రశ్నలకు సమాధానం రాయండి.

Q.1 What is milky way. Explain.

Q.2 What is malnutrition?

Q.3 How is food preserved?

Q.4 What is artificial satellite?

SCIENCE AND TECHNOLOGY - A FOUNDATION COURSE : SYLLABUS

Unit-1	Science - A Human Endeavour
Unit-2	Science and Technology in Ancient Times
Unit-3	Science and Technology in Medieval Times-1
Unit-4	Science and Technology in Medieval Times-2
Unit-5	Modern Scientific Revolution
Unit-6	Electricity, Light, Magnetism, Electromagnetism
Unit-7	Semi Conductors and Electronics
Unit-8	Atoms, Molecules and Compounds
Unit-9	Industrial Carbon Compounds
Unit-10	Molecules of Life
Unit-11	Living cells and Tissues
Unit-12	Evolution and Heredity
Unit-13	Human Body and Regulatory Systems
Unit-14	Clinical Biochemistry
Unit-15	Our Universe
Unit-16	Land, Water, Air
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Unit-19	Agriculture and Population
Unit-20	Nutrition and World Outlook
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